

SEMESTER-II

M. Sc. Chemistry Syllabus, 2021-22
F. M. University, Belasore

Paper Code	Paper Name	Credit	Int. Mark	Ext. Mark
CH-421	ORGANIC CHEMISTRY-II	4	40	60

Objectives	Introduce students on the basic concepts of the mechanism incorporated with aromatic system and some new kind of mechanism like pericyclic reaction mechanism
Pre-Requisites	Knowledge on basic reaction mechanisms and stereochemical aspects of organic reactions.
Teaching Scheme	Regular classroom lectures, interactive session with focus on problem solving activities.

Detailed Syllabus

Unit I– Aromatic Substitution Reactions

Aromatic Electrophilic Substitution: The Arenium ion mechanism, orientation and reactivity, energy profile diagrams. The ortho/para ratio, ipso attack, orientation in other rings systems. Quantitative treatment of reactivity in substrates and electrophiles. Diazonium coupling, Vilsmer reaction, Gattermann-Koch reaction.

Aromatic Nucleophilic Substitution: The S_NAr, S_N1, Benzyne and S_{RN}1 mechanisms. Reactivity – effect of substrate structure, leaving group and attacking nucleophile. Von-Richter, Sommelet-hauser, Smiles rearrangements.

Unit II– Rearrangement Reactions

General mechanistic consideration- nature of migration, migratory aptitude, memory effects. A detailed study of the following rearrangement reactions: Pinacol-pinacolone, Wagner-Meerwein, Demjanov, Benzil- Benzilic acids, Favorskii, Arndt-Eistert synthesis, Neber, Beckmann, Hofman, Curtius, Schmidt, Baeyer-Villiger, Shapiro reaction.

Unit III– Addition to C-C Multiple Bonds

Mechanistic and stereo chemical aspects of addition reactions involving electrophiles, nucleophiles and free radicals, region and chemoselectivity, orientation and reactivity, addition to cyclopropane rings. Hydrogenation of aromatic rings. Hydroboration. Michael reaction. Sharpless Asymmetric Epoxidation (SAE).

Unit IV– Addition to Carbon-Hetero Multiple Bonds

Mechanism of metal hydride reduction of saturated and unsaturated carbonyl compounds, acids, esters, nitriles. Addition of Grignard reagents, organozinc and organolithium reagents to carbonyl and unsaturated carbonyl compounds. Wittig reaction. Mechanism of condensation reactions involving enolates-Aldol, Konevenagel, Claisen, Mannich, Benzoin, Perkin and Stobbe reactions.

Unit V– Pericyclic Reactions

Molecular orbital symmetry, Frontier orbitals of ethylene, 1, 3-butadiene, 1, 3, 5-hexatriene and allyl system. Classification of pericyclic reactions. Woodward-Hoffmann correlation diagrams. FMO and PMO approach. Electrocyclic reactions- con rotatory and dis rotator motions, 4n, 4n+2 and allyl systems. Cycloadditions- antrafacial and suprafacial additions, 4n and 4n+2 systems, 2+2 addition of ketones, 1,3 dipolar cycloadditions and cheletropic reactions.

Sigmatropic rearrangements- - antarafacial and suprafacial shifts of -H, sigmatropic shifts involving carbon moieties, 3,3-and 5,5- sigmatropic rearrangements. Claisen, Cope and aza-Cope rearrangements. Fluxional tautomerism. Ene reaction.

Course Outcome	<p>After studying this paper, students shall be able to know:</p> <ul style="list-style-type: none"> • Know the mechanism involved in various name reactions and rearrangement based mechanism. • New pericyclic reaction and detailed mechanism with its implications in conventional and advance organic reactions.
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Books Recommended;

Text book:

1. Advanced organic chemistry: reactions, mechanisms, and structure, Jerry March, JohnWiley.
2. Organic Chemistry by S. H. Pine, McGraw Hill, 1987
3. Pericyclic reactions by Ian Fleming, Oxford University Press.

Referencebook:

1. Some Modern Method of Organic Synthesis, W. Carruthers, 3rd Edition, Cambridge UniversityPress.
2. Organic Chemistry by J Clayden, N Greeves, S Warren & P. Wothers, Oxford UniversityPress
3. Advanced Organic Chemistry, Part – A/Part B by F. A Carey and R. J Sundberg, PlenumPress
4. Pericyclic Reactions by R. T.Morrisonand R. N.Boyd
5. Modern Synthetic Reactions by H. O. House, W.A. Benjamin, Inc., 1972
6. Understanding Organic Reaction Mechanism by A. Jacobs, Cambridge 1998.
7. Organic Chemistry by J. M. Hornback, Books Coley, 1998.
8. Organic Chemistry by P.Y. Bruice, Prentice Hall, 1998.
9. Principles of Organic Synthesis by R.O.C Norman and J. m. Coxon, Blackie Academic& Professional.
10. Modern Methods of Organic Synthesis: William Carruthers, Iain Coldham
11. Organic Chemistry, L. G. Wade, Pearson Prentice Hall, 2006

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
CH-422	INORGANIC CHEMISTRY- II	4	40	60

Objectives	The basic objective of this course is to introduce students the different theory, spectral and magnetic properties of transition metal complexes as well as mechanism of various organometallic compounds.
Pre-Requisites	Knowledge on transition metals and their electronic structure.
Teaching Scheme	Regular classroom lectures with use of chalk and black board. Sessions are planned to be interactive with focus on problem solving activities.

Detailed Syllabus

Unit I– Metal- Ligand Bonding

Crystal field theory, limitations of Crystal field theory; CFSE, Crystal Field Stabilization in Octahedral, Tetragonal, Square Planar and Pyramidal Fields. ACFT/Ligand Field Theory (LFT), molecular orbital theory (qualitative) for octahedral, tetrahedral and square planar complexes. σ and π -bonding in molecular orbital theory. Elementary idea of angular overlap model.

Unit II– Spectral Properties of Transition Metal Complexes.

Spectroscopic ground states, Elementary idea about spectral properties of simple metal complexes. Electronic spectra and Orgel Diagrams of some simple complexes of ions like Co^{2+} , Cr^{2+} , Ti^{2+} in Octahedral and Tetrahedral fields. Tanabe-Sugano diagrams, Measurement of Dq , B and β Parameters.

Unit III–Magnetic properties of Transition Metal Complexes

Elementary idea about magnetochemistry of metal complexes; diamagnetism, paramagnetism, temperature independent paramagnetism. Susceptibility and its measurements. Ferromagnetism and Anti- Ferromagnetism. Determination of magnetic susceptibility, spin-only formula, spin-orbit coupling, spin crossover.

Unit IV– Metal π - Complexes and Metal Clusters

Metal Complexes: Metal Carbonyls, Structure and Bonding, Vibrational Spectra of Metal Carbonyls for bonding and structural elucidation, 18-electron rule, important reactions of metal Carbonyls, Preparation, bonding, structure and important reactions of Transition Metal Nitrosyls, dinitrogen, and dioxygen Complexes, isolobal analogy, tertiary Phosphine as ligand.

Metal Clusters: Higher boranes, Carboranes, Metalloboranes and Metallocarboranes. Metal Carbonyl and halide cluster, Compounds with metal- metal bonding.

Unit V– Inorganic Reaction mechanism and organometallics

Metal alkyls, carbenes, carbynes, alkenes, alkynes, and allyl complexes. Hydrides, Metallocenes, Metal arene complexes. Carbonylate anions, agostic interaction, Oxidative addition and reductive elimination, insertion reactions (insertion of CO , SO_2 , alkenes)

and elimination reactions. Homogeneous and heterogeneous catalysis. Fluxional molecules, Fluxonality and dynamic equilibrium in compounds such as η^2 -olefin and η^3 -allyl and dienyl complexes.

Course Outcome	At the end of the course, the students will be able to: i) Various theories of transition metal complexes. ii) Mechanism of various organometallic compounds. iii) Know the spectral and magnetic properties of materials.
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Books Recommended;

Text book:

1. Inorganic Chemistry: Principles of Structure and Reactivity by J. E. Huheey, E. A. Keiter and R. L. Keiter, 4th Ed. Harper Collins 1993.
2. Concepts and Models of Inorganic Chemistry by B. E. Douglas, D. H. McDaniel, J. J. Alexander, John Wiley, 1993, 3rd Ed.
3. The Organometallic Chemistry of Transition Metals by R. H. Crabtree, John Wiley

Reference book:

1. Physical Inorganic Chemistry: A Coordination Chemistry Approach by S. F. A. Kettle, Spektrum, 1996
2. Advanced Inorganic Chemistry by F. A. Cotton and G. W. Wilkinson, 5th edition, John Wiley
3. Mechanism of Inorganic Reactions: Fred Basolo, Ralph G. Pearson.
4. Introduction to Magnetochemistry by A. Ernshaw, Academic press, 1968
5. Elements of Magnetochemistry by R. L. Dutta and A. Syamal, 2nd edition.
6. Organotransition metal chemistry; Fundamental concept and applications by A. Yamamoto, John Wiley, 1986
7. Inorganic Chemistry: Catherine E. Housecraft, Aian G. Sharpe

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
CH-423	PHYSICAL CHEMISTRY-II	4	40	60

Objectives	The basic objective of this course is to introduce students about the thermodynamic properties of microscopic particles. They know the chemical dynamics of various chemical reactions. They also able to know the ion solvent interaction and adsorption process.
Pre-Requisites	Knowledge state function and variables, basic concept of kinetics, adsorption and interaction of ions in solvent.
Teaching Scheme	Regular classroom lectures with use of chalk and black board. Sessions are planned to be interactive with focus on problem solving activities.

Detailed Syllabus

Unit I- Statistical Thermodynamics

Thermodynamic probability and entropy, Maxwell-Boltzmann statistics, partition function for diatomic molecules (translational, vibrational, rotational and electronic), relationship between partition and thermodynamic function (internal energy, enthalpy, entropy and free energy). Calculation of equilibrium constant, Fermi-Dirac statistics, Bose-Einstein statistics, Distribution law and its application to metal and Helium.

Unit II- Chemical Dynamics

Methods of determining the rate law, collision theory of reaction rates, steric factor, activated complex theory and Arrhenius equation. ionic reactions, kinetic salt effects, steady state kinetics, kinetic and thermodynamic control of reactions.

Dynamic chain (hydrogen-bromine reaction, decomposition of ethane), photochemical (hydrogen-bromine and hydrogen-chlorine reactions) and oscillatory reactions (Belousov-Zhabotinsky reaction), homogenous catalysis, kinetics of enzyme reactions, general features of fast reactions, study of fast reactions by flow method, relaxation method, flash photolysis method.

Unit III- Adsorption

Surface tension, capillary action, pressure difference across curved surface (Laplace equation), vapour pressure of droplets (Kelvin equation), different Isotherm: Freundlich, Langmuir, and Gibbs, estimation of surface area (BET equation).

Unit IV- Micelles

Introduction to Sol and Gel, Colloid and interface phenomenon, Surface active agents, classification, Micellization, hydrophobic interaction, hydrophilic interactions, critical micelles concentration (CMC), Factors affecting CMC of surfactants, thermodynamics of micellazation, reverse micelles.

Unit V–Electrochemistry

Electro chemistry of solution, Debye-Huckel-Onsager treatment, ion solvent interaction, Debye-Huckel-Jerum model, thermodynamics of electrified interface equations, Derivation of electrocapilarity, Lippmann equation, structure of electrified interface (Guoy, Champman, Stern model) over potential, exchange current density, derivation of Butler- Volmer equation, Tafelplot.

Course Outcome	At the end of the course, the students will be able to: i) Known the thermodynamic properties of microscopic particles. ii) Chemical dynamics of simple to complex reactions. iii) Process of adsorption as well as ion-ion/solvent interaction.
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Books Recommended;

Text book:

1. Chemical Kinetics by Keith Laidler, Harper and Row, 1995.
2. Chemical Kinetics: The study of reaction rates in solution by Kenneth A. Connors, VCH, 1990
3. Electrochemistry by Carl H. Hamann, Andrew Hamnett and Wolf Vielstich, Wiley VCH, 1998.
4. Statistical Thermodynamics by Donald A. McQuarrie,

Reference book:

1. Thermodynamics: Statistical Thermodynamics and Kinetics by Thomas Engel and Philip Reid, Pearson
2. Reaction Kinetics by M. J. Pilling and P. W. Seakins, Oxford Press, 1997
3. Modern Electrochemistry 1. Volume 1 and 2, by J. O'M. Bockris and A. K. N. Reddy, Kluwer Academic, 2000.
4. Electrochemical Methods, by A. J. Bard and L. R. Faulkner, John Wiley, 1980
5. Advanced Physical Chemistry, (vol- I, II, III, IV, V) K. L. Kapoor, Macmillan, 2004
6. Statistical Thermodynamics by M. C. Gupta

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
CH-424	SPECTROSCOPY-II	4	40	60

Objectives	The basic objective of this course is to introduce students about the deep knowledge about the various analytical instruments.
Pre-Requisites	Knowledge about the basic principles of instruments.
Teaching Scheme	Regular classroom lectures with use of chalk and black board. Sessions are planned to be interactive with focus on problem solving activities.

Detailed Syllabus

Unit I- Ultraviolet and Visible Spectroscopy

Various electronic transitions (185-800nm); Beer Lambert Law, effect of solvent on electronic transitions, ultraviolet bonds for carbonyl compounds, unsaturated carbonyl compounds, dienes, conjugated polyenes, Fieser-Woodward rule for conjugated dienes and carbonyl compounds, ultraviolet spectra of aromatic and heterocyclic compounds. Optical Rotatory Dispersion (ORD) and Circular Dichroism (CD): Definition, deduction of absolute configuration, octant rule for ketones.

Unit-II Infrared Spectroscopy

Instrumentation and sample handling, Characteristic Vibrational frequencies of alkane, alkenes, alkynes, aromatic compounds, alcohols, ethers, phenols and amines. Detailed study of Vibrational frequencies of carbonyl compounds (ketones, aldehydes, esters, amide, conjugated carbonyl compounds). Effect of hydrogen bonding and solvent effect on vibrational frequencies, overtones, combination bands, Fermi resonance, FTIR.

Unit III- NMR Spectroscopy-I

Nuclear Spin, nuclear resonance, saturation, shielding of magnetic nuclei, chemical shift, deshielding, spin-spin interactions, factors influencing coupling constant 'J'. Classification (ABX, AMX, ABC, A₂B₂), spin-decoupling, basic ideas about instrument, Two dimension NMR spectroscopy- COSY, NOESY, DEPT, INEPT, APT and INDIQUATE techniques.

Unit IV-NMR Spectroscopy-II

Carbon-13NMR (¹³C-NMR) Spectroscopy: General considerations, chemical shift, (Aliphatic, olefinic, alkyne, aromatic, hetero aromatic and carbonyl carbon), coupling constants. NMR studies of nuclei other than proton: ¹⁹F, and ³¹P. FT NMR, use of NMR in medical diagnostics (MRI).

Unit V– Mass Spectrometry

Introduction, ion production–EI, CI and FAB factors affecting fragmentation, ion-analysis, ion abundance, mass spectral fragmentation of organic compounds, common functional groups, molecular ion peak, metastable peak, McLafferty rearrangement, nitrogen rule, high resolution mass spectrometry, examples of mass spectral fragmentation of organic compounds with respect to their structure determination.

Course Outcome	At the end of the course, the students will be able to: i) Identify precisely the unknown materials. ii) Know the various complicated principles of different analytical instruments.
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Books Recommended;

Text book:

1. Physical Methods in Chemistry by R. S. Drago, Saunders, 1992
2. Inorganic Electronic Spectroscopy by A. B. P. Lever, Elsevier, 1984, 2nd Ed.
3. Chemical Applications of Group Theory by F A Cotton
4. Introduction to Spectroscopy by D.L. Pavia, G. M. Lampman, G. S. Kriz, Harcourt College Publisher, NY, 2001

Reference book:

1. Windawi Applied Electron Spectroscopy for Chemical Analysis by H. Windawi and F. L. Ho, Wiley Interscience
2. Spectrometric Identifications of Organic Compounds by R. M. Silverstein, John Wiley, 1991.
3. Modern Spectroscopy by J. M. Hollas, John Wiley
4. Mössbauer Spectroscopy by Y. Yoshida and G. Langouche, Springer
5. Basic Principle of Spectroscopy by R Chang, McGrawHill
6. Theory and Application of UV Spectroscopy, H. H. Jafee and M. Orchin, IBH-Oxford.
7. Introduction to Magnetic Resonance by A. Carrington and A. D. Maclachalan, Harper and Row
8. Inorganic Spectroscopic Method by A. K. Brisdon, Oxford Chem. Primers
9. NMR, NQR, EPR and Mössbauer Spectroscopy in Inorganic Chemistry by R. V. Parish, Ellis Harwood

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
CH-425	INORGANIC CHEMISTRY PRACTICAL	8	-	100

Objectives	The basic objective of this course is to introduce students to identify the unknown inorganic compounds using not only chemical tests but also using various spectroscopy techniques. They will also synthesize various inorganic compounds as well as estimation.
Pre-Requisites	Knowledge about properties of various inorganic elements and concept of various analytical instruments.
Teaching Scheme	Regular laboratory using test tube, chemicals and instruments. Sessions are planned to be interactive with focus on problem solving activities.

Detailed Syllabus

1. Mixture analysis

The supplied Mixture Must Contains Any one of the:

- Rare metal ions – Mo, W, Ti, V, U.
- Insoluble oxides, Sulfates, and Halides.

2. Reaction of Cr(III) with a Multidentate ligand; A kinetic study experiment.

(Visible Spectra Cr- EDTA Complex) J.A.C.S., 1953, 75,5670

3. Preparation of the following compounds and their studies by I.R., Electronics spectra measurements.

- Cis/ Trans- $K [Cr(C_2O_4)_2(OH_2)_2]$
- $[Ni(NH_3)_6] Cl_2$
- $Ni(dmg)_2$
- $K_3[Fe(C_2O_4)_3]$
- $Mn(acac)_3$

4. Spectrophotometric determination of;

- Iron- Phenanthroline complex; Job's Continuous variation method
- Mn/Cr/ V in steel sample

5. Synthesis and characterization of inorganic compound including co-ordination complexes, assemblies;

Synthetic methods: solution chemistry, solid state synthesis, sol-gel methods, multi step synthesis, preparation of isomers, synthesis under inert atmosphere, electrosynthesis.

Characterization: quantitative and qualitative determination of ligand and metal, use of spectral techniques (UV - visible, IR, NMR, ESR, magnetic moment, analytical methods (conductance, TG, DSC, cyclic voltametry, coulometry).

Course Outcome	At the end of the course, the students will be able to: i) Identify the unknown inorganic compound. ii) Synthesize high purity inorganic compounds as well as its characterization.
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Books Recommended;

Text Books:

1. Synthesis and Technique in Inorganic Chemistry: A Laboratory Manual,
2. Gregory S. Girolami, Thomas B. Rauchfuss and Robert J. Angelici. University
3. Science Books. 2. Synthetic methods of organometallic and inorganic chemistry ed. by Wolfgang A. Herrmann, Georg Thieme Verlag, New York, 1997, Vol 7 and 8
4. Vogel's qualitative inorganic analysis, by Svehla, G. Publisher: Harlow:
5. Longman, 1996. 4. Vogel's textbook of quantitative inorganic analysis: including elementary instrumental analysis. By: Arthur Israel Vogel; John Bassett Publisher: London; New York: Longman, 1978.

SEMESTER-III

M. Sc. Chemistry Syllabus, 2021-22
F. M. University, Bangalore

Paper Code	Paper Name	Credit	Int. Mark	Ext. Mark
CH-531	ORGANIC CHEMISTRY-III	4	40	60

Objectives	To introduce students about the photochemical reactions and mechanisms. Idea on oxidation-reduction of various organic compounds. Understanding the organometallic reagents and uses.
Pre-Requisites	Knowledge about basic idea on oxidation, reduction, photochemistry, and organometallic reagents.
Teaching Scheme	Regular classroom lectures with focus on light induced reactions and highlights of various organometallic catalysis.

Detailed Syllabus

Unit I– Photochemical Reaction mechanisms

Photochemical Reactions: Interaction of electromagnetic radiation with matter, types of excitations, fate of the excited molecule, quantum yield, transfer of excitation energy, actinometry.

Determination of Reaction mechanism: Classification, rate constants, life time of reactive energy states-determination of rate constants of reactions. Effect of light intensity on the rate of photochemical reactions; Types of photochemical reactions-photo dissociation, gas- phase photolysis.

Unit II– Photo Chemistry of Alkenes and Carbonyl Compounds

Photo Chemistry of Alkenes: Intramolecular reactions of olefinic bond- geometrical isomerism, cyclisation reactions, rearrangement of 1, 4- and 1, 5-dienes.

Photo Chemistry of Carbonyl Compounds: Intramolecular reactions of carbonyl compounds- saturated, cyclic and acyclic, β , γ -unsaturated and α , β - unsaturated compounds. Cyclohexadienones.

Unit III– Photo Chemistry of Aromatic Compounds

Isomerisations, additions & substitutions. *Miscellaneous Photochemical Reactions:* Photo-Fries reactions of anilides. Photo-Fries rearrangement, Barton reaction, Singlet molecular reactions, Photochemical formation of smog, Photo-degradation of polymers, Photochemistry of vision.

Unit IV– Oxidations and Reductions

Different oxidative processes, Oxidation of hydrocarbon, Alkenes, Aromatic rings, Alcohol, 1,2-diol, Allylic & benzylic alcohols, Aldehydes, ketones, Carboxylic acids, amines.

Different Reductive processes, Reduction of alkenes, alkynes, aromatic ring, cycloalkanes, carbonyl compounds, aldehydes, ketones, acids, Hydrogenesis.

Unit V– Organometallic Reagents

metal atom functionality in organometallic reactions, organometallics as protecting and stabilizing groups, palladium catalyzed reactions, Heck reaction, cross coupling reactions (Suzuki, Stille, Negishi, Kumada, Hiyama, Sonogashira, Buchwald-Hartwig), Fischer carbenes, Schrock carbenes, Olefin metathesis, Shi epoxidation, Jacobsen epoxidation. Introduction to domino/tandem/cascade reaction concepts with selected examples.

Course Outcome	After studying this paper, students shall be able to know: <ul style="list-style-type: none">• Photochemical reactions and mechanisms.• Redox pathways in organic chemistry.• Important organo-metal catalyzed reactions and synthesis.
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Books Recommended;

Text book:

1. Frontier Orbitals and Organic Chemical Reactions by I. Fleming, John Wiley, 1976.
2. Introduction to Organic Photochemistry by J. D. Coyle, John Wiley & Sons
3. G. S. Zweifel and M. H. Nantz, Modern Organic Synthesis-An Introduction, W. H. Freeman and Company, 2006

Reference book:

1. Fundamentals of Photochemistry by K. K. Rohatgi and S. M. Mukherji, Wiley Eastern
2. Introduction to Photochemistry by A. Cox and T. Camp, McGraw-Hill
3. Organic Photochemistry by J. Coxon and B. Halton, Cambridge Univ. Press
4. Some Modern Methods of Organic Synthesis, W. Carruthers, 3rd Edition, Cambridge University Press.
5. Principle and Application of Photochemistry by B. Wardle, John Wiley & Sons
6. Comprehensive organic synthesis, B. M. Trost and I. Fleming, Pergamon Press, 1992.
7. Organometallics in Organic Synthesis, J. M. Swan, D. St. C. Black, Chapman and Hall, London, 1974
8. Organotransition Metal Chemistry: Applications to Organic Synthesis, S. G. Davis, Pergamon Press, Oxford, 1982.
9. Basic Organometallic Chemistry, B. D. Gupta, A. J. Elias, Universities Press, Chennai, 2010
10. Transition Metals in the total synthesis of complex organic molecules, L. S. Hegedus, University Science Books, 1994.
11. Strategic Application of Named Reactions in Organic synthesis by L. Kurti and B. Czako, Elsevier Academic Publication
12. Application of Redox and Reagents in Organic Synthesis/ vol-I by Ratan Kumar Kar, 2008, new Central Agency (P) Ltd.
13. Basic Organometallic chemistry by Anil Elias, Univ. Publication

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
CH-532	BIOINORGANIC AND SUPRAMOLECULAR CHEMISTRY	4	40	60

Objectives	The basic objective of this course is to introduce students about the basic knowledge on the role of different metals in biological systems as well as its characterization. They also know about photosynthesis and role of hazardous materials on biological system.
Pre-Requisites	Knowledge about basic concept about the properties of various metal ions as well as principle of instruments such as NMR, EXAFS, XANES and ENDOR.
Teaching Scheme	Regular classroom lectures with use of chalk and black board. Sessions are planned to be interactive with focus on problem solving activities.

Detailed Syllabus

Unit I–Metal Ions in Biological Systems & Bio-mineralization

Essential trace elements, Na⁺/K⁺ pump, Ferritin, transferrin, and siderophores; Calcium in Biology: Transported regulation, Intracellular Ca²⁺ transport, Ca²⁺ ATPase, Na⁺/ Ca²⁺ exchange, mitochondrial influx and efflux. Inositol triphosphate, Ca²⁺ regulated intracellular processes: Calmodulin, Troponin C.

Unit II- Metals in Medicine and Coenzyme

Metal deficiency and disease, toxic effects of metals, metals used for diagnosis and chemotherapy with particular reference to anticancer drugs.

Coenzyme: Vitamin B₁₂. Role of hazardous materials such as nitric oxide, cyanide and methyl isocyanate etc. in biological systems.

Unit III– Chemistry of Nitrogenase&dioxygen Transport and Storage

Nitrogenase: Biological nitrogen fixation, molybdenum nitrogenase, spectroscopy and other evidence, other nitrogenases model systems;

Photosynthesis: Chlorophylls, photosystem I and photosystem II in cleavage of water model system;

Transport and Storage of Dioxygen: Heme-proteins and oxygen uptake, structure and function of hemoglobin, myoglobin, hemocyanins and hemerthrin, model synthetic complexes of iron, cobalt and copper.

Unit IV- Metalloenzymes and Their Characterisation Techniques

Metalloenzymes: Zinc enzymes: Carboxy peptidase and carbonic anhydrase; Iron enzymes: Catalase, peroxidase and cytochrome P-450; Copper enzymes: Superoxide dismutase; Molybdenum oxatransferase enzyme: Xanthine oxidase; electronic spectra, EPR (emphasis on first row transition metal ions and their spectra), brief description of CD / MCD and multinuclear NMR. Applications of newer methods like EXAFS, XANES and ENDOR in characterization of biological molecules.

Unit V- Supramolecular Chemistry

Molecular recognition: Molecular receptors for different type of molecules, Design and synthesis of co receptor molecules and multiple recognition; Supramolecular reactivity and catalysis; Transport process and carrier design; Supramolecular devices, self-assembly in Supramolecular chemistry.

Course Outcome	At the end of the course, the students will be able to: i) The role of metal ions in biological systems. ii) Characterize various biological compounds. iii) Know supramolecular compounds and their reactivity..
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Books

Recommended; Text

book:

1. S.J. Lippard and J.M. Berg, Principle of Bioinorganic Chemistry, University Science Books (1994).
2. Lawrence Que, Jr, Physical Methods in Bioinorganic Chemistry: Spectroscopy and Magnetism, University Science Books(2000).
3. Supramolecular Chemistry by J. W. Steed and J. L. Atwood, Wiley

Reference book:

1. Progress in inorganic Chemistry, vol.18 and 38 ed, J. J. Lippard, Wiley
2. Bioinorganic Chemistry: A chemical Approach to enzyme action, Hermann Dugas and C. Penny, SpringerVerlag.
3. Inorganic Biochemistry, Vol. I and IIed, G. L. Eichhorn, Elsevier.
4. Supramolecular Chemistry, J. M. Lehn, VCH.

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
CH-533	ANALYTICAL AND ENVIRONMENTAL CHEMISTRY	4	40	60

Objectives	The basic objective of this course is to introduce students about the environment and measurement of various components as well as the sampling procedure. They are able to know fertilizers along with basic principle of some instrument such as various chromatography, TGA, DTA, DSC, SEM, TEM, XRD, XRF.
Pre-Requisites	Knowledge about basic concept about the environment and its components, fertilizer and fuel.
Teaching Scheme	Regular classroom lectures with use of chalk and black board. Sessions are planned to be interactive with focus on problem solving activities.

Detailed Syllabus

UNIT- I Sampling & Data handling

Sample Handling: Classification of Analytical Methods; Types of samples, Preparation of sample for analysis, effect of sampling uncertainties, sample treatment, moisture in sample, decomposition of organic & inorganic compounds, procedure of sampling of solids, liquids and gases.

Errors and Evaluation: Definition of terms in mean and median; Precision- standard deviation; Accuracy, absolute and relative errors, detection limits, significant figures, rounding off; Types of errors – determinate and indeterminate errors; Ways of expressing; Confidence limit, Test of significance – the F-test and T-test. The statistical Q-test for rejection of a result, statistics for small data sets. Linear least squares method; the correlation coefficient; Calculation for the above parameters.

UNIT- II Agricultural and Fuel Analysis

Agricultural Analysis: Analysis of soils for available Major Nutrients - Estimation of available Nitrogen (Kjeldahl Method), Phosphorus (Olsen's Method and Bray and Kurtz Method), and Exchangeable Calcium & Magnesium (by EDTA); Soil analysis for Micronutrients and Pesticide Residues.

Fuel Analysis: Solid, liquid, gas; Ultimate and proximate analysis- heating values grading of coal. liquid fuels-flashpoint, aniline point, octane number and carbon residue; Gaseous fuel- producer gas, water gas-calorific value.

UNIT- III- Water Pollution and Management

Sources and characteristics of industrial waste water, Standards related to industrial wastewater; Primary, Secondary and Tertiary treatment of industrial wastewater.

Advanced technology for removal of toxic ions from industrial effluents such as Ion exchange, Electro dialysis, Reverse osmosis, Membrane technology, Ozonation, Wet air oxidation.

Unit-IV-Air Pollution and Management

Permissible limit of pollutants in ambient air and emission standards, Monitoring technique of particulate and gaseous pollutants (SPM, RSPM, SO₂, NO_x, Ozone), Principles and operations of gravity settling chamber, cyclones, scrubbers, filters, ESP; Control gaseous pollutants through adsorption, absorption, mass transfer, condensation, and combustion; Control of motor vehicle emissions, Stack monitoring.

UNIT- V – Analytical Techniques

Principle and Application of Chromatography (Paper, TLC, HPLC and GC), AAS, Bomb Calorimeter, Flame Photometry, XRD, XRF.

Thermal Methods: TGA, DSC and DTA.

General idea on advance microscopic techniques; SEM, TEM

Course Outcome	At the end of the course, the students will be able to: i) The sample collection and its measurement using various techniques. ii) Know the basic principle of various instruments. iii) Know about fuels and determination its calorific value.
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Books Recommended;

Text book:

1. Analytical Chemistry by G. D. Christian, JohnWiley.
2. Quantitative Analysis by R. A. Day Jr. and A. L. Underwood, 6thedition, Pearson
3. Analytical Chemistry; Principle and Techniques by L. G. Hargis, PrenticeHall
4. Environmental Chemistry and Pollution Control by S. S. Dara, S Chand

Referencebook:

1. Analytical Chemistry by A Gupta, PragatiPrakashan
2. Handbook of Analytical Instruments by R. S. Khandtur, TataMcgraw-Hill
3. Environmental Engineering by Gerard Kiely, Tata McgrawHill

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
CH-534	The Chemistry of Life and Surroundings	4	40	60

Objectives	The basic objective of this course is to introduce students about the environment, measurement of various components and its impact. They are aware about various commonly used chemical products such as soap, detergents, sanitizer, fuel, battery as well as vitamins and drugs with its impact.
Pre-Requisites	Knowledge about basic concept of atoms and its components.
Teaching Scheme	Regular classroom lectures with use of chalk and black board. Sessions are planned to be interactive with focus on problem solving activities.

Detailed Syllabus

Unit-I: History of Chemistry

Father of Alchemist and Modern chemistry, History of Organic chemistry, Matter (Physical and chemical classification), Chemical classification (Pure substance and mixture), Pure substance (Elements and compounds) Mixture (Homogeneous and heterogeneous), Atom and atomic mass, Molecule and molecular mass, Atomic structure (Basic idea), atomic number, mass number, Isotope, Isobars and Isotones, Symbol and electronic configuration up to atomic number 30, Basic concept of periodic table.

Unit-II: Water and Bio-molecules: A Basic Concepts

Water, Types of water (Soft and Hard water), Types of hardness (temporary and permanent), acidic and basic concept of aqueous solution, Concept of pH with simple problem, Carbohydrates, Protein, Vitamins (Utility to human body), nutrients.

Unit-III: Chemistry in day to day Life

Chemistry of Battery, Primary and Secondary battery, Lead-acid storage cell, Difference between primary and secondary battery, Solar cells, Chemistry of light (photosynthesis) and heat (thermal reaction). Chemistry of fuel and foods (Determination of calorific value), Chemistry of detergent, soap and beauty products, medicines and drugs, sanitization.

Unit-IV: Chemistry in our surrounding-I (Air pollution)

Types of air pollution, Acid rain, Global warming, Methods to control the air pollution.

Industrial disasters: Types of Industrial Safety Hazards, Classification of Explosions, Bhopal gas tragedy, Chernobyl, Fukushima Daiichi nuclear accident, Three miles island and Minamata.

Unit-V: Chemistry in our surrounding-II (Water pollution)

Types of water pollution, Primary treatment of water pollution, Methods to control water pollution, Quality of drinking water.

Eco system: Types of ecosystem such as Terrestrial ecosystem, Forest ecosystem, Grassland ecosystem, Desert ecosystem, Freshwater ecosystem, Marine ecosystem (Briefly describe each ecosystem)

Course Outcome	At the end of the course, the students will be able to: i) History of chemistry, knowledge about various household products. ii) Know the environment and its impact. iii) Know about commonly used daily products.
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Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
CH-535	PHYSICAL CHEMISTRY PRACTICAL	8	-	100

Detailed Syllabus

Objectives	The basic objective of this course is to introduce students to determine dynamics various chemical reactions as well as various properties of electrolytes.
Pre-Requisites	Knowledge about rate, order of chemical reaction and concept of strong and weak electrolyte.
Teaching Scheme	Regular laboratory using test tube, chemicals and instruments. Sessions are planned to be interactive with focus on problem solving activities.

1. Chemical Dynamics

(a) Determination of effect of (i) Change of Temperature (ii) Change of Conc. of reactants and Catalyst and (b) Ionic Strength of the media on the velocity constant of hydrolysis an Ester/ ionic reaction. (c) Determination of the velocity constant of Hydrolysis of an Ester / Ionic reaction in micellar media. (d) Determination of the rate constant for the oxidation of Iodide ions by Hydrogen peroxide, Studying the Kinetics as an Iodine Clock Reaction.

2. Electrochemistry, Counductometry, Potentiometry and Spectroscopy

Electrochemistry

(i) Determination of degree of dissociation of weak electrolyte and to study the deviation from Ideal behavior that occurs with a strong Electrolyte.

Counductometry

(i) Determination of velocity constant, Order of the reaction and energy of activation for saponification of ethyl acetate by Sodium hydroxide conductometrically.

(ii) Determination of Solubility and solubility product of sparingly soluble (PbSO_4 , BaSO_4) conductometrically.

(iii) Determination of the Strength of Strong and Weak Acids in a given mixture Conductometrically.

(iv) Determination of Activity coefficients of Zinc ions in the solution of 0.002M zinc Sulfate using Debye- Huckel's limiting law.

Potentiometry/pH metry

(i) Determination of strength of halides in a mixture Potentiometrically.

(ii) Determination of the valency of mercurous ions potentiometrically.

(iii) Determination of the strength of strong and weak acids in a given mixture using Potentiometer.

- (iv) Acid-base titration in a Non-aqueous media using a pH meter.
- (v) Determination of dissociation constant of Acetic acid in an acetone by titrating it with KOH.

Spectroscopy

- (i) Determination of pKa of an Indicator (e.g., Methyl red) in aqueous and micellar media.
- (ii) Determination of stoichiometry and stability constant of inorganic (e.g., ferric-salicylic acid) and Organic (e.g., amine-iodine) complexes.
3. Determination of viscosity average molecular weight of Polystyrene.
4. Synthesis of Polymethylmethacrylate by emulsion polymerization.
5. Viscosity average molecular mass of Polyacrylonitrile.

Course Outcome	At the end of the course, the students will be able to: i) Determine order and rate constant of chemical reaction. ii) Determine the various properties of electrolytes as well as some organic compounds.
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Books Recommended;

Text book:

1. Practical Physical Chemistry, A. M. James and F. E. Prichard, Longman.
2. Finley's Practical Physical Chemistry by B. P. Levitt, Longman.
3. Experimental physical Chemistry by R. C. Das and B. Behera, Tata McGrawHill.

SEMESTER-IV

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Paper Code	Paper Name	Credit	Int. Mark	Ext. Mark
CH-541	ORGANIC & POLYMER CHEMISTRY	4	40	60

Objectives	To introduce students about the broader concept of molecule designing through retro-synthetic approach.
Pre-Requisites	Have good understandings/holds on all the organic chemistry papers studied in last three semesters of the course.
Teaching Scheme	Regular classroom lectures, retrosynthetic application through various examples and logical disconnection approach with examples using software.

Detailed Syllabus

Unit I-Reagents in Organic Synthesis

Use of reagents in organic synthesis and functional group transformations; complex metal hydrides, Gilman's reagent, lithium dimethylcuprate, lithium diisopropylamide (LDA), dicyclohexyl carbodiimide, 1,3-dithiane (reactivity Umpolung), trimethylsilyliodide, tri-n-butyltinhydride, Woodward and Perovost hydroxylation, osmium tetroxide, DDQ, selenium dioxide, Phase transfer catalysts, crown ethers and Merrifield resin, Peterson's synthesis, Wilkinson's catalyst, Baker yeast. Role of silicon in organic synthesis.

Unit II- Disconnection Approach

An introduction to synthon and synthetic equivalents. Disconnection approach. Functional group Inter conversions. The importance of the order of events in organic Synthesis. one group C-X and two group C-X disconnections. Chemoselectivity. Reversal of polarity. Cyclisation reactions. Amine synthesis.

Unit III- One and Two Group C-C Disconnection

One Group C-C Disconnection: Alcohols and carbonyl compounds. Regioselectivity, Alkene synthesis. use of acetylenes and aliphatic nitro compounds in organic Synthesis.

Diels-Alder reaction. 1,3-functionalised compounds. α, β - unsaturated carbonyl compounds. Control in carbonyl condensations. 1,5-di functionalized compounds. Michael addition and Robinson annulation.

Unit IV– Protecting Groups and Ring Synthesis

Protecting groups: Principle of protection of alcohols, amine, carbonyl and carboxyl groups
Ring Synthesis: Saturated heterocycles, synthesis of 3-, 4-, 5- and 6- membered rings, aromatic heterocycles in Organic Synthesis.

Unit V– Organic Polymer

Polymer basic concepts, Classification, Mechanism (Condensation, addition, copolymerization), Polymer characterization and Morphology study, conducting polymer, biomedical polymer, polymeric reagents and catalysis, resins, synthesis of polymers like phenolic resins, PVC, bakelite, nylon, polyamides, photo responsive polymer, elastomer, curatives, fillers, reinforcing agents, vulcanization.

Course Outcome	After studying this paper, students shall be able to know: <ul style="list-style-type: none">• Designing organic compounds based on bio mimic.• Use of the software for molecule draw and plausible mechanism of desired organic compound.
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Books Recommended

Text book:

1. G. S. Zweifel and M. H. Nantz, Modern Organic Synthesis-An Introduction, W. H. Freeman and Company, 2006
2. Some Modern Method of Organic Synthesis by W. Carruthers and I. Coldham, Cambridge University Press
3. Organic Synthesis: The Disconnection Approach by Stuart Warren, Wiley
4. Protective Groups in Organic Synthesis by T.W. Greene, Wiley-VCH, 1999
5. Heterocyclic Chemistry by J. A. Joule and K. Mills, Blackwell publishing.
6. Textbook of polymer science, Fred W. Billmeyer. JR., John Wiley & Sons.

Reference book:

7. The Logic of Chemical Synthesis by E. J. Corey and Xue-Min Cheng, John Wiley and Sons
8. Classics in Total Synthesis: Targets, Strategies, Methods by K. C. Nicolaou and E. J. Sorensen, VCH
9. Classics in Total Synthesis II: More Targets, Strategies, Methods by K. C. Nicolaou and S. A. Snyder, Wiley-VCH.

10. Designing Organic Syntheses: A programmed Introduction to the Synthron Approach by S. Warren, John Wiley and Sons
11. Organic Synthesis: Concept, Methods and Starting material by J. Fuhrhop and G. Penzillin, VCH, Weinheim, Germany
12. Classics in Stereoselective Synthesis by E. M. Carreira and L. Kvaerno, Wiley-VCH Verlag GmbH & Co
13. Organic Synthesis: Strategy and Control by P. Wyatt and S. Warren, Wiley
14. Workbook of Organic Synthesis: The Disconnection Approach by P. Wyatt and S. Warren, Wiley
15. Strategic Application of Named Reactions in Organic synthesis by L. Kurti and B. Czako, Elsevier Academic Publication
16. Organic Chemistry from Retrosynthesis to Asymmetric Synthesis by Vitomir Šunjić and Vesna Petrović Peroković, Springer
17. Biocatalysis in Organic Synthesis: The Disconnection Approach by N. Turner, Royal Society of Chemistry
18. Heterocyclic Chemistry by T. R. Gilchrist, Longman, 1989.
19. Selectivity in Organic Synthesis by Ward, Wiley-VCH, 1999
20. Fundamentals of Organic Synthesis: The Retrosynthetic Analysis/ vol-I & II Ratan Kumar Kar, 2008, new Central Agency (P) Ltd.
21. Polymer science, V. R. Gowariker, N.V. Viswanathan and Jayadev Sreedhar, New Age International (P) Limited.
22. Additives for Plastics hand book, John Murphy, Elsevier Advanced Technology.
23. Compounding materials for Polymer industries, J.S. Dick, Noyes Publication, USA, 1987.

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
CH-542	BIO PHYSICAL AND SOLID STATE CHEMISTRY	4	40	60

Objectives	The basic objective of this course is to introduce students about the knowledge of biochemical reactions and ion transport. They also able to understand the defects of solids and its properties.
Pre-Requisites	Knowledge about basic concept various biochemical reagents and electronic structure of metals.
Teaching Scheme	Regular classroom lectures with use of chalk and black board. Sessions are planned to be interactive with focus on problem solving activities.

Detailed Syllabus

Unit I- Biophysical Chemistry I

Bioenergetics: Standard free energy change in biochemical reactions, exergonic, endergonic. Hydrolysis of ATP, Synthesis of ATP from ADP.

Statistical Mechanics: Chain configuration of macromolecules, statistical distribution end to end dimensions, calculation of average dimensions for various chain structures, Polypeptide and protein structures, introduction to protein folding problem.

Unit II- Biophysical Chemistry II

Biopolymer Interactions: Forces involve dinbiopolymerinte ractions, Electrostatic charges and molecular expansions, hydrophobic forces. Multiple Equilibria and various types of binding processes in biological systems, Hydrogenion titration curve.

Unit III- Thermodynamics of Biopolymer and Transport Phenomenon

Thermodynamics of biopolymer Solutions, osmotic pressure, membrane equilibrium, muscular contraction and energy generation in mechano chemical reactions.

Transport of Ions: Structure and functions of cell membrane, ion transport through cell membrane, irreversible thermodynamic treatment of membrane transport, Nerve conduction.

Unit IV– Solid State Chemistry I

Crystal Defects and Non-stoichiometry: Perfect and imperfect crystal, intrinsic and extrinsic defects, point defects, line and plane defects, vacancies-Schottky defects and Frenkel defects, Thermodynamics of Schottky and Frenkel defect formation, colour centers, non- stoichiometry and defects.

Solid State Reactions: General principles, experimental procedures, co-precipitation as a precursor to solid state reactions, kinetics of solid state reactions. Principle and Application of X-ray and Neutron Diffraction.

Unit V– Solid State Chemistry II

Electronic Properties of Solids: Metals, insulators and semiconductors, electronic structure of Solids-Band theory, band structure of metals, insulators and semiconductors. Intrinsic and extrinsic semiconductors, doping semiconductors, p-n junctions, super-conductors. *Organic Solids:* Electrically conducting solids, organic charge transfer complex, organic metals, new superconductors.

Course Outcome	At the end of the course, the students will be able to: i) Know various biochemical reactions and its properties. ii) Know the properties of solids.
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Books Recommended;

Text book:

1. Principle of Bio-Chemistry, A. L. Lehninger, WorthPublishers
2. Biophysical Chemistry by J. P. Allen, BlackwellPublishing
3. Solid State Chemistry: An Introduction by L. E. Smart and E. A. Moore, Taylor and Francis

Reference book:

1. Modern Aspects of Solid State Chemistry by C. N. R. Rao, Springer
2. Introduction to Biomolecular Energetics by I. M. Klotz, Academic Press, London
3. Amino Acids and Peptides by J. S. Davies, Chapman and Hall
4. Principle of Nucleic Acid Structure by W. Saenger, Springer
5. Solid State Chemistry and Its Application by A. R. West, Wiley
6. Principle of Solid State, H. V. Keer, Wiley Eastern
7. Solid State chemistry, D. K. Chakrabarty, New
8. Macromolecules by H. G. Elias, Sringer
9. Biophysical Chemistry by Dagmar Klostermeier, Markus G. Rudolph, CRC Press/ Taylor and Francis
10. Biophysical Chemistry: Molecules to Membranes P. R. Bergethon and E. R. Simons, Springer

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
CH-543	GRAND VIVA	4	-	100

This is a face-to-face Viva-voce by the Experts; comprises all faculty members of the Department and at least one member (External) from outside to gauge the overall depth and control of a student on entire syllabus of all four semesters.

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Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
CH-544	ANALYTICAL CHEMISTRY PRACTICAL	4	-	100

Detailed Syllabus

1. Verification of Beer- Lambert's Law by Colorimetric method.
2. Determination of Na⁺/K⁺ ion by Flame Photometry.
3. Determination of Ascorbic acid in tablets.
4. Determination of Dissolved Oxygen (DO) in Water sample.
5. Measurements of pH of soils by a pH-meter.
6. Determination of chemical oxygen demand (COD) in water sample.
7. Determination of moisture contents in soils by gravimetric method.
8. Analysis of fat in butter sample.
9. Determination of Biochemical Oxygen Demand (BOD) in water sample.
10. Estimation of metal ion by ion-exchange method.

Books

Recommended; Text

book:

1. Instrumental techniques for Analytical Chemistry by Frank Settle, Prentice
2. Analytical Chemistry: Principles by J. H. Kennedy, Brooks/Cole
3. Standard methods for the Examination of Water and Waste Water, APHA, Washington DC.
4. Analytical Chemistry; A Practical Approach by E. E. Hywel, Oxford University Press
5. Analytical Chemistry, G.D. Christian, J. Wiley.
6. Analytical Chemistry-Principle and Techniques, L.G. Hargis, Prentice Hall.

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
CH-545	DISSERTATION WORK PRESENTATION & DEFENSE	8	-	100

This is a project/ review type of work, has to be carried out by each Final year student under direct supervision of faculty member(s) allotted against his/her name by the Department, that shall be notified by the Department in the due course of time in second year and the report shall be submitted by the students during end term Examination of the fourth semester.

*****End of The Syllabus*****