

MASTER OF SCIENCE IN CHEMISTRY

(SEMESTER PATTERN)

CHOICE BASED CREDIT SYSTEM (CBCS) SYLLABUS

TWO YEARS FULL TIME PROGRAMME

COURSE OF STUDIES-2018

(AS PER U.G.C. MODEL SYLLABUS)



**DEPARTMENT OF CHEMISTRY
BERHAMPUR UNIVERSITY
BHANJABIHAR, BERHAMPUR**



BERHAMPUR UNIVERSITY
COURSES OF STUDIES
FOR THE
M. Sc. EXAMINATION IN CHEMISTRY
(2018-)

As per the UGC model syllabus, the choice based credit system syllabus in M. Sc. Chemistry shall comprises of four semesters, having total of 2000 marks and 80 credits. There shall be 16 theory papers of 04 credit weightage each, 100 (80+20) full marks each and having three hours of examination duration. There shall be 3 practical papers (each 4 credit) of six hours duration and 01 MSc dissertation in last semester to carry out project work of 04 credit.

Questions will be set unit wise. The paper will comprise both subjective and objective. Problem oriented approach should be there.

**DISTRIBUTION OF COURSES IN SEMESTER PATTERN UNDER CHOICE BASED CREDIT SYSTEM (CBCS)
FOR M. SC. (CHEMISTRY) PROGRAMME EFFECTIVE FROM -2018**

Semester-I

Paper No.	Subject	Marks	Credits	Time
CHE-CC-401	Organic Chemistry-I	80+20 100	04	3h
CHE-CC-402	Inorganic Chemistry-I	80+20 100	04	3h
CHE-CC-403	Physical Chemistry-I	80+20 100	04	3h
CHE-CC-404	Spectroscopy-I	80+20 100	04	3h
CHE-CC-405	Organic Practical	100	04	6h

Semester-II

Paper No.	Subject	Marks	Credits	Time
CHE-CC-406	Organic Chemistry-II	80+20 100	04	3h
CHE-CC-407	Inorganic Chemistry-II	80+20 100	04	3h
CHE-CC-408	Physical Chemistry-II	80+20 100	04	3h
CHE-CC-409	Spectroscopy-II	80+20 100	04	3h
CHE-CC-410	Inorganic Practical	100	04	6h

Semester –III

Paper No.	Subject	Marks	Credits	Time
CHE-CC-501	Organic Chemistry-III	80+20 100	04	3h
CHE-CE-502	Analytical Chemistry-I	80+20 100	04	3h
CHE-CE-503	Organometallic Chemistry	80+20 100	04	3h
CHE-CE-504	Environmental and Analytical Chemistry	80+20 100	04	3h
CHE-CE-505	Nano Chemistry	80+20 100	04	3h
CHE-OE-506	Chemistry and Society	80+20 100	04	3h
CHE-OE-507	Chemistry and Environment	80+20 100	04	3h
CHE-CC-508	Physical & Analytical Practical	100	04	6h

Semester –IV

Paper No.	Subject	Marks	Credits	Time
CHE-CC-509	Organic Chemistry-IV	80+20 100	04	3h
CHE-CC-510	Physical Chemistry-III	80+20 100	04	3h
CHE-CE-511	Bio-Organic Chemistry	80+20 100	04	3h
CHE-CE-512	Bio-inorganic and Supramolecular Chemistry	80+20 100	04	3h
CHE-CE-513	Polymer Chemistry	80+20 100	04	3h
CHE-CE-514	Industrial Chemistry	80+20 100	04	3h
CHE-CC-515	Project	100	04	300h

CC - Chemistry Core, CE – Chemistry Elective, OE – Outer Elective, N.B. The students of M.Sc. Chemistry have to take two elective papers out of four (CHE-CE-502, 503, 504, and 505) in 3rd semester and two elective papers (CHE-CE-511, 512, 513, and 514) in 4th semester. In addition to the above electives, the students have to take another paper from other department during 3rd semester.

SEMESTER-I

ORGANIC CHEMISTRY-I

Paper-CHE-CC-401

Unit-I: Basic Concept of Organic Chemistry

Drawing correct structure of organic molecules. Delocalisation and conjugation, resonance, hyperconjugation, Huckel rule for Aromaticity, non-aromatic, homoaromatic and anti-aromatic nature of benzenoid and non-benzenoid compounds, Acidity, basicity, and pKa of organic molecules. Organic Lewis acids and bases. Regioselective, Stereospecific, Stereoselective and Chemoselective reactions, Thermodynamic and kinetic controls of organic reaction. Keto-enol tautomerism, methods required to identify organic molecules. Basic Idea of organic intermediates (carbenes, cation, anion, radical cation, radical anion and free radical).

Unit-II: Stereochemistry of Organic compounds

E-Z-notation, cis/trans isomer, Zimmerman-Traxler model, Conformational analysis of cycloalkanes, decalins, effect of conformation on reactivity, conformation of sugars. Elements of symmetry, chirality (N, S, P, C), molecules with more than one chiral center, threo and erythro isomers, enantiotropic and diastereotropic atoms, groups and faces, Absolute and relative configuration (D/L-, d/l, R/S and +/-) nomenclature, Fischer, Newmann and Sawhorse projection. Optical activity in the absence of chiral carbon (biphenyls, allenes and spiranes), chirality due to helical shape. Methods of resolution (Chiral HPLC, lanthanide shift reagents, Mohr's reagent). Optical purity, Specific rotation, Enantiomeric excess (ee), diastereomeric ratio, chiral auxiliary and reagent. Asymmetric synthesis: stereospecific and stereoselective synthesis, Sharpless epoxidation and Dihydroxylation, Noyori reduction, CBS reduction, Baker's yeast Reduction.

Unit-III: Pericyclic Reactions

Molecular orbital symmetry, Frontier orbital of ethene, 1,3- Butadiene, 1,3,5-Hexatriene, Allyl system, Classification of pericyclic reaction, Woodward-Hoffmann method, Frontier molecular orbital theory approach, Huckel-Mobius approach. Electrocyclic reactions: Dis- and Con- rotation, $4n$, $4n+2$ and allylic system, Explanation through correlation diagram and Huckel-Mobius approach, Cycloaddition reaction: $2+2$ and $4+2$ cycloaddition, 1,3-Dipolar cycloaddition, Cheletropic reactions, Sigmatropic rearrangements, Claisen Rearrangement, Cope rearrangement, Ene reaction.

Unit-IV: Organic Photochemistry

Electronic excitation, Jablonski diagram, Fluorescence, Phosphorescence, Photodissociation reactions: Norrish Type-I & II cleavage, Photo isomerisation, Photo-Fries rearrangement, Paterno-Buchi reaction, Barton reaction, Di-Pi methane rearrangement, Photochemistry of aromatic compounds, Photo-Oxidation of alkenes. Photochemistry of vision.

Recommended Books;

- 1) Organic synthesis: Clayden, Greeves, Warren and Wothers, Oxford Univ. Press, 2nd Ed (2012).
- 2) Advanced Organic Chemistry, F. A. Carey and R. J. Sundberg, Part A and B Springer, 5th Ed.(2005)

- 3) A Guide Book of Mechanism in Organic Chemistry, Peter Sykes, Longman.6th Ed.(1999)
- 4) Structure and Mechanism in Organic Chemistry, C. K. Ingold, Cornell University Press,3rd (1957).
- 5) Organic Chemistry, R. T. Morrison and R. N. Boyd, Prentice-Hall, 6th Ed.(1992)
- 6) Modern Organic Reactions, H. O. House, W.A. Benjamin. 2nd Ed.(1972)
- 7) Principles of Organic Synthesis, R.O.C. Norman and J. M. Cox, CRC Press 3rd (2014).
- 8) Reaction Mechanism in Organic Chemistry, S. M. Mukherjee and S. P. Singh, Macmillan.3rd Ed. (2009).
- 9) Stereochemistry of Organic Compounds, E. L. Eliel, S. H. Wilen, L.N. Mander, John Wiley & Sons, Inc., New York, NY. (1994).
- 10) Fundamentals of Photochemistry, K. K. Rohtagi-Mukherji, Wilcy-Eastern.
- 11) Molecular Photochemistry, N. J. Turro, W. A. Benjamin.
- 12) Introductory Photochemistry, A. Cox and T. Camp. McGraw-Hill.
- 13) Photochemistry, R. P. Kundall and A. Gibert, Thomson Nelson.
- 14) Organic reaction mechanism (Benjamin) R. Breslow
- 15) Mechanism and structure in Organic chemistry (Holt Reinh.) B. S. Gould.
- 16) Organic chemistry (McGraw-Hill)Hendrikson, Cram and Hammond.
- 17) Basic principles of Organic chemistry (Benjamin) J. D.Roberts and M. C. Caserio.
- 18) Organic Stereochemistry (McGraw-Hill) by Hallas.
- 19) Organic reaction mechanism (McGraw-Hill) R. K. Bansal.
- 20) Organic chemistry- R. T. Morrison and R. N. Boyd,(Prentice Hall.)
- 21) Advanced Organic Chemistry-Reactions, Mechanism and Structure, Jerry March, John Wiley, 6th Ed.(2006).

INORGANIC CHEMISTRY-I

Paper-CHE-CC-402

Unit-I: Covalent Bond

Qualitative discussion on valence bond theory-formation of hydrogen molecule, Qualitative discussion on molecular orbital theory, bonding and antibonding orbitals, energy distribution and stability, MO energy level diagrams of simple diatomic molecules like N_2 , O_2 , F_2 , CO and NO, Hybridization and wave mechanical description for sp , sp^2 and sp^3 hybrid orbitals, qualitative idea about dsp^2 , dsp^3 and d^2sp^3 hybrid orbitals, VSEPR theory, shapes of simple molecules and ions, Linnet's double quartet theory and spectra of simple molecules.

Unit-II: Metal II-Complexes

Chemistry of metal carbonyls, Constitution of metal carbonyls: mononuclear, poly nuclear clusters with terminal and bridge carbon monoxide ligand units, Carbonylate anions, Carbonyl hydrides and Carbonyl halides. Metal nitrosyl and other types of metal nitric oxide complexes, Cyanonitrosyl complexes of metals, Brown ring compounds, dinitrogen complexes.

Unit-III: Rings, Cages and Metal Clusters

Inorganic catenation and hetero catenation, Inorganic ring: borazine, phosphorazine and their derivatives, Inorganic cages: borides and carbides, higher boranes, carboranes, metallaboranes and metallacarboranes, compounds with metal-metal multiple bonds.

Unit-IV: Nuclear Chemistry

Radioactive decay and equilibrium, Artificial radioactivity, Disintegration by α -particle and neutron, Types of nuclear reaction: fission and fusion, Applications radio isotopes to physico- chemical problems, Uses of radio isotopes for dating, medicine agriculture and industry.

Books recommended

1. Advanced Inorganic Chemistry: F. A. Cotton and G. Wilkinson, John Wiley.
2. Inorganic Chemistry: J. E. Huheey, E. A. Keiter, R. L. Keiter, Pearson Education.
3. Inorganic Chemistry: Missler and Tarr, Prentice Hall.
4. Chemistry of the Elements: N. N. B. Greenwood and A. Earnshaw, Pergamon.
5. Essential of Nuclear Chemistry: H. J. Arnikar, ACS.

PHYSICAL CHEMISTRY-I

Paper-CHE-CC-403

Unit-I: Symmetry and group theory

Group, Subgroup and Classes, Symmetry elements and Symmetry operations, Relationship between orders of a finite group and its subgroup, Conjugacy relation and classes, symmetry Point group, Matrix representation of point groups and matrix representation for the E, C_n, σ_v , S_n), Nomenclature and symmetry classification of molecules, Irreducible representation and Orthogonality theorem, Standard reduction, Character table (C_{2v}, C_{3v}, C_{4v}, C_{2h}, D₂, D_{2d}), Direct product.

Unit-II: Application of group Theory

Transformation properties of atomic orbitals, Hybridization scheme for σ -bonding (C_{3v}, C_{4v}, D_{3h}, T_d) projection operator, Symmetry adopted LCO, Hybrid orbital as linear combination of atomic orbitals, MO treatment of coordination compounds, σ -bonding in octahedral complexes, Formation of LCO, Formation of MO, Construction of MO diagram.

Unit-III: Quantum chemistry

Principle of superimposition, Angular momentum, Particle in one and three dimensional boxes, Hydrogen atom, Transformation of co-ordinate, Separation of variables, ϕ -equation, θ -equation, The radial equation, Shapes of s, p and d orbitals. Postulates of quantum mechanics, Simple harmonic oscillator, Rigid rotator, The variation theorem, Linear variation theorem, Linear variation principle, Perturbation theory (first order and nondegenerate), Application of various methods and perturbation theory to Helium atom, Huckel theory of conjugated systems, Bond order and charge density calculation, Application to ethylene, butadiene, cyclopyl radical, cyclobutadiene.

Unit-IV: Computer for chemists

Computer programming in C: Elements of computer language, Constant and Variables, Operation and symbols, Expressions, Arithmetic assignment, Input and output, Conditional statement, Loops, Logical variables. C Programming in chemistry: Development of small computer codes involving simple formulae in chemistry such as Vander-Waal's equation, Radioactive decay constant, Rate constant, Evaluation of energy level and radius of an orbit.

Books recommended

1. K. Veera Reddy, Symmetry and Spectroscopy of Molecules, New Age International, Delhi
2. I.N. Levine, Quantum Chemistry, 5th edition (2000), Pearson Educ. Inc., New Delhi.

3. A.K. Chandra, Introductory Quantum Chemistry, 4th edition, Tata McGraw Hill, New Delhi.
4. L. Pauling and E. B. Wilson, Introduction to Quantum Mechanics with Applications to Chemistry (1935), McGraw Hill, New York.
5. R.K.Prasad,|| Quantum Chemistry||, Wiley.
6. F.A. Cotton, Chemical Applications of Group Theory, Wiley
7. Ramesh Kumari, Computers and their Applications to Chemistry, Narosa, New Delhi

SPECTROSCOPY-I

Paper-CHE-CC-404

Unit-I: Electronic and Molecular Spectroscopy

Electronic Spectroscopy: Energies of atomic orbital, Spectra of H-like atoms, (Lyman, Balmer, Paschen and P-fund series) Spectra of alkali metal atom. Charge transfer spectra,

Molecular spectroscopy-Energy levels, Vibrational progression and geometry of excited state, Frank-Condon principle. Jablonski diagram, Electronic spectra of poly atomic molecule

Unit-II : Microwave and Atomic Spectroscopy

Microwave spectroscopy: Classification of molecules, Rigid rotator model, Effect of isotopic substitution on transition frequencies, Non- rigid rotator., Stark effect, Applications.

Atomic Spectroscopy: Electronic configuration, Russell-Saunders terms and coupling schemes, magnetic effects: spin-orbit coupling and Zeeman splitting, spectra of hydrogen atom and alkali metal atoms

UNIT-III: Vibrational Spectroscopy

Vibrational energy of diatomic molecules, zero point energy, force constant and bond strength, Morse potential energy diagram, vibrational-rotational spectroscopy, P,Q,R branches, break – down of Oppenheimer approximation, vibration of polyatomic molecules, Selection rules, Normal mode of vibration, Group frequencies, Overtones, Hot bands, Factors affecting the band positions and intensities for IR- region.

Unit-IV : Raman and Photoelectron Spectroscopy

Raman Spectroscopy: Classical and quantum theories of Raman effect. Pure rotational, vibrational and vibrational-rotational Raman spectra, selection rules, Mutual exclusion principle. Resonance Raman spectroscopy, coherent anti Stokes Raman spectroscopy (CARS).

Photo electron spectroscopy: Basic principles, Photoelectric effect, Ionisation process, Koopmans's thermo photoelectron spectra of simple molecules, ESCA, Chemical information from ESCA, Auger electron spectroscopy.

Books recommended

- 1) Modern Spectroscopy, J.M. Hollas, John Wiley, 2004, 4th edition, Sussex.
- 2) Applied Electron Spectroscopy for Chemical Analysis Ed. H. Windawi and F.L.Ho, Wiley Inter science.

- 3) NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry, R.V. Parish, 1990, 1st edition, Ellis Harwood.
- 4) Physical Methods in Chemistry, R.S. Drago, Saunders College.
- 5) Chemical Applications of Group Theory, F.A. Cotton.
- 6) Introduction to Molecular Spectroscopy, G.M. Barrow, McGraw Hill
- 7) Basic Principles of Spectroscopy, R. Chang, McGraw Hill.
- 8) Theory and Applications of UV Spectroscopy, H.H. Jaffe and M. Orchin, IBH-Oxford.
- 9) Introduction to Photoelectron Spectroscopy, P.K. Ghosh, John Wiley.
- 10) Introduction to Magnetic Resonance, A. Carrington and A.D. MacLachlan, Harper & Row.
- 11) Inorganic spectroscopic methods, A.K. Brisdon, Oxford University Press, Oxford Chem. Primers, 1997, New York.
- 12) Spectroscopy, S. Walker and H. Straw, Chapman and Hall Ltd.
- 13) Energy levels in atom and molecules, W.G. Richards and P.R. Scott, Oxford University Press, Oxford Chemistry Primer vol. 26, 1994, New York.
- 14) Atomic Spectra, T.P. Softley, Oxford University Press, Oxford Chemistry Primer, Vol. 19, New York.
- 15) Introduction to Spectroscopy, Pavia, Brooks/Cole Cengage, 4th edition, 2009, Belmont.
- 16) Symmetry and Spectroscopy of Molecules, K.V. Reddy, New Age International (P) Ltd., 1st edition, 1998, New Delhi.
- 17) Fundamental Concepts of Inorganic Chemistry, A. K. Das and M. Das, Vol. 7, 1st edition, 2014, CBS Publisher Pvt. Ltd., New Delhi.
- 18) Electronic Absorption Spectroscopy and Related Techniques, D. Sathyanarayana, University Press (India) Ltd., 2001, Hyderabad.
- 19) Molecular Spectroscopy, P.S. Sindhu, Tata McGraw Hill, 1985, New Delhi.
- 20) Fundamental of Molecular Spectroscopy, C. N. Banwell and E. McCash, Tata McGraw Hill, 4th edition, 1994, New Delhi.

ORGANIC PRACTICAL

Paper-CHE-CC-405

1. Qualitative Analysis

- i. Identification of unknown organic compounds by general chemical test
- ii. Identification of organic compounds of binary mixture by (Thin Layer Chromatography) and determination of R_f value
- iii. Purification of organic compounds of binary mixture by Column Chromatography
- iv. Characterization of functional group by IR spectra/NMR/Mass

2. Synthesis of organic compounds:

- i. p- Nitroacetanilide.
- ii. p- Nitroaniline.
- iii. Ethylbenzoate.
- iv. m-Dinitrobenzene.
- v. Dibenzyl acetone and its derivatives
- vi. Anthranilic acid
- vii. Methyl Orange
- viii. Adipic acid by chromic acid oxidation of cyclohexanol

3. Quantitative Analysis

- I. Estimation of Acetyl group
- II. Estimation Phenolic group
- III. Estimation of Keto group

Book recommended

- 1) Quantitative and Qualitative analysis By A.I. Vogel
- 2) Experiments and Techniques in Organic Chemistry, D.Pasto, C.Johnson, & M.Miller, Prantice Hall.
- 3) Systematic Qualitative Organic Analysis, H. Middleton, Edward Arnold (Publisher).
- 4) Hand Book of Organic Analysis, Qualitative & Quantitative, M.T. Clarke, Edward Arnold (Publisher).
- 5) Vogel's Text Book of Practical Organic Chemistry, A.R. Tatchell, John Wiley.
- 6) Macroscale and Microscale Organic Experiments, K. L. Williamson, D. C. Heath.
- 7) A Text Book of Practical Organic Chemistry (Qualitative). Arthur I. Vogel.

SEMESTER -II

ORGANIC CHEMISTRY-II Paper-CHE-CC-406

Unit –I: Oxidation Reaction

Different oxidative processes , Oxidation of hydrocarbon , alkanes, Alkene, aromatic ring, alcohol , α , β -diol, allylic and benzylic alcohols, aldehydes ketones, carboxylic acids , amines, m-CPBA, Dioxirane, Sharpless Epoxidation and Dihydroxylation, Fentens oxidation, Swern Oxidation, Ozone, Hydroboration Oxidation, Oxymercuration. Baeyer villager Oxidation, Oxidation with RuO_4 , Iodobenzene diacetate (BAIB), PCC, PDC, IBX, DESMARTIN-PERIODINAN(DMP), KMnO_4 , $\text{K}_2\text{Cr}_2\text{O}_7$, SeO_2 , CrO_3 , TPAP, CrO_2Cl_2 , Sulfonium ylide oxidation and N-Oxidation. Wacker Oxidation.

Unit –II: Reduction Reaction

Different reductive processes, Reduction of alkenes, alkynes, aromatic rings, cycloalkanes, carbonyl compounds, aldehydes , ketones , acids and their derivatives, Catalytic Hydrogenation: (Hydrogenolysis, $\text{H}_2/\text{Pd/C}$, H_2/Pt , Rosenmund Reduction, Lindlar reduction, Adam's reduction, Raney Nickel) NaBH_4 , Luche reduction, NaCNBH_3 , B_2H_6 , LiAlH_4 , LiEt_3BH , DIBAL, L-selectride, K-selectride, Birch Reduction, Wilkinson reduction, CBS reduction, Baker-Yeast Reduction, Wolf-Kishner Reduction, Clemmenson reduction, Noyori Reduction.

Unit-III: Name reaction and molecular rearrangement

Reactions: Chichibabin, Claisen-Schmidt, Claisen Condensation, Bayer-villiger , Hoffman elimination, Stobbe condensation, Fischer-Indole, Vilsmeier-Heck, Baylis–Hillman, Aldol, Cannizzaro, Knoevenagel, Claisen condensation, Mannich, Benzoin, Perkin and Stobbe, Wittig, The Von-Richter, Sommelet-Hauser, Vilsmeier-Heck, Gattermann-Koch, Sandmeyer, Free radical rearrangement, Hunsdiecker, Prevost and Woodward Dihydroxylation. Barton, Robinson annulations, Hantzsch Pyridine Synthesis, Sterk-enamine, Michael addition, Gilman-Corey, Friedel-Craft.

Rearrangements: General mechanistic considerations: nature of migration, migratory aptitude, memory effects. A detailed study of the following rearrangements; Pinacol-pinacolone, Wagner-Meerwein, Demjanov, Benzil-Benzilic acid, Favorskii, Arndt-Eistert synthesis, Neber, Beckmann, Hofmann, Curtius, Schmidt, Baeyer-villiger, Shapiro, Dienone-Phenol rearrangement, Lossen rearrangement, Neber rearrangement, Steven rearrangement, Benzidine rearrangement, Fries and Photo-Fries. Claisen and Cope rearrangement, Di-Pi methane.

Unit-IV: Applications of Organometallic compounds

Synthetic applications of organozinc, organocadmium, organolithium, organomercury and organocopper compounds. Gilman-Corey reagent. Oxidative addition and reductive elimination, Coupling reaction (Heck, Stille, Negeshi, Kumada, Suzuki, Sonogashira, Hartigw-Buchwald, Miyamera and Pauson-khand),

Books Recommended:

1. Organic synthesis: Clayden, Greeves, Warren and Wothers, Oxford Univ. Press, 2nd Ed (2012).
2. Advanced Organic Chemistry, F. A. Carey and R. J. Sundberg, Part A and B Springer, 5th Ed.(2005)
3. A Guide Book of Mechanism in Organic Chemistry, Peter Sykes, Longman.6th Ed.(1999)
4. Structure and Mechanism in Organic Chemistry, C. K. Ingold, Cornell University Press,3rd (1957).
5. Organic Chemistry, R. T. Morrison and R. N. Boyd, Prentice-Hall, 6th Ed.(1992)
6. A guide book to mechanism in Organic chemistry (Orient-Longmens)- Peter Sykes
7. Fundamentals of Photochemistry, K. K. Rohtagi-Mukherji, Wilcy-Eastern.
8. Molecular Photochemistry, N. J. Turro, W. A. Benjamin.
9. Introductory Photochemistry, A. Cox and T. Camp. McGraw-Hill.
10. Photochemistry, R. P. Kundall and A. Gibert, Thomson Nelson.
11. Organic Photochemistry, J. Coxon and B. Halton, Cambridge University Press.
12. Organic reaction mechanism (Benjamin) R. Breslow
13. Mechanism and structure in Organic chemistry (Holt Reinh.) B. S. Gould.
14. Organic chemistry (McGraw-Hill)Hendrikson, Cram and Hammond.
15. Basic principles of Organic chemistry (Benjamin) J. D.Roberts and M. C. Caserio.
16. Stereochemistry of Carbon compounds. (McGraw-Hill) E.L.Eliel
17. Organic Stereochemistry (McGraw-Hill) by Hallas.
18. Organic reaction mechanism (McGraw-Hill) R. K. Bansal.
19. Organic chemistry- R. T. Morrison and R. N. Boyd,(Prentice Hall.)
20. Modern organic reactions(Benjumin) H. O. House.
21. Principle of organic synthesis- R.O.C. Norman and J. M. Coxon.(ELBS)
22. Reaction mechanism in organic chemistry- S. M. Mukharji and S. P. Singh.
23. Advanced organic chemistry (McGraw-Hill) J. March.
24. Some Modern Methods of Organic synthesis. W. Carruthers, Cambridge Univ. Press.
25. Modern Synthetic Reactions, H. O. House, W.A. Benjamin
26. Advanced Organic Chemistry: Reactions, Mechanisms and Streucture, J. March, Wiley.
27. Principles of Organic synthesis, R. Norman and J. M. Coxon, Blackie Academic & Professional.
28. Advanced Organic Chemistry Part B, F. A. Carey and R. J. Sundberg, Plenum Press.
29. Organic Chemistry: The disconnection approach, S. Warren, John Wiley and Sons.

INORGANIC CHEMISTRY-II

Paper-CHE-CC-407

Unit-I: Bonding in Co-ordination Compounds

Valence bond theory-strength and short comings, Crystal field theory-effect spin types, CFSE, Evidence for crystal stabilization energy in octahedral, tetrahedral, tetragonal, square pyramidal and square planner fields, Applications of Crystal Field Splitting, Molecular orbital theory (qualitative), MO energy level diagrams, Sigma –pi bonding and their importance in co-ordination compounds

Unit-II: Spectral and Magnetic Properties of Transition Metal Complexes

Spectroscopic ground states, Correlation and Orgel diagrams for transition metal complexes (d^1 - d^9 states), Tanabe-Sugano diagrams, Charge transfer spectra, Elementary idea about magneto chemistry of metal complexes, Diamagnetism, Para magnetism, Temperature independent paramagnetism, Magnetic susceptibility and its measurement, Paramagnetism applied to metal complexes, Ferromagnetism, Ferrimagnetism and Anti-ferromagnetism.

Unit-III: Metal-Ligand Equilibria in Solution

Stepwise and overall formation constants, Trends in stepwise constants, Inert and labile complexes, Kinetic application of valence bond and crystal field theories, Kinetics of octahedral substitution, Factors affecting stability of metal complexes with reference to the nature of metal ion and ligand, Chelate effect and its thermodynamic origin, Determination of binary formation constants by potentiometric and spectrophotometric methods.

Unit-IV: Reaction Mechanism of Transition Metal Complexes

Acid hydrolysis, Factors affecting acid hydrolysis, Base hydrolysis, Conjugate base mechanism, Direct and indirect evidences in favour of conjugate mechanism, Anation reactions, Reactions without metal ligand bond cleavage, Substitution reactions in square planar complexes, Trans effect, Mechanism of one electron reactions, Outer-sphere type reactions, Marcus-Hush theory, Inner sphere type reactions.

Books recommended

1. Mechanism of Inorganic Reactions: F. Basalo and R. G. Pearson, Wiley Eastern publication 1967.
2. Advanced Inorganic Chemistry: F. A. Cotton and G. Wilkinson, Wiley Eastern 1988.
3. Inorganic Chemistry: J. E. Huheey, E. A. Keiter, R. L. Keiter, Pearson Education.
4. Inorganic Electronic Spectroscopy: A. B. P. Lever, Elsevier.
5. Magnetochemistry: R. L. Carlin, Springer Verlag.

PHYSICAL CHEMISTRY-II

Paper-CHE-CC-408

Unit-I: Classical thermodynamics

Brief resume of the concept of enthalpy, entropy, free energy and laws of thermodynamics, Partial molar properties, Chemical potential, Effect of temperature and pressure, Determination of partial molar properties by: (1) Direct Method, (ii) Apparent method, (iii) Method of intercept.

Concept of fugacity and its determination by (i) Graphical method, (ii) From equation of state (iii) Approximation method, Nernst heat theorem and its application to solid, Third law of thermodynamics, Experimental determination of entropy by third law.

Unit-II: Statistical thermodynamics

Thermodynamic probability and entropy, Maxwell-Boltzmann statistics, Partition function (translational, vibrational, rotational and electronic) for diatomic molecules, 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.

Unit-III: Non-equilibrium thermodynamics

Thermodynamic criteria for non-equilibrium states, Entropy production and entropy flow, Entropy balance equation for the different reversible processes (heat flow and chemical reaction), Transformation of the generalized fluxes and forces, Non-equilibrium stationary state, Microscopic reversibility, Onsager's reciprocity relation, Electrokinetic phenomena, Diffusion, Electric conduction.

Unit-IV: Chemical Dynamics

Collision theory of reaction rate, Activated complex theory, Arrhenius equation, Ionic reaction, Kinetic salt effect, Steady state kinetics, Photochemical reaction (Hydrogen-Bromine and Hydrogen-Chlorine reactions), Oscillatory reactions (Belousov-Zhabotinsky reaction), Homogeneous catalysis, General features of fast reaction, Study of fast reaction by flow method and relaxation method. Dynamics of Unimolecular reactions (Lindemann-Hinshelwood and Rice-Ramsperger-Kassel-Marcus theories)

Books recommended:

- 1) K.L. Kapoor, Text book on Physical Chemistry, Volume 2, Macmillan India Ltd. Delhi
- 2) P. W. Atkins, Physical Chemistry, 7th Edition, (2002) Oxford University Press, New York.
- 3) Andrew Maczek, Statistical Thermodynamics, (1998) Oxford University Press Inc., New York.
- 4) F.W. Billmeyer, Jr., Text Book of Polymer Science, 3rd Edition (1984), Wiley-Interscience, New York.
- 5) K. J. Laidler, Chemical Kinetics, Third Edition (1987), Harper & Row, New York.
- 6) P. W. Atkins, Physical Chemistry, Seventh Edition (2002), Oxford University Press, New York.
- 7) I.N. Levine, Physical Chemistry, 5th Edition (2002), Tata McGraw Hill Pub. Co. Ltd., New Delhi.
- 8) J. Raja Ram and J.C. Kuriacose, Kinetics and Mechanism of Chemical Transformations (1993), MacMillan Indian Ltd., New Delhi.

SPECTROSCOPY-II

Paper-CHE-CC-409

Unit-1: Ultraviolet and IR Spectroscopy

Various electronic transitions (185–800 nm), Jablonski diagram, Beer–Lambert Law, effect of solvent on electronic transitions, ultraviolet bands for carbonyl compounds, unsaturated carbonyl compounds, dienes, conjugated polyenes.

Woodward-Fisher rules for conjugated dienes and carbonyl compounds, ultraviolet spectra of aromatic and heterocyclic compounds. Steric effect in biphenyls.

Optical Rotatory Dispersion (ORD) and Circular Dichroism(CD). Definition, deduction of absolute configuration, octant rule for ketones.

IR Spectroscopy: Instrumentation and sample handling, Characteristic vibrational frequencies of alkanes, alkenes, alkynes, aromatic compounds, alcohols ethers, phenols and amines. Detailed study of vibrational frequencies of carbonyl compounds (ketones, aldehydes, esters, amides, acids, anhydrides, lactones, lactams and conjugated carbonyl compounds) Effect of hydrogen bonding and solvent effect on vibrational frequencies, overtones, combination bands and Fermi resonance, FTIR.

Unit-II Nuclear Magnetic Resonance Spectroscopy

Basic principle, Chemical shift, Spin-spin interaction, Shielding mechanism, Chemical shift values and correlation to protons bonded to carbon and other nuclei, Chemical exchange, Effect of deuteration, Complex spin-spin interaction between two, three, four and five nuclei, Hindered rotation, Shift reagent, Nuclear overhauser effect (NOE). ^{19}F and ^{31}P NMR.

Carbon-13 NMR spectroscopy: General consideration, Chemical shift (aliphatic, olefinic, alkyne, aromatic, heteroaromatic, and carbonyl carbon), Coupling constant.

2D- NMR: COSY ; NOSEY, HETCOR, HMQC, HMBC, DEPT, INDEQUATE.

Unit-III: Mass Spectroscopy

Introduction, E1, C1, FD and FAB, Factors affecting fragmentation, Ion analysis, Ion abundance fragmentation of organic compounds with common functional groups, Molecular ion peak , Metastable ions , Mc-Lafferty rearrangement , Nitrogen rule, High resolution mass spectrometry, Examples of mass spectra fragmentation for the determination of structure of simple organic molecules.

Unit-IV: EPR and Mossbauer Spectroscopy

B. Electron spin resonance spectroscopy : Basic principles , Zero- field splitting and Kramer's degeneracy, Factors affecting the g-value, Isotopic and anisotropic hyperfine coupling constant, Measurement techniques, Application.

C. Mossbauer spectroscopy: Basic principles, Spectral parameters and spectral display, Application of the techniques to study the bonding and structure of Fe^{2+} and Fe^{3+} compounds including those of intermediate spins.

Books recommended

1. Instrumental Methods of analysis- Willard, Merrit, Dean and Settle.
2. Spectroscopic identification of organic compounds- R.M. Silverstein and G.C. Bassler
3. Spectroscopic methods in organic chemistry- D.H. Williams and I. Fleming
4. Absorption spectroscopy of organic molecules- V.M. Parikh
5. Applications of spectroscopic techniques in Organic chemistry- P.S. Kalsi
6. Modern Spectroscopy, J.M. Hollas, John Wiley, 4th edition, 2004, Sussex.
7. Applied Electron Spectroscopy for Chemical Analysis Ed. H. Windawi and F.L.Ho, Wiley Inter science.
8. NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry, R.V. Parish, Ellis Harwood, 1st edition, 1990.
9. Physical Methods in Chemistry, R.S.Drago, Saunders College.
10. Introduction to Molecular Spectroscopy, G.M.Barrow, McGraw Hill
11. Basic Principles of Spectroscopy, R.Chang, McGraw Hill.
12. Theory and Applications of UV Spectroscopy, H.H.Jaffe and M.Orchin, IBH-Oxford.
13. Introduction to Photoelectron Spectroscopy, P.K.Ghosh, John Wiley.
14. Introduction to Magnetic Resonance, A. Carrington and A.D. MacLachalan, Harper & Row.
15. Inorganic spectroscopic methods, A.K. Brisdon, Oxford university Press, Oxford Chem. Primers, 1997, New York.
16. Spectroscopy, S. Walker and H. Straw, Chapman and Hall Ltd.
17. Energy levels in atom and molecules, W.G. Richards and P.R. Scott, Oxford University Press, Oxford Chemistry Primer vol. 26, 1994, New York.
18. Introduction to Spectroscopy, Pavia, Brooks/Cole Cenage, 4th edition, 2009, Belmont.
19. EPR: Elemental theory and applications, J.A. Well. J.R. Bolton, Wiley, 2nd edition, 2007, New Jersey.
20. Electron Paramagnetic resonance of transition ions, A. Abraham and B. Bleaney, Clarendon Press, 1970, Oxford.

21. Fundamental of Molecular Spectroscopy, C. N. Banwell and E. McCash, Tata McGraw Hill, 4th edition, 1994, New Delhi.
22. Symmetry and Spectroscopy of Molecules, K.V. Reddy, New Age International (P) Ltd., 1st edition, 1998, New Delhi.
23. Fundamental Concepts of Inorganic Chemistry, A. K. Das and M. Das, Vol. 7, 1st edition, 2014, CBS Publisher Pvt. Ltd., New Delhi.
24. Molecular Spectroscopy, P.S. Sindhu, Tata McGraw Hill, 1985, New Delhi.
25. Textbook of Organic Chemistry 1st Ed., P. S. Kalsi, New Age International (P) Ltd. Pub.
26. Organic Chemistry, R. T. Morrison, & R. N. Boyd, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
27. Organic Spectroscopy, W. Kemp, Palgrave
28. A Complete Introduction to Modern NMR Spectroscopy, Roger S. Macomber, Wiley Publication, 1997
29. Modern NMR Spectroscopy: A Guide for Chemists. J. K. M. Sanders, B. K. Hunter. Oxford University Press, 1993.
30. Principles of nuclear magnetic resonance in one and two dimensions. R. R. Ernst, Geoffrey Bodenhausen, and Alexander Wokaun. Oxford University Press, 1987
31. Spectrometric Identification of Organic Compounds, R. M. Silverstein, F. X. Webster, D. J. Kiemle, D. L. Bryce, Wiley, 8th Edition (2015).
32. Mössbauer Spectroscopy, N.N. Greenwood and T.C. Gibb, Chapman and Hall 1971, London.
33. Mössbauer Spectroscopy and Transition Metal Chemistry, P. Gülich, R. Link, A. Trautwein, Springer, 1978, Verlag, Berlin-Heidelberg-New York.
34. Fundamental Concepts of Inorganic Chemistry, A. K. Das

INORGANIC PRACTICAL

Paper CHE-CC-410

1. Qualitative analysis of mixtures containing not less than six radicals (organic radicals should be excluded). Anyone of the following rare metal ions may be included.

(V, Mo, W, Ti)

2. **A) Volumetric analysis involving EDTA as reagent.**

- i) Determination of Ca^{2+} and Mg^{2+} in Dolomite.
- ii) Determination of Nickel in Stainless steel.

- B) Complete analysis of:**

- i) Brass ii) Cement iii) chromo iron ore.

- C) Preparation of Hexamine Cobalt (III) chloride.**

- D) Gouy's method for Determination of magnetic susceptibility of coordination complex.**

Book recommended

Quantitative and Qualitative analysis By A.I. Vogel Semester-III

SEMESTER-III

ORGANIC CHEMISTRY-III

Paper-CHE-CC-501

Unit-I Disconnection approach and Retrosynthesis

Synthons and synthetic equivalents, disconnection approach, functional group interconversions. One group C-X and two group disconnections in 1,2,1,3-, 1,4- & 1,5-bifunctional compounds, Chemoselectivity, reversal of polarity, cyclisation reaction, amine synthesis. Protecting Groups: Principle of protection of alcohol, amine, carbonyl, carboxyl groups and their deprotection, Diels-Alder reaction, Michael addition and Robinson annulation. Retro-synthesis of aromatic Heterocycles, 3, 4, 5 and 6 membered carbocyclic and heterocyclic rings.

Unit-II Synthesis of Heterocycles, Natural Product and Drugs

Saturated heterocycles, synthesis of 3-, 4-, 5- and 6-membered rings, aromatic heterocycles in organic synthesis. Synthesis of Porphyrin, Paal-knorr pyrrole synthesis, Fisher-Indole Synthesis, Hantzsch Pyridine Synthesis, Saccharin Synthesis. Synthesis of Salbutamol, L-DOPA, prostaglandin F₂α, Aspirin, α-pinene, Longifolene, Artemisinin, Imatiniv.

Unit –III Synthetic Reagents

Complex metal hydrides, Me₂CuLi, LDA, n-BuLi, t-BuLi, DIPA, NaH, DCC, Me₃SiI, m-CPBA, Dioxirane, Pb(OAc)₄, PPA, CH₂N₂, O₃, AgNO₃/I/H₂O, LiTMP, NBS, SnBu₃H, AIBN, DCC, PCC, PDC, IBX, DMP, SeO₂, OsO₄, CBS, NaBH₄, NaBH₃, NaCNBH₃, B₂H₆, LAH, DIBAL, L-selectride, K-selectride, Na/Liq. NH₃, CBS, Raney Ni, Wittig Ylide, Sulfur Ylide.

Unit –IV Organic Polymers

Basic concepts of Polymer, Classification, Number, weight and viscosity average molecular weights. Polydispersity and molecular weight distribution. Mechanism of polymerization (Cationic/anionic/Free radical). Synthesis and application of Polyamide, Polyester, Poly carbonate, Living Polymer, Biodegradable polymer, Zeigler-Natta polymerization, Atactic, Syndiotactic and isotactic Polymer, Solid state peptide synthesis.

Book recommended

- 1) Organic synthesis: Clayden, Greeves, Warren and Wothers, Oxford Univ. Press, 2nd Ed (2012).
- 2) Advanced Organic Chemistry, F. A. Carey and R. J. Sundberg, Part A and B Springer, 5th Ed.(2005)
- 3) A Guide Book of Mechanism in Organic Chemistry, Peter Sykes, Longman.6th Ed.(1999)
- 4) Structure and Mechanism in Organic Chemistry, C. K. Ingold, Cornell University Press,3rd (1957).
- 5) Organic Chemistry, R. T. Morrison and R. N. Boyd, Prentice-Hall, 6th Ed.(1992)
- 6) Designing Organic Synthesis, A programmed introduction to synthon approach, S. Warren, Wiley.
- 7) Organic Synthesis-Concept, Methods and Starting Materials, J. Fuhrhop and G. Penzillin, VCH, Weinheim, Germany.
- 8) Some Modern Methods of Organic synthesis. W. Carruthers, Cambridge Univ. Press.
- 9) Modern Synthetic Reactions, H. O. House, W.A. Benjamin
- 10) Advanced Organic Chemistry: Reactions, Mechanisms and Structure, J. March, Wiley.
- 11) Principles of Organic synthesis, R. Norman and J. M. Coxon, Blackie Academic & Professional.
- 12) Advanced Organic Chemistry Part B, F. A. Carey and R. J. Sundberg, Plenum Press.
- 13) Organic Chemistry: The disconnection approach, S. Warren, John Wiley and Sons.

ANALYTICAL CHEMISTRY

Paper-CHE-CE-502

Unit- Thermal methods of analysis

Thermo analytical methods: TGA, DTGA and DTA, Instrument, Instrumental and application to physical studies (reaction kinetics and information for the constitution of phase diagram), Analytical applications, Separation of Ca, Sr, and Ba comparison of purity.

Unit-II Electrical methods of analysis

Voltametry and polarography: Dropping mercury electrode, Ilkovic equation, Current-potential curves, Reversible reactions, The residual current, Current maxima, Analytical applications, Amperometric titration using rotating platinum electrode, Cyclic voltammetry.

Unit-III Analysis of Food and Soil

a) Analysis of food: Moisture, ash, crude protein, fats and carbohydrates. Food adulteration common adulterants in food, contamination of food stuffs. Microscopic examination of foods for adulterants. Pesticide analysis in food products. Extraction and purification of sample. Thin layer chromatography for identification of chlorinated pesticides in food. Separation of pesticides by HPLC.

(b) Analysis of soil: Moisture, pH, total nitrogen phosphorous, silica, lime, magnesia, manganese, sulphur and alkali salts.

Unit-IV i) Analysis of Fuel and Drugs

(a) Fuel analysis: Solid, liquid and gas. Ultimate and proximate analysis—heating values grading of coal. Liquid fuels-flash point, Aniline point, octane number and carbon residue. Gaseous fuels-producer gas and water gas-calorific value.

(b) Drug analysis: Narcotics and dangerous drugs. Classification of drugs. Screening by gas and thin layer chromatography and separation of Amino acids by gas chromatography method.

ii) Analysis of data: Types of errors, determinate error, indeterminate error, minimisation of error, Accuracy and precision. Mean (Average Deviation), Standard deviation, Median, Methods of repeating analytical data, statistical evaluation of data, statistical analysis. Problems.

Book Recommended: (Will be given by Instructor)

ORGANOMETALLIC CHEMISTRY

Paper-CHE-CE-503

Unit I: Main Group Organometallics

Synthesis and reactions of organolithium compounds; Synthesis and reactions of organomagnesium compounds; Organometallics of zinc and mercury: preparation, structure, bonding and reactions of aluminum organyls; Thallium(I) organyls (synthesis of TICp); Organyls of sodium, synthesis of NaCp; Silicon and tin organyls of coordination number 4.

Unit II: Transition Metal–Carbon Bond

(a) *Transition Metal–Carbon σ -Bond*: Brief review of metal alkyl compounds; transition metalcarbene and transition metal-carbyne compounds; transition metal vinylidene and transition metal allenylidene compounds.

(b) *Transition Metal–Carbon π -Bond*: Cyclopropenyl cation ($C_3R_3^+$) as a ligand; C_4R_4 as a ligand (R = H, Me, Ph), cyclopentadienyls as ligand

Unit III: Syntheses of Cyclopentadienyl and Arene Metal Analogues

Synthesis and reactions of cyclopentadienyl metal carbonyls, cyclopentadienyl metal hydrides, cyclopentadienyl metal halides, arene metal carbonyls, η^6 -arene-chromium tricarbonyl in organic synthesis.

Unit IV: Applications to Organic Synthesis and Catalysis

Stoichiometric reactions for Organometallic catalysts: Dissociation & Substitution, Oxidative addition & carbonylation, Oxygen transfer from Peroxo and Oxo Species, Reductive & Hydride elimination, Insertion, Displacement and Isomerization reaction, Hydrogenation, Hydrosilation and Hydrocyanation of unsaturated compounds, Hydroformylation, Wacker (Smidt) Process, Olefin Metathesis, Fischer-Tropsch synthesis, Zeigler-Natta polymerization, Water gas reaction.

Book recommended

1. Molecular Chemistry of the Transition Elements: F. Mathey & A. Sevin, John Wiley.
2. Organometallic Chemistry: A Unified Approach (2nd edn.), R. C. Mehrotra & A. Singh, New Age International.
3. The Organometallic Chemistry of the Transition Metals (4th edn.): R. H. Crabtree John Wiley.
4. Basic Organometallic Chemistry: Concepts, Synthesis and Applications (2nd edn.), B. D. Gupta & A. J. Elias, Springer Science.

ENVIRONMENTAL AND ANALYTICAL CHEMISTRY

Paper-CHE-CE-504

Unit-I Air pollution:

Primary pollutants like Carbon monoxide, nitrogen oxides, hydro carbons, sulphur dioxide, particulate matter, Consequences of air pollution : Acid rain, Green house effect, Ozone layer depletion, Smog formation, Sampling, monitoring and analysis of Carbon monoxide, Nitrogen oxide, Sulphur dioxide, Hydrocarbons, Aromatic hydrocarbons. Aromatic hydrocarbons in exhaust petrol and acid.

Unit-II Water pollution and water analysis:

Water pollutants, type of water pollutants: Ground water, surface water, lake water, river water and sea water. Sources of water pollution: Domestic source, industrial effluents, agricultural discharge, radioactive material. General effect of water pollution, analysis of water pollutants: important parameters like colour turbidity, electrical conductivity, total suspended solids, hardness, alkalinity,

fluoride, dissolved oxygen, chemical oxygen demand, biochemical oxygen demand. Detrimental effect of some toxic elements like Cd, Cr, Pb, Zn and Hg. Waste water treatment.

Unit-III Absorption and Emission Spectroscopy:

Principle, difference between atomic absorption spectroscopy and flame emission spectroscopy, advantages and disadvantages of atomic absorption spectroscopy. Instrumentation, detection limit and sensitivity. Fluorimetry and Phosphorimetry, Comparison of Fluorimetry and Phosphorimetry, Some Fluorimetric applications and some phosphorimetric applications.

Unit-IV Radio isotopes in Analysis:

Applications of radio isotopes to physico-chemical problems: solubility of sparingly soluble salt, surface area of powder or precipitate, rate of diffusion and study of reaction mechanism. Analytical applications of radioactivity: Radio chromatography, isotopic dilution analysis, Neutron activation analysis and radiometric titration. Use of radio isotopes for dating, in medicine, agriculture and industry.

Book recommended

1. Environment and Ecology by Sunakar Panda
2. Text book of Environmental chemistry by A.K. De
3. Analytical chemistry by Gurdeep Chatwal 4. Environmental Chemistry by B.K.Sharma

NANOCHEMISTRY

Paper-CHE-CE-505

Unit I Introduction to nano scale Science and Technology

Introduction and classification - What is nanotechnology? - Classification of nanostructures - Nanoscale architecture; Summary of the electronic properties of atoms and solids - The isolated atom - Bonding between atoms - Giant molecular solids - The free electron model and energy bands - Crystalline solids - Periodicity of crystal lattices - Electronic conduction; Effects of the nanometre length scale - Changes to the system total energy - Changes to the system structure - How nanoscale dimensions affect properties- Fabrication methods: Top-down processes, Bottom-up processes, Methods for templating the growth of nanomaterials, Ordering of nanosystems

Unit II: Synthesis and Stabilization of Nano particles:

Chemical Reduction; Reactions in Micelles, Emulsions; Photochemical and Radiation Cryochemical Synthesis: Physical Methods; Particles of Various Shapes and Films.

Unit III: Experimental Techniques: Electron Microscopy:

Transmission electron microscopy (TEM), Scanning electron microscopy (SEM): Diffraction Techniques: X-ray diffraction, Neutron diffraction and some miscellaneous Techniques: X-ray fluorescence spectroscopy, UV- visible spectroscopy

Unit IV: Applications of Nanoparticle:

Catalysis on Nano particles, Semiconductors, Sensor, Electronic Devices, Photochemistry and nanophotonics, Application of Carbon Nano tubes, Nanochemistry in Biology and Medicine

Book recommended

1. Nanomaterials and Nanochemistry, Bréchnac C., Houdy., and Lahmani M. (Eds.) Springer Berlin Heidelberg New York. 2007.
2. Nanoscale Science and Technology, Robert W. Kelsall, Ian W. Hamley and Mark Geoghegan, John Wiley & Sons, Ltd., UK, 2005.
3. Introduction to Nanotechnology, Charles P. Poole Jr and Frank J. Owens, Wiley Interscience, 2003.
4. Bio-Inspired Nanomaterials and Nanotechnology, Edited by Yong Zhou, Nova Publishers.
5. Nano:The Essentials: Understanding Nanoscience and Nanotechnology, T.Pradeep, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2008.
6. Nanoparticle Technology Handbook. M. Hosokawa, K. Nogi, M. Naito and T. Yokoyama (Eds.) First edition 2007. Elsevier
7. Nanotechnology Basic Calculations for Engineers and Scientists. Louis Theodore, John wiley & sons, inc., publication, 2006.

CHEMISTRY AND SOCIETY

Paper-CHE-OE-506

Unit-I Chemicals in food:

- a) Carbohydrates: Classification, sugar and non-sugar, Glucose, fructose, starch and cellulose. Importance of carbohydrates.
- b) Amino acids: Classification, essential and nonessential amino acids, Zwitter ion structure, polypeptides, proteins (classification and function).
- c) Lipids: Classification, oils and fats, metabolism of lipids.
- d) Vitamins: Classification, Nomenclature and disease caused by the deficiency of vitamins.

Unit-II Chemicals in Medicines:

Development of new drugs, procedure followed in drug design, different types of drugs, analgesics, antipyretics, antiseptics and antibiotics, broad spectrum antibiotics. Metals in medicines: Metal deficiency and disease, toxic effect of metals.

Unit-III Chemicals in Agriculture:

Fixation of Nitrogen, fertilisers, classification of fertilisers: nitrogenous, phosphorous and potassium fertiliser. Pesticides classification, insecticides, fungicides and rodenticides. Detrimental effects of pesticides (DDT, BHC, Parathion).

Unit-IV Chemicals in daily life:

General idea about soap, synthetic detergents and shampoo, preparation of soap and synthetic detergents. Advantage and disadvantage of synthetic detergent, cosmetics and perfumes. Plastic and its detrimental effects on environment.

CHEMISTRY AND ENVIRONMENT

Paper-CHE-OE-507

Unit-I Environmental Processes

Environment and its classification, Factors influencing environment, Components of Environment; Environmental degradation, Biogeochemical cycles; Hydrological cycle, Gaseous cycles (Oxygen cycle, CO₂ cycle, Nitrogen cycle), Sedimentary cycles (Sulfur cycle, Phosphorous cycle)

Unit-II Natural Resources

Introduction of , classification of resources; land resources , formation of soil, soil erosion, Water resources, Sources of fresh water, Uses of water, causes for the depletion of water resources ;mineral resources, Forest resources, Deforestation, consequences of deforestation; affords to control deforestation, Renewable and nonrenewable resources, Conventional and nonconventional energy resources

Unit-III Environmental pollution

Introduction, Pollutants, Types of pollutants, Classification of pollution, effects of pollution, Radiation pollution: sources, effect and control of radiation pollution, Thermal pollution: sources, effects and its control, Industrial pollution, Sewage and sewage treatment.

Unit-IV Air Pollution and its control

Atmosphere; structure and composition of atmosphere, Classification of air pollutants, Consequences of air pollution (Ozone layer depletion, Greenhouse effect, Smog, Acid rain) , Control of air pollution, air quality and standards.

Book recommended

1. Environment and Ecology By Dr. Sunakar Panda
2. Environmental Chemistry By A.K. De
3. Air Pollution By Wark & Werner
4. Environmental Pollution Control in Process Industries By S.P. Mahajan
5. Environmental Chemistry By B.K. Sharma & H.Kaur
6. Introduction to Air Pollution By P.K. Trivedi
7. Environmental Pollution Analysis By S.M. Khopkar
8. A Text Book of Environmental Pollution By D.D. Tyagi, M. Mehre
9. Environmental Pollution Engineering and Control By C.S. Rao

PHYSICAL AND ANALYTICAL CHEMISTRY PRACTICAL

Paper-CHE-CC-508

3Hrs duration (Physical Chemistry Practical)

F.M.-50 1.

- 1) Determination of surface excess of amyl alcohol

- 2) To determine the critical Micelle Concentration (CMC) of surfactant from the measurement of surface tension.
- 3) To determine the Molecular weight of a polymer from viscosity measurements.
- 4) To determine the Isoelectric point of gelatine and to find out the Intrinsic Viscosity at isoelectric point.
- 5) Determination of critical solution temperature (CST) of phenol-water system
- 5) A study of phase diagram of three-component liquid (ternary) system at room temperature: (Benzene-acetic acid-water system)
- 6) To determine the strength of HCL and acetic acid (AcOH) from the mixture of acids by strong alkali (NaOH) conductometrically.
- 7) Potentiometric titration of a weak acid (acetic acid) with caustic soda solution and determination of the dissociation constant of the acid using quinhydrone electrode at room temperature
- 8) To determine the energy of activation from the Kinetic measurement of hydrolysis of ester
- 9) Determination of rate constant of inversion of sucrose by polarimeter and also verification of the effect of catalyst on the rate constant.

3Hrs duration (Analytical Chemistry Practical) F.M.-50

- 1) To find out the dissociation constant of the given tribasic acid, i.e. phosphoric acid by treating it against NaOH using a pH Meter
- 2) Determination of hydrolytic constant (K_h) of ammonium chloride solution pH-metrically.
- 3) To estimate the iron content in the given ferrous ammonium sulphate solution by Colorimetry
- 4) To determine the composition and stability constant of Fe(III) –salicylic acid complex colorimetrically by Job's method of continuous variation.
- 5) To determine the Λ_0 and K_a of weak electrolyte at a definite temperature by Debye Huckel Onsagar equation.
- 6) To determine the stoichiometric ratio in the complexometric titration of $HgCl_2$ against potassium iodide conductometrically.
- 7) To determine the total cation concentration in natural water.
- 8) To estimate the amount of Na^+ ion in a given sample using ionisation resin column.
- 9) Potentiometric estimation of Mohr salt solution with standard potassium dichromate solution and also determination of formal potential (reduction) of ferric-ferrous system.
- 10) Determination of activity solubility product of silver chloride by emf measurement

Book recommended

1. Physical Chemistry Practical by Saroj Kr Maity and Naba Kr Ghosh
2. Experimental Physical Chemistry by R.C. Das and B. Behera
3. Text book of Quantitative Inorganic Analysis by A.I. Vogel, ELBS(1978)
4. Experimental Physical chemistry by J B Yadav, Goel Pub. House,(1981)
5. Senior Practical Physical Chemistry by B. C. Kosla, Simla Printers New Delhi (1987).
6. Experimental Physical Chemistry by Daniel et al., McGraw Hill, New York (1962).
7. Practical Physical Chemistry by A.M James and P. E. Pritchard, Longman's Group Ltd (1968)

SEMESTER IV

ORGANIC CHEMISTRY-IV

Paper-CHE-CC-509

Unit-I: Aliphatic Nucleophilic and Electrophilic Substitution

Aliphatic Nucleophilic Substitution : The S_N^2 , S_N^1 , mixed S_N^1 and S_N^2 and SET mechanisms. The neighbouring group mechanism, neighbouring group participation by p and σ bonds, anchimeric assistance; Classical and non-classical carbocations, phenonium ions, norbornyl system, common carbocation rearrangements. The S_N1 mechanism. Nucleophilic substitution at an allylic, aliphatic trigonal and a vinylic carbon. Reactivity effects of substrate structure, attacking nucleophile, leaving group and reaction medium.

Aliphatic Electrophilic Substitution: Bimolecular mechanisms (S_E^2) and S_E^i . The S_E^1 mechanism, electrophilic substitution accompanied by double bond shifts. Effect of substrates, leaving group and the solvent polarity on the reactivity.

UNIT-II: Aromatic Electrophilic Substitution

The arenium ion mechanism, orientation and reactivity, energy profile diagrams. The ortho/para ratio, ipso attack, orientation in other ring systems. Diazonium coupling, Vilsmeier reaction, Gattermann-Koch reaction. Friedel Craft reaction.

Aromatic Nucleophilic Substitution: The S_NAr , S_N^1 , Benzyne and SAr^1 mechanisms. Reactivity- effect of substrate structure, leaving group and attacking nucleophile. The Von Richter, Sommelet-hauser, and Smiles rearrangements.

Free Radical Reactions: Types of free radical reactions, free radical substitution mechanism, mechanism at an aromatic substrate, Reactivity for aliphatic and aromatic substrates at a bridgehead. Reactivity in the attacking radicals. The effect of solvents on reactivity. Allylic halogenation (NBS), oxidation of aldehydes to carboxylic acids, auto-oxidation, coupling of alkynes and arylation of aromatic compounds by diazonium salts. Sandmeyer reaction. Free radical rearrangement. Hunsdiecker reaction.

UNIT-III Addition to Carbon-Carbon Multiple Bonds

Mechanistic and stereochemical aspects of addition reactions involving electrophiles, nucleophiles and free radicals, regio- and chemoselectivity, orientation and reactivity, Addition to cyclopropane ring. Hydrogenation of double and triple bonds, hydrogenation of aromatic rings. Hydroboration, Oxymercuration, Epoxidation, Sulfonium Ylides, Halohydrin addition, Michael reaction, Sharpless asymmetric epoxidation and dihydroxylation.

Addition to Carbon-Hetero Multiple Bonds : Mechanism of metal hydride reduction of saturated and unsaturated carbonyl compounds, acids, esters and nitriles. Addition of Grignard reagents, organozinc

and organolithium reagents to carbonyl and unsaturated carbonyl compounds. Wittig reaction. Mechanism of condensation reactions involving enolates– Aldol, Knoevenagel, Claisen, Mannich, Benzoin, Perkin and Stobbe reactions.

Elimination Reactions : The E^2 , E^1 and E^1cB mechanism and their spectrum. Orientation of the double bond. Reactivity – effects of substrate structures, attacking base, the leaving group and the medium. Mechanism and orientation in pyrolytic elimination. Saytzeff and Hofmann Elimination, Bredt's rule.

Unit-IV: Reaction Mechanism : Structure, Reactivity and Rearrangements

Types of mechanisms, types of reactions, thermodynamic and kinetic requirements, kinetic and thermodynamic control, Hammond's postulate, Curtin-Hammett principle. Potential energy diagrams, transition states and intermediates, methods of determining mechanisms, isotope effects. Hard and soft acids and bases. Generation, structure, stability and reactivity of carbocations, carbanions, free radicals, carbenes and nitrenes. Effect of structure on reactivity- resonance and field effects, steric effect, quantitative treatment. The Hammett equation and linear free energy relationships, substituent and reaction constants, Taft equation. Baldwin's rule for cyclisation.

Books recommended

- 1) Organic synthesis: Clayden, Greeves, Warren and Wothers, Oxford Univ. Press, 2nd Ed (2012).
- 2) Advanced Organic Chemistry, F. A. Carey and R. J. Sundberg, Part A and B Springer, 5th Ed.(2005)
- 3) A Guide Book of Mechanism in Organic Chemistry, Peter Sykes, Longman.6th Ed.(1999)
- 4) Structure and Mechanism in Organic Chemistry, C. K. Ingold, Cornell University Press,3rd (1957).
- 5) Organic Chemistry, R. T. Morrison and R. N. Boyd, Prentice-Hall, 6th Ed.(1992)
- 6) Advanced organic chemistry (McGraw-Hill) J. March.
- 7) Advanced organic chemistry by F.A.carey and R.M.Saundberg
- 8) A guide book to mechanism in Organic chemistry (Orient-Longmans)- Peter Sykes
- 9) Organic reaction mechanism (Benjamin) R. Breslow
- 10) Mechanism and structure in Organic chemistry (Holt Reinh.)B. S. Gould.
- 11) Advanced Organic Chemistry-Reactions, Mechanism and Structure, Jerry March, John Wiley, 6th Ed.(2006).
- 12) Advanced Organic Chemistry, F. A. Carey and R. J. Sundberg, Part A and B Springer, 5th Ed.(2005)
- 13) A Guide Book of Mechanism in Organic Chemistry, Peter Sykes, Longman.6th Ed.(1999)
- 14) Structure Mechanism in Organic Chemistry, C. K. Ingold, Cornell University Press,3rd (1957).
- 15) Organic Chemistry, R. T. Morrison and R. N. Boyd, Prentice-Hall.
- 16) Modern Organic Reactions, H. O. House, W.A. Benjamin. 2nd Ed.(1972)
- 17) Principles of Organic Synthesis, R.O.C. Norman and J. M. Cox, CRC Press 3rd (2014).
- 18) Reaction Mechanism in Organic Chemistry, S. M. Mukherjee and S. P. Singh, Macmillan.3rd Ed. (2009).

PHYSICAL CHEMISTRY-III

Paper-CHE-CC-510

Unit-I Electrochemistry-I

A. Electrochemistry of solution: Ion-solvent interactions, Born Model, Ion-ion interactions: Debye-Huckel (ion-cloud), Bjerrum Model, Thermodynamics of electrified interface equations; Ion transport in solution: Debye Huckel-Onsager equation, Derivation of electrocapillarity, Lippmann equations, Structure of electrified interfaces, Over potential, Derivation of ButlerVolmer equation, Tafel plot.

B. Activity and activity coefficient, Ionic strength, Debye-Huckel limiting law and its verification, Degree of dissociation and its determination, Determination of activity coefficient by freezing point, Vapour

pressure and solubility measurement, Ion association, Association constant, Determination of dissociation constant of electrolyte.

Unit-II Electrochemistry-II

A. Semiconductor interfaces, Theory of double layer at semiconductor, Electrolytic solution interfaces, Structure of double layer interfaces, Effect of light at semiconductor solution interface, Fuel cell, Corrosion: Homogeneous theory forms of corrosion, corrosion monitoring and prevention, Passivity of metals.

B. Electromotive force, Measurement of EMF, Relationship between EMF and thermodynamics parameters (free energy change, enthalpy change and entropy change), Thermodynamics of reversible cells, Electrode potential in terms of osmotic pressure and solution pressure. Nernst equation relating electrode potential and concentration.

Unit-III Surface Chemistry

A. Adsorption, Surface tension, Capillary action, Pressure difference across curved surface (Laplace equation), Vapour pressure of droplets (Kelvin equation), Gibb's adsorption isotherm, Estimation of surface area (BET equation), Surface films on liquids (electrokinetic phenomenon), Catalytic activity at surfaces.

B. Micelles

Surface active agents, Classification, Micellization, Hydrophobic interaction, Critical micellar concentration (CMC), Factors affecting CMC of surfactants, Counter ion Binding to micelles. Thermodynamics of micellization, Phase separation and mass action models, Solubulisation, Microemulsion, Reverse micelles.

Unit-IV Solid state

Crystal systems and lattices, Miller planes, Crystal packing, Crystal defects; Bragg's Law, Ionic crystals, Band theory, Metals and semiconductors, Types of solid state reactions.

Books recommended

1. J.O'M. Bockris and A.K.N. Reddy, Modern Electrochemistry, Vol. 1 & 2A and 2 B, (1998) Plenum Press, New York.
2. Y. Moroi, Micelles: Theoretical and Applied Aspects, (1992) Plenum Press, New York.
3. F.W. Billmeyer, Jr., Text Book of Polymer Science, 3rd Edition (1984), Wiley-Interscience, New York.
4. A.R. West, Solid State Chemistry and its Applications, (1984) John Wiley & Sons, Singapore.
5. C.N.R. Rao and J. Gopalkrishnan, New Directions in Solid State Chemistry, (1997) Cambridge Univ. Press. 6. S. Glasstone, — Introduction to Electrochemistry|| Affiliated East West

BIO-ORGANIC CHEMISTRY

Paper-CHE-CE-511

Unit-I: Chemistry of Carbohydrates and Lipids

Structure of polysaccharides: starch and glycogen, Structure and biological functions of glucoaminoglycans, Carbohydrate metabolism: Photosynthesis, Kreb's cycle, Glycogenolysis. Characterization and degradation of Fatty acids, Oils,

Unit-II: Chemistry of Amino acids and Proteins

Amino acids, Peptides and Proteins, Chemical and enzymatic hydrolysis of proteins to peptides, Amino acid sequencing, Primary structure proteins, Secondary structure proteins: α -helix, β sheet, super secondary structure, triplex helix structure of collagen. Tertiary structure of proteins, folding and domain structure. Quaternary structure, Amino acid metabolism: degradation and bio synthesis of Proline, valine and isoleucine

Unit-III: Chemistry of Nucleic acids

Purine and pyrimidines bases of nucleic acids, Pairing via hydrogen bonding, Structure of ribo nucleic acid (R.N.A) and de-oxyribo nucleic acid (D.N.A), Double helix model of DNA, Chemical and enzymatic hydrolysis of nucleic acid, The chemical basis of heredity, An overview of replication of DNA, Transcription, Translation and Genetic code.

Unit-IV: Mechanisms in Biological Chemistry

Nature's oxidizing agent (NAD^+), Nature's reducing agent (NADH), ATP, ADP, Phosphoenolpyruvate, Mechanism of glycolysis and citric acid cycle, amino acid ammonia lyases, Synthesis of Haemoglobin and its function, DNA synthesis

Books Recommended

1. Principle of Biochemistry (Lehninger): D. L. Nelson and M. M. Cox, W. H. Freeman and company, New York.
2. Fundamentals of Biochemistry: D. Voet, J. G. Voet and C. W. Pratt; John Wiley and sons.
3. Bioinorganic Chemistry: Bertini, Gray, Lippard, Valentine, Viva Books Private Limited.
4. Outlines of Biochemistry by Eric Conn, Paul Stumpf, George Bruening & Roy H. Doi, John Wiley & Sons
5. Organic synthesis: Clayden, Greeves, Warren and Wothers, Oxford Univ. Press, 2nd Ed (2012).
6. Advanced Organic Chemistry, F. A. Carey and R. J. Sundberg, Part A and B Springer, 5th Ed.(2005)
7. A Guide Book of Mechanism in Organic Chemistry, Peter Sykes, Longman.6th Ed.(1999)
8. Structure and Mechanism in Organic Chemistry, C. K. Ingold, Cornell University Press,3rd (1957).
9. Organic Chemistry, R. T. Morrison and R. N. Boyd, Prentice-Hall, 6th Ed.(1992)

BIO-INORGANIC AND SUPRAMOLECULAR CHEMISTRY

Paper-CHE-CE-512

Unit-I: Bioinorganic Chemistry of Alkali and Alkaline Earth Metals

Essential and trace elements in biological systems, structure and functions of biological membranes; mechanism of ion transport across membranes; sodium pump; ionophores: valinomycin and crown ether complexes of Na^+ and K^+ ; photosynthesis: chlorophyll a, PS I and PS II; role of calcium in muscle contraction, blood clotting mechanism.

Unit- II: Metalloproteins

Heme proteins and oxygen uptake, Structure and functions of haemoglobin, myoglobin, hemocyanin and hemerythrin, Iron-sulphur proteins: rubredoxin and ferredoxins, Nitrogenase, Bio-inorganic aspects of nitrogen fixation.

Unit- III: Metalloenzymes

Zinc enzymes – carboxypeptidase and carbonic anhydrase, Iron Enzymes – catalase peroxidase and cytochrome p-450, Copper enzymes – superoxide dismutase, Mg enzymes – vitamin B₁₂.

Unit IV: Supra molecular Chemistry

A) Molecular recognition: Spherical recognition, Recognition of anionic Substrate, Tetrahedral recognition, Co receptor molecules and multiple recognition, Binding and recognition of neutral molecules.

B) Supra molecular reactivity and catalysis.

C) Molecular assembly in supra molecular chemistry.

D) Supra molecular devices: Suitable binding, photochemical and electrochemical sensor wires.

Books Recommended:

1. Principle of Biochemistry (Lehninger): D. L. Nelson and M. M. Cox, W. H. Freeman and company, New York.
2. Fundamentals of Biochemistry: D. Voet, J. G. Voet and C. W. Pratt; John Wiley and sons.
3. Bioinorganic Chemistry: Bertini, Gray, Lippard, Valentine, Viva Books Private Limited.
4. Supramolecular Chemistry: J. M. Lehn; VCH

POLYMER CHEMISTRY

Paper-CHE-CE-513

Unit-I: Basics of Polymer

Importance of polymers, Basic concepts: Monomer, repeat units, degree of polymerization, Linear, branched and network polymers, Classification of polymers, Polymerization: Condensation, addition, radical and coordination polymerization, Polymerization conditions and polymer reactions, Polymerization in homogeneous and heterogeneous systems.

Unit-II: Polymer Characterization

Polydispersion-average molecular concept, Number, weight and viscosity average molecular weights, Polydispersity and molecular weight distribution, Practical significance of molecular weight, Measurement of molecular weights, End group, viscosity, Light scattering, osmotic and ultracentrifugation methods, Analysis and testing of polymers, chemical analysis of polymers,

Spectroscopic methods, X-ray diffraction study, Microscopy, Thermal analysis and physical testing-tensile strength, Fatigue impact, Tear resistance, Hardness and abrasion resistance.

Unit-III: Structure and Properties

Morphology and order in crystalline polymers-centrifugation of polymer chains, Crystal structure of polymers, Morphology of crystalline polymers, strain induced morphology, crystallization and melting,

Polymer structure and physical properties-crystalline melting point, melting points of homogenous series, effect of chain flexibility and other steric factors, entropy and heat of fusion, Glass transition temperature, T_g , Relationship between T_m and T_g , effects of molecular weight, diluents, chemical structure, chain topology, branching and cross linking, Property requirements and polymer utilization.

Unit-IV: Properties of Commercial Polymers

Polyethylene, poly vinyl chloride, polyamides, phenolic resins, epoxy resins and silicone polymers, Functional polymers- Fire retarding polymers and electrically conducting polymers, Biomedical polymers –contact lens, dental polymers, artificial heart, kidney, skin and blood cells.

Books Recommended

1. Textbook of Polymer Science: F. W. Billmeyer Jr, Wiley
2. Polymer Science: V. R. Gowariker, N. V. Biswanathan and J. Sreedhar, Wiley, Eastern.
3. Physics and Chemistry of Polymers: J. M. G. Cowie, Blackie Academic and Professional.

INDUSTRIAL CHEMISTRY

Paper-CHE-CE-514

Unit-I. Petroleum and coal based chemicals:

Composition of petroleum, cracking processes, commercial production of Ethylene, Acetylene, Polymerisation mechanism, addition, condensation, step growth, chain growth, method of polymerisation, distillation of coal.

Unit-II a) Oil based industries:

Oils and fats, solvent extraction of oils, hydrogenation of oils, use of oil in the manufacturing of soap, paints and varnishes.

b) Surface active agents:

Classification and manufacturing of detergents used for cleaning purpose.

c) Fermentation industries:

A general discussion of Fermentation conditions, manufacturing of Penicillin.

Unit-III Pesticides and Pharmacological industries:

Manufacture of DDT, BHC.2,4-D manufacture, Parathion manufacture. Pharmaceutical industries.

Unit-IV Stoichiometry and unit operation:

Distillation, Absorption and Stripping, Extraction and leaching, crystallisation, Psychometric, Drying, Evaporation, less conventional operation.

Books Recommended

1. Analytical Chemistry by G. D. Christain
2. Introduction to chromatography : Bobbit
3. Instrumental Methods of analysis (CBS)- H.H . Willard, L.L. Mirrit, J.A. Dean
4. Instrumental Methods of Analysis : Chatwal and Anand

5. Instrumental Methods of Inorganic Analysis(ELBS) : A.I. Vogel
6. Chemical Instrumentation: A Systematic approach- H.A. Strobel
7. The principals of ion-selective electrodes and membrane transport: W.E.Morf
8. Physical Chemistry – P.W. Atkins 9. Principal of Instrumental Analysis- D. Skoog and D.West

PROJECT AND SEMINAR

Paper-CHE-CC-515

Each student has to work for at least 300 hours in a reputed research laboratory or industry on a specific project under the guidance of a Professor/Associate Professor/Assistant Professor/Reader/lecturer or a Scientist. The research work will be submitted in the form of a dissertation within 15 days of last theory examination. The student has to present his work in power point before an External examiner and an Internal examiner for evaluation.

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