Syllabus of 3-Year Degree/4-Year Honours in Chemistry

Based on National Curriculum and Credit Framework for Undergraduate Programme with effect from 2023-24

Kazi Nazrul University

Asansol, West Bengal

SEMESTER – I

COURSE TYPE: MAJOR

COURSE NAME: GENERAL CHEMISTRY–I

COURSE CODE: BSCCEMMJ101

<table>
<tr><td>Course Type: MAJOR</td><td colspan="2">Course Details: MJC-1</td><td colspan="2">L-T-P: 3-0-4</td></tr>
<tr><td rowspan="3">Credit: 5

3 (Theory) + 2 (Practical)</td><td rowspan="3">Full Marks: 100</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
<tr><td>Practical</td><td>Theoretical</td><td>Practical</td><td>Theoretical</td></tr>
<tr><td>30</td><td>15</td><td>20</td><td>35</td></tr>
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On completion of this course, the students will be able to understand:

Learning objectives:

1. Learning scientific theory of atoms, concept of wave function.

2. Elements in periodic table; physical and chemical characteristics, periodicity.

3. To predict the atomic structure, chemical bonding, and molecular geometry based on accepted models.

4. Identity of given element, relative size, charges of proton, neutron and electrons, and their assembly to form different atoms.

5. Physical and chemical characteristics of elements in various groups and periods according to ionic size, charge, etc. and position in periodic table.

6. Characterize bonding between atoms, molecules, interaction and energetics hybridization and shapes of atomic, molecular orbitals, bond parameters, bond- distances and energies.

7. Basic of organic molecules, structure, bonding, reactivity and reaction mechanisms.

8. Aromatic compounds and aromaticity, mechanism of aromatic reactions.

9. Understanding hybridization and geometry of atoms, 3-D structure of organic molecules, identifying chiral centers.

10. Electrophile, nucleophiles, free radicals, electronegativity, resonance, and intermediates along the reaction pathways.

11.Mechanism of organic reactions (effect of nucleophile/leaving group, solvent), substitution vs. elimination.

Syllabus:
Theory

1. Atomic Structure (8 Lectures)

Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de' Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of ψ and ψ^2. Quantum numbers and their significance. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of s, p, d and f orbitals. Contour boundary and probability diagrams. Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number.

2. Periodic Table (7 Lectures)

Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table. Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy. Electron gain enthalpy, trends of electron gain enthalpy. Electronegativity, Pauling, Mullikan, Allred-Rochow scales, electronegativity and bond order, partial charge, hybridization, group electronegativity. Sanderson electron density ratio.

3. Chemical Bonding (10 Lectures)

Covalent bond: Lewis structure, Valence Shell Electron Pair Repulsion Theory (VSEPR), Shapes of simple molecules and ions containing lone-and bond-pairs of electrons multiple bonding, sigma and pi-bond approach, Valence Bond theory, (Heitler-London approach). Hybridization containing s, p and s, p, d atomic orbitals, shapes of hybrid orbitals, Bents rule, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of simple homonuclear and heteronuclear diatomic molecules, MO diagrams of simple tri and tetra-atomic molecules, e.g., N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions; HCl, BeF_2, CO_2, BF_3 (idea of s-p mixing and orbital interaction to be given). Covalent character in ionic compounds, polarizing power and polarizability. Fajan rules, polarization. Ionic character in covalent compounds: Bond moment and dipole moment. ionic character from dipole moment and electronegativities. Metallic Bond: Qualitative idea of free electron model, Semiconductors, Insulators.

4. Basics of Organic Chemistry (20 Lectures)

Organic Compounds: Classification and nomenclature, concept of hybridization, orbital pictures of bonding and shapes of molecules, calculation of formal charges and double bond equivalent.

Electronic displacements: Inductive effect, electromeric effect, resonance, hyperconjugation, mesomeric effect, bond polarizability, steric effect, steric inhibition of resonance.

Reactive intermediates: Method of generation, shape and relative stability of carbocations, carbanions, free radicals, carbenes, nitrenes, arynes, energy profile diagrams, electrophilic/ nucleophilic behaviour of reactive intermediates (elementary idea).

Introduction to organic reactions: Electrophiles and nucleophiles, hemolytic and heterolytic bond cleavage, homogenic and heterogenic bond formation, addition, elimination (E_1, E_2, E_{1CB} etc.) and substitution (SN^1, SN^2, SN^i etc.) reactions, curly arrow rules in representation of mechanistic steps.

Stereochemistry: Concept of asymmetry; Stereoisomerism; Conformations and configurations; Flying-wedge, Fischer, Sawhorse and Newman projection formulae and their interconversions; nomenclature D/L, R/S, E/Z

Practical

Qualitative analysis of organic special element N, S, Cl, Melting point, Functional group detection $-NH_2$, $-NO_2$, $-CONH_2$, phenolic-OH, -COOH, >C=O, -CHO and derivative preparation.

Recommended Books :

1. R. L. Dutta and G. S. De, Inorganic Chemistry, Pt – I, 7th Edn, 2013, The New Book Stall, 2013.
2. R. Sarkar, General and Inorganic Chemistry, Pt- I, 2nd Edn, Books & Allied (P) Ltd, 2009.
3. A. K. Das, Fundamental Concepts of Inorganic Chemistry, (Vol. 1-3), 2nd Edn, CBS Publisher, 2012.
4. D. F. Shriver, P. W. Atkins and C. H. Langford, Inorganic Chemistry, Oxford University Press, New York, 1990.

5. J. E. Huheey, E. A. Keiter and R. L. Keiter, Inorganic Chemistry: Principles of Structure and Reactivity, 4th Edn, Pearson Education, India, 2006.
6. N. N. Greenwood and A. Earnshaw, Chemistry of the Elements, 2nd Edn, Elsevier, India, 2005.
7. J. D. Lee, Concise Inorganic Chemistry, 5th Edn, Oxford University Press, 1999.
8. F. A. Cotton, G. Wilkinson, C. M. Murillo and M. Bochmann, Advanced Inorganic Chemistry, 6th Edn, John Wiley and Sons, Inc., New York, 1999.
9. F.A. Carey and R.J. Sundberg, Advanced Organic Chemistry Part A and Part B, 4th Edn., Plenum Press, New York, 2001.
10. M. B. Smith, March's Advanced Organic Chemistry 8th Edition, Wiley.
11. T. H. Lowry and K.C. Richardson, Mechanism and Theory in Organic Chemistry, 3rd Edn., Harper and Row, New York, 1998.
12. H. Neurath, The Proteins: Composition, Structure and Function, Vols. 1-5, Academic Press, New York, 1963.
13. T. W. G. Solomons, C. B. Fryhle and S. A. Snyder, Organic Chemistry, 12th Edition, Wiley.
14. M. Loudon and J. Parise, Organic Chemistry 6th Edition, Mc Millan Learning.
15. J. Clayden, N. Greeves, S. Warren and P. Wothers, Organic Chemistry, Oxford University Press, Oxford, 2001.
16. P. Sykes, A Guide to Mechanism in Organic Chemistry 6th Edition, Orient Longman.
17. D. Nasipuri, Stereochemistry of Organic Compounds, 2nd Edn, Wiley Eastern, New Delhi, 1993.
18. E. L. Eliel, S.H. Wilen and L.N. Mander, Stereochemistry of Organic Compounds, John Wiley & Sons, New York, 1994.
19. N. Tewari, Organic Chemistry, A Modern Approach Volume 1 & 2, Mc Graw Hill Education.
20. R. T. Morrison and R. N. Boyd, Organic Chemistry 6th Edition, Prentice Hall of India.
21. L. Finar, Organic Chemistry, Vol I, 6th Edn., Addison Wesley Longmann, London, 1998.
22. A. K. Nad, B. Mahapatra & A. Ghosal, An Advanced Course in Practical Chemistry, New Central, 2007.
23. S. Ghosh, M. Das Sharma, D. Majumdar and S. Manna, Chemistry in Laboratory, Santra Publication Pvt. Ltd.

24. Vogel's Text Book of Practical Organic Chemistry 5th Edn. Longman.

COURSE TYPE: MINOR

COURSE NAME: GENERAL CHEMISTRY–I

COURSE CODE: BSCCEMMN101

Course Type: **MINOR**	Course Details: MNC-1			L-T-P: **3-0-4**	
		CA Marks		ESE Marks	
Credit: **5**	Full Marks: **100**	Practical	Theoretical	Practical	Theoretical
3 (Theory) + 2 (Practical)		**30**	**15**	**20**	**35**

Learning Objectives and Syllabus are same as Chemistry Major course code BSCCEMMJ101

COURSE TYPE: SEC

COURSE NAME: INDUSTRIAL CHEMISTRY (SEC-1)

COURSE CODE: BSCCEMSE101

Course Type: **SEC (Theoretical)**	Course Details: SEC-1			L-T-P: **2-1-0**	
Credit: **3**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
			15		**35**

On completion of this course, the students will be able to understand:

Learning objectives:

1. *Understanding to the chemistry of paints, varnishes and dyes.*
2. *Preparation and uses of various compounds including KMnO4, CaC2, alloy steels etc.*
3. *Understanding the chemistry of ceramics.*
4. *Concepts of corrosion: cause and prevention.*
5. *Various fire-extinguishers and their chemical contents.*

Syllabus:

Theory

Paints (8 Lectures)

Paints, Varnishes and Synthetic Dyes: Primary constituents of a paint, binders and solvents for paints. Oil based paints, latex paints, baked-on paints (alkyd resins). Constituents of varnishes. Formulation of paints and varnishes. Synthesis of Methyl orange, Congo red, Malachite green, Crystal violet.

Electrochemical and Electro-thermal Industries (3 Lectures)

Preparation and use of Potassium permanganate, hydrogen peroxide, synthetic graphite, calcium carbide, carborundum, alloy steels

Ceramics (4 Lectures)

Refractories, pottery, porcelain, glass, fibre glass

Rusting of Iron and Steel (3 Lectures)

Cause and prevention of corrosion

Industrial Safety and Fire Protection (4 Lectures)

Flash point, fire extinguishers – foam, carbon dioxide, sprinkler system, inert gases.

Recommended Books :

1. G. T. Austin, Shreve's Chemical Process Industries, Mc Graw Hills, 5th Edition.
2. Jain, P.C. & Jain, M. Engineering Chemistry Dhanpat Rai & Sons, Delhi.
3. B.K. Sharma & H.Gaur, Industrial Chemistry, Goel Publishing House, Meerut 1996.
4. E.Stocchi, Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK 1990.

SEMESTER – II

COURSE TYPE: MAJOR

COURSE NAME: GENERAL CHEMISTRY–II

COURSE CODE: BSCCEMMJ201

Course Type: **MAJOR**	Course Details: MJC-2			L-T-P: **3-0-4**	
		CA Marks		ESE Marks	
Credit: **5**	Full Marks: **100**	Practical	Theoretical	Practical	Theoretical
3 (Theory) + 2 (Practical)		**30**	**15**	**20**	**35**

On completion of this course, the students will be able to understand:

Learning objectives:

1. Physical properties and related laws of gas and liquid states are described.

2. Understanding Kinetic model of gas and its properties.

3. Maxwell distribution, mean-free path, kinetic energies.

4. Behaviour of real gases, its deviation from ideal behaviour, equation of state, isotherm, and law of corresponding states.

5. Liquid state and its physical properties related to temperature and pressure variation.

6. Properties of liquid as solvent for various household and commercial use.

7. Understand the basics of chemical kinetics: determination of order, molecularity, theories of reaction rates, determination of rate of opposing/parallel/chain reactions with suitable examples, application of steady state kinetics, Steady-state approximation.

Syllabus :

Theory

1. Acid-Base and Ionic Equilibrium (12 Lectures)

Brönsted Lowry's concept, co-solvating agents, differentiating and leveling effect, Theory of solvent system, Lux Flood concept, Lewis concept- Stability of the adduct (Drago-Wayland equation), change of bond length parameter in adduct formation, -acidity of the

ligands, synergistic effect, Usanovich's concept. Strength of hydracids and oxyacids, different factors in determining acid-base strength: steric effects (B- and F-strain), salvation, H-bonding; Hard and Soft acid base (HSAB) principle: classification and characteristic, hardness and frontier molecular orbital (FMO), Non-aqueous solvent (liq. NH_3, liq. SO_2). Ionic Equilibria: Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono-, di- and tri-protic acids Ostwald's dilution law, pH, buffer solution and buffer capacity, Henderson equation, hydrolysis and hydrolysis constant of salts, indicators: acid-base and its function, Hammett acidity function

2. Redox Potential and Redox Equilibria (10 Lectures)

Some basic aspects of redox reactions, equivalent weights of oxidants and reductants, ion-electron method of balancing redox reactions, complimentary and noncomplimentary redox reactions, overpotential, electron and atom transfer in redox reactions, Standard redox potentials, sign convention, Nernst equation, electrochemical series, formal potential and its importance in analytical chemistry; Redox potential: effect of complex formation, effect of precipitation, effect of pH change, EMF Diagram (Latimer, Frost), thermodynamic aspects of disproportionation and comproportionation reactions, redox potential and equilibrium constants, redox titration and redox indicators, function of Zimmermann Reinhardt (ZR) solution

3. Chemical Kinetics – I (8 Lectures)

Introduction, reaction rate and extent of reaction, order and molecularity; kinetics of zero, first, second, fractional and pseudo-first order reactions; determination of order of reaction, opposing, consecutive and parallel reactions (first order), concept of steady state and rate determining step, chain reaction: elementary idea, illustrations with H_2-Br_2 and H_2-O_2 reactions. Temperature dependence of reaction rate, Arrhenius equation.

4. Properties of Fluids (15 Lectures)

a) Properties of Gas - Maxwell's speed and energy distributions in one-, two- and three-dimensions, distribution curves, different types of speeds and their significance, principle of equipartition of energy and its application to calculate the classical limit of molar heat

capacity of gases, Transport properties of gas, Thermal conductivity, Viscosity: mechanism, temperature and pressure dependence, relationship with mean free path. Collision of gas molecules, collision diameter, collision number and mean free path, frequency of binary collision in same and different molecules, wall collision and rate of effusion.

Nature of imperfect gases with reference to van der Waals, Diterici and virial equations of state; Amagat's and Andrews' curves; continuity of states; critical constants; Boyle temperature; reduced equation of state. Vapour density and limiting density, intermolecular forces.

b) Properties of Liquids - Viscosity of liquids: principles of determination (falling sphere, Poiseuille's equation and Ostwald viscometer); temperature dependence, liquid crystal.

Surface energy and surface tension: temperature dependence; vapour pressure over a curved surface; conditions of convexity and concavity of meniscus; wetting. Principles of determination (capillary-rise and drop-weight methods).

Practical

1. **CO_3^{2-}/HCO_3^-estimation**

Titration of Na_2CO_3 + $NaHCO_3$ mixture vs HCl using phenolphthalein and methyl orange indicators

2. **Hardness of Water**

To find the total hardness of water by EDTA titration

3. **Estimation of Fe^{2+}**

Titration of ferrous iron by $KMnO_4$/$K_2Cr_2O_7$

4. **Estimation of alkali content in antacid tablet**
5. **Surface tension of a liquid/solution by drop-weight/drop number.**
6. **Viscosity coefficient of a liquid/solution by Ostwald viscometer.**

Recommended Books :

1. R. L. Dutta and G. S. De, Inorganic Chemistry, Pt – I, 7th Edn, 2013, The New Book Stall, 2013.
2. R. Sarkar, General and Inorganic Chemistry, Pt- I, 2nd Edn, Books & Allied (P) Ltd, 2009.

3. A. K. Das, Fundamental Concepts of Inorganic Chemistry, (Vol. 1-3), 2nd Edn, CBS Publisher, 2012.
4. D. F. Shriver, P. W. Atkins and C. H. Langford, Inorganic Chemistry, Oxford University Press, New York, 1990.
5. J. E. Huheey, E. A. Keiter and R. L. Keiter, Inorganic Chemistry: Principles of Structure and Reactivity, 4th Edn, Pearson Education, India, 2006.
6. N. N. Greenwood and A. Earnshaw, Chemistry of the Elements, 2nd Edn, Elsevier, India, 2005.
7. J. D. Lee, Concise Inorganic Chemistry, 5th Edn, Oxford University Press, 1999.
8. F. A. Cotton, G. Wilkinson, C. M. Murillo and M. Bochmann, Advanced Inorganic Chemistry, 6th Edn, John Wiley and Sons, Inc., New York, 1999.
9. G. W. Castellan, Physical Chemistry, Narosa Publishing House, Calcutta, 1995.
10. K. L. Kapoor, A Text Book of Physical Chemistry (Vol. 1 & 5), Macmillan India Limited, New Delhi.
11. P. C. Rakshit (Revised by S.C. Rakshit), Physical Chemistry, Sarat Book Distributers, Kolkata.
12. Ira N. Levine, Physical Chemistry, PHI Learning Pvt. Ltd.
13. R. A. Alberty and R. J. Silbey, Physical Chemistry, John Wiley and Sons, Inc., New York, 1995.
14. D. A. McQuarrie and J. D. Simon, Physical Chemistry: A Molecular Approach, Viva Books Private Limited.
15. P. W. Atkins & Julio De Paula, Physical Chemistry, Eighth Edition, Oxford University Press, Oxford
16. P. W. Atkins & Julio De Paula, Elements of Physical Chemistry, Fifth Edition, Oxford University Press, Oxford
17. A. Bahl, B. S. Bahl and G. D. Tuli, Essentials of Physical Chemistry, S Chand Publications.
18. Pahari and Pahari, Problems on Physical Chemistry, New Central Book Agency (P) Ltd.
19. A. Ghoshal, Numerical Problems on Physical Chemistry, Books and Allied (P) Ltd.
20. A. K. Nad, B. Mahapatra & A. Ghosal, An Advanced Course in Practical Chemistry, New Central, 2007.

21. S. Ghosh, M. Das Sharma, D. Majumdar and S. Manna, Chemistry in Laboratory, Santra Publication Pvt. Ltd.

COURSE TYPE: MINOR

COURSE NAME: GENERAL CHEMISTRY–II

COURSE CODE: BSCCEMMN201

Course Type: **MINOR**	Course Details: MNC-2			L-T-P: **3-0-4**	
		CA Marks		ESE Marks	
Credit: **5**	Full Marks: **100**	Practical	Theoretical	Practical	Theoretical
3 (Theory) + 2 (Practical)		**30**	**15**	**20**	**35**

Learning Objectives and Syllabus are same as Chemistry Major course code BSCCEMMJ201

COURSE TYPE: MD

COURSE NAME: CHEMICAL SCIENCE

COURSE CODE: MDC213

Course Type: **MD**	Course Details: MDC213			L-T-P: **3-0-0**	
Credit: **3**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
			15		**35**

On completion of this course, the students will be able to understand:

Learning objectives:

- *Knowledge of Polymer chemistry*
- *Application of polymer in everyday life*
- *Basic concepts and classifications of drugs, medicines, cancer therapy*
- *Knowledge of applications of different essential drug molecules*
- *Elementary idea about bioinorganic chemistry*

Syllabus:

Theory

Unit-I: Polymer (15 Lectures)

Basic concept, definition of polymers, natural and synthetic polymers, monomers, polymers, degree of polymerization, simple idea of polymer structure: homopolymer (linear, branched, cross-linked) and copolymer (random, block, graft), polymerization reaction step (growth, addition, ring opening), importance of polymers both natural and synthetic, Biodegradable polymers.

Number and weight average molecular weights of polymers – significance, structure, properties and use of natural rubber, synthetic rubber (neoprene), synthetic fibres (Nylon 66, polyester), plastics like polyethylene and PVC, macromolecules and environment.

Unit-II: Chemistry in everyday life (30 Lectures)

Drugs: Definition of drug, relation between drugs and medicine, designing a drug: drug target & drug metabolism, drug-target interaction, side effects, secondary effects and toxic effects of drugs, classification of drugs, Some important class of drugs and its use: antacids, antihistamines, antifertility, neurologically active drugs (tranquilizers, narcotic analgesic and non-narcotic analgesic), antimicrobials, antibiotics, antiseptics, disinfectants.

Cancer treatment: Anticancer compounds (Pt-complexes and metallocenes), Basic concept in chemotherapy, radiation therapy, immunotherapy.

Bioinorganic Chemistry: metal dependent disease, Essential metals: role of metal ions in biological systems (specially Na+, K^+, Mg^{2+}, Ca^{2+}, $Fe^{3+/2+}$, $Cu^{2+/+}$, and Zn^{2+}) detoxification by chelation therapy for Pb and As poisoning, lithium therapy in psychiatric mind disorder.

Recommended Books:

1. S. R. Palit, Elementary Physical Chemistry; Book Syndicate Private Limited.
2. M. S. Bhatnagar, A text book of polymer chemistry, S. Chand Publication
3. Mamta & M. Nithya Devi, Elements of Polymer Chemistry, Anmol Publishers.
4. A. K. Das, Bioinorganic Chemistry, 2nd Edn, Books & Allied (P) Ltd, Kolkata, 2004.
5. G. L. Patrick, Introduction to Medicinal Chemistry, Oxford University Press, UK, 2013.
6. H. Singh & V.K. Kapoor, Medicinal and Pharmaceutical Chemistry, Vallabh Prakashan, Pitampura, New Delhi, 2012.
7. A. Kar, Medicinal Chemistry, New Age International (P) Limited, Publishers.

COURSE TYPE: SEC

COURSE NAME: PHARMACEUTICAL CHEMISTRY (SEC-2)

COURSE CODE: BSCCEMSE201

Course Type: **SEC (Theoretical)**	Course Details: **SEC-2**			L-T-P: 2**-1-0**	
Credit: **3**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
			15		**35**

On completion of this course, the students will be able to understand:

Learning objectives:

1. *Understanding of different drug design and discoveries.*
2. *Different classes of drugs and their examples*
3. *Some knowledge about aerobic and anaerobic fermentation chemistry.*
4. *Some idea about production of various drug related components.*

Syllabus :

Theory

1. Drugs & Pharmaceuticals (15 Lectures)

What are drugs and why do we need new ones? Drug discovery and design, Sources of drugs and lead compounds, Natural sources, Drug synthesis, pharmacokinetics and pharmacodynamics? Introduction to drug action, Absorption, Distribution, Metabolism, Elimination, Solubility and drug design, The importance of water solubility, Salt formation, Structure–activity relationships (SARs), Lipophilicity, Electronic effects and steric effects.

Drugs & Pharmaceuticals Drug discovery, design and development; Basic Retrosynthetic approach. Synthesis of the representative drugs of the following classes: analgesics agents, antipyretic agents, anti-inflammatory agents (Aspirin, paracetamol, lbuprofen); antibiotics (Chloramphenicol); antibacterial and antifungal agents (Sulphonamides; Sulphanethoxazol, Sulphacetamide, Trimethoprim); antiviral agents (Acyclovir), Central Nervous System agents

(Phenobarbital, Diazepam), Cardiovascular (Glyceryltrinitrate), antilaprosy (Dapsone), HIV-AIDS related drugs (AZTZ idovudine).

2. Fermentation (5 Lectures)

Aerobic and anaerobic fermentation. Production of (i) Ethyl alcohol and citric acid, (ii) Antibiotics; Penicillin, Cephalosporin, Chloromycetin and Streptomycin, (iii) Lysine, Glutamic acid, Vitamin B2, Vitamin B12 and Vitamin C.

Recommended Books :

1. G. L. Patrick, Introduction to Medicinal Chemistry, Oxford University Press, UK, 2013.
2. H. Singh & V.K. Kapoor, Medicinal and Pharmaceutical Chemistry, Vallabh Prakashan, Pitampura, New Delhi, 2012.

SEMESTER – III

COURSE TYPE: MAJOR

COURSE NAME: INORGANIC CHEMISTRY–I

COURSE CODE: BSCCEMMJ301

Course Type: **MAJOR**	Course Details: MJC-3			L-T-P: **3-0-4**	
		CA Marks		ESE Marks	
Credit: **5**	Full Marks:	Practical	Theoretical	Practical	Theoretical
3 (Theory) + 2 (Practical)	**100**	**30**	**15**	**20**	**35**

On completion of this course, the students will be able to understand:

Learning objectives:

1. Understanding coordination compounds – its nomenclature, and various types of ligands

2. Concept of Valence Bond Theory and its applications and drawbacks

3. Different types of isomerism (both geometrical and optical) in coordination chemistry

4. Understanding chelate effect, macrocyclic effect and their relation with the stability of the complex

5. Application of coordination complexes

6. Chemistry, reactivity and various properties of s- and p-block elements.

7. Hands on experience on the identifications of various acid and basic radicals and qualitative analysis of radicals from a mixture of salts.

8. d- block chemistry including 1st, 2nd and 3rd row transition elements on their various oxidations state, magnetic properties, complex formation etc.

Syllabus:

Theory

1. Coordination Chemistry– I (20 Lectures)

Coordinate bonding: Double and Complex salts, Werner's Coordination theory, different types of ligands, metal chelates, IUPAC nomenclature of coordination compounds (up to two metal centers), electronic theory of complex compounds, effective atomic number (EAN) and its limitations, Valence bond theory in coordination compounds: different geometry, outer and inner orbital complexes, magnetic criterion of bond type, Principle of electro neutrality of atoms, limitations of VBT. Stereochemistry, Coordination number,

factors favouring low and high coordination numbers, isomerism (ionization, hydrate, ligand, linkage, coordination, geometrical, optical isomerism in square planar and octahedral complex) in coordination compounds, concept of Stability constant (stepwise and overall), chelate effect, macrocyclic effect and macro-polycyclic effect, application of coordination complexes in chemical analysis. Crystal Field Theory: splitting of d^n configurations in octahedral, square planar and tetrahedral fields, crystal field stabilization energy (CFSE) in weak and strong fields; pairing energy. Spectrochemical series, Jahn-Teller distortion. Octahedral site stabilization energy (OSSE) and structures of spinels.

2. Chemistry of s and p Block Elements (13 Lectures)

General properties of s-and p-block elements, Comparative account of physical and chemical properties of the s and p-block elements, Relative stability of different oxidation states, diagonal relationship and anomalous behaviour of first member of each group. Allotropy (if any) and catenation (if any), hydrides, halides, oxides, oxy- acids (if any), inert pair effect (if any), complex chemistry (if any); Properties and reactions of important compounds (i) Structure, bonding and reactivity of B_2H_6; (SN)x with x = 2, 4; phosphazines; interhalogens. (ii) Structure of borates, silicates, polyphosphates, borazole, boron nitride, silicones, thionic acids (iii) Reactivity of polyhalide ions, pseudohalogens, fluorocarbons, freons and NOx with environmental effects. (iv) Chemistry of hydrazine, hydroxylamine, phosponitrile, N^{3-}, thio- and per-sulphates.

Compounds of Noble Gases: Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation and properties of XeF_2, XeF_4andXeF_6; Bonding in noble gas compounds, Xenon oxygen compounds. Molecular shapes of noble gas compounds (VSEPR theory).

3. Chemistry of d Block Elements (12 Lectures)

General comparison of 3d, 4d and 5d elements with special reference to electronic configuration, variable valency, ability to form coordination complexes, spectral magnetic catalytic properties

Chemistry of some representative compounds: $K_2Cr_2O_7$, $KMnO_4$, Prussian blue, Turnbull's blue, $K_4[Fe(CN)_6]$, $K_2[Ni(CN)_4]$, H_2PtCl_6, $Na_2[Fe(CN)_5NO]$, Millon's Base, Ruthenium red, Magnus green salt, Reinecke's salt.

Practical

Qualitative analysis

Qualitative analysis of mixtures containing not more than three radicals from among the following:

1. Basic Radicals: Silver, lead, mercury, bismuth, copper, cadmium, arsenic, antimony, tin, iron, aluminium, manganese, chromium, nickel, cobalt, zinc, calcium, strontium, barium, sodium, potassium

2. Acid Radicals: Chloride, bromide, iodide, bromate, iodate, silicate, fluoride, arsenite, arsenate, phosphate, nitrite, nitrate, sulphide, sulphite, thiosulphate, sulphate, borate, ferro/ferri-cyanide, chromate, dichromate.

Insoluble Materials: Al_2O_3, Fe_2O_3, Cr_2O_3, SnO_2, $SrSO_4$, $BaSO_4$, CaF_2.

Recommended Books:

1. R. L. Dutta and G. S. De, Inorganic Chemistry, Pt – I, 7th Edn, 2013, The New Book Stall, 2013.
2. R. Sarkar, General and Inorganic Chemistry, Pt- I, II, 2nd Edn, Books & Allied (P) Ltd, 2009.
3. A. K. Das, Fundamental Concepts of Inorganic Chemistry, (Vol. 1-3), 2nd Edn, CBS Publisher, 2012.
4. A. K. Das, Fundamental Concepts of Inorganic Chemistry, (Vol. 4-7), CBS Publisher, 2014.
5. D. F. Shriver, P. W. Atkins and C. H. Langford, Inorganic Chemistry, Oxford University Press, New York, 1990.
6. Douglas, D. McDaniel and J. Alexander, Concepts and Models of Inorganic Chemistry, 3rd Edn, John Wiley and Sons, Inc., New York, 2001.
7. J. E. Huheey, E. A. Keiter and R. L. Keiter, Inorganic Chemistry: Principles of Structure and Reactivity, 4th Edn, Pearson Education, India, 2006.

8. A. Das and G. N. Mukherjee, Elements of Bioinorganic Chemistry, 2nd Edn, U. N. Dhur and Sons, Kolkata, 2002.
9. N. N. Greenwood and A. Earnshaw, Chemistry of the Elements, 2nd Edn, Elsevier, India, 2005.
10. J. D. Lee, Concise Inorganic Chemistry, 5thEdn, Oxford University Press, 1999.
11. F. A. Cotton, G. Wilkinson, C. M. Murillo and M. Bochmann, Advanced Inorganic Chemistry, 6th Edn, John Wiley and Sons, Inc., New York, 1999.
12. J. J. Katz, G. T. Seaborg and L. R. Morss (Eds), The Chemistry of the Actinide Elements, Vols I and II, 2nd Edn, Springer Verlag Gmbh, 1986.
13. R. B. Jordan, Reaction Mechanisms of Inorganic and Organometallic Systems, Oxford University Press, 1998.
14. A. G. Sharpe, Inorganic Chemistry, 3rdEdn, Pearson Education, New delhi, 2004.
15. D. Banerjea, Inorganic Chemistry: A Modern Treatise, Asian Books Private Ltd, 2012.
16. I. Vogel, A Text Book of Quantitative Inorganic Analysis, 3rd Edn, Longmans, 1961.
17. M. Kolthoff, P. J. Elving and E. B. Sandell, Treatise on Analytical Chemistry, Pt-I, II, III, The Interscience Encyclopedia, Inc., New York. 1959.
18. A. K. Nad, B. Mahapatra & A. Ghosal, An Advanced Course in Practical Chemistry, New Central, 2007.

COURSE TYPE: MAJOR

COURSE NAME: PHYSICAL CHEMISTRY–I

COURSE CODE: BSCCEMMJ302

Course Type: **MAJOR**	Course Details: MJC-4			L-T-P: **3-0-4**	
		CA Marks		ESE Marks	
Credit: **5**	Full Marks:	Practical	Theoretical	Practical	Theoretical
3 (Theory) + 2 (Practical)	**100**	**30**	**15**	**20**	**35**

On completion of this course, the students will be able to understand:

Learning objectives:

1. Understanding different mathematical functions.

2. Learning about mathematical probability and correlations.

3. Concepts of sampling and analysis of data.

4. First Law of thermodynamics and concepts.

5. Understanding the concept of system, variables, heat, work, and their relations.

6. Concept of heat of reactions and use of equations in calculations of bond energy, enthalpy, etc.

7. Solids, lattice parameters – its calculation, application of symmetry, solid characteristics of simple salts.

8. Basic principle of laws of electrochemistry.

9. Concept of ion atmosphere.

10. Application of conductance measurement.

Syllabus:

Theory

1. Mathematics in Physical Chemistry (8 Lectures)

Preliminary ideas of functions, limits, derivative, physical significance, basic rules of differentiation, maxima and minima, applications in chemistry, Error function, Properties of Gamma function, exact and inexact differential, Idea of distribution functions. Transformation properties for Cartesian to polar coordinates. Partial differentiation, rules of integration, definite and indefinite integrals. Separation of variables, Permutations,

combinations, theory of probability, complex number. Introduction to matrix algebra, addition and multiplication of matrices, inverse, adjoint and transpose of matrices, unit and diagonal matrices.

2. Thermodynamics – I (12 Lectures)

Basic formalism, concept of thermal equilibrium and zeroth law of thermodynamics, state and path functions, partial derivatives and cyclic rule, concept of heat and work, reversible and irreversible processes, graphical representation of work done.

First law, U and H as state functions, concept of C_P and C_V and their relations for ideal and van der Waals equation, Joule's experiment and its consequence, isothermal and adiabatic processes, calculations of *q*, *w*, *U* and *H* for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions.

Thermochemistry: Kirchoff's equation, heat changes during physicochemical processes at constant Pressure and Volume, bond dissociation energies, resonance energy.

3. Properties of solids (13 Lectures)

Crystal, Steno's Law, Hauy's Law (law of rational intercepts), law of constancy of symmetry, Weiss indices, Miller's indices, Unit cell, Bravais Lattice, Crystal systems, crystal class, Bragg's equation with derivation, methods of crystal analysis, application of Bragg's equation, Born Haber cycle, Born-Lande equation, crystal structure of sodium chloride and potassium chloride, Lattice vector and reciprocal lattice vector, Brillouin zone.

Some basic crystal geometries: simples cube (sc), body centred cube (bcc), face centred cube (fcc), diamond cube (dc), close packing models: hexagonal close packing (hcp) (ABAB… type), cubic close packing (ccp) (ABCABC… type), tetrahedral and octahedral holes, packing efficiency.

Crystal defects: stoichiometric and nonstoichiometric, point defects, Schottky and Frenkel, colour centres, dislocations, free electron theory of metallic bonding (qualitative treatment), band theory and electrical properties of solids (qualitative idea),conductor, semiconductor, insulator in the light of band theory, n–type and p–type semiconductors.

4. Electrochemistry – I (12 Lectures)

Conductance and its measurement, cell constant, specific and equivalent conductance, their variations with dilution for strong and weak electrolytes, molar conductance, transport

number and determination by Hittorf methods, Kohlrausch's law, Walden's rule, ion conductance and ionic mobility, application of conductance measurement (determination of solubility product and ionic product of water), conductometric titrations.

Ion atmosphere, asymmetry and electrophoretic effects, Wien effect and Debye-Falkenhagen effect, Activity and activity coefficients of electrolyte/ion in solution, Debye-Hückel theory, Debye-Hückel limiting law (with derivation), solubility equilibrium and influence of common and indifferent ions.

Practical

1. pH-metric titration of weak (mono- and di-basic acid) against strong base.
2. Study of kinetics of H_2O_2 decomposition catalysed by KI.
3. Conductometric titration of an acid (strong, weak, monobasic, dibasic, mixture of weak and strong acid) against strong base.

Recommended Books:

1. G. W. Castellan, Physical Chemistry, Narosa Publishing House, Calcutta, 1995.
2. Ira N. Levine, Physical Chemistry, PHI Learning Pvt. Ltd.
3. R. A. Alberty and R. J. Silbey, Physical Chemistry, John Wiley and Sons, Inc., New York, 1995.
4. S. Glasstone, Text Book of Physical Chemistry, Macmillan and Company Ltd., London, 1951.
5. T. Engel and P. Reid, Physical Chemistry, Pearson Education, New Delhi, 2006.
6. D. A. McQuarrie and J. D. Simon, Physical Chemistry: A Molecular Approach, Viva Books Private Limited.
7. P. C. Rakshit (Revised by S.C. Rakshit), Physical Chemistry, Sarat Book Distributers, Kolkata.
8. P. W. Atkins & Julio De Paula, Physical Chemistry, Eighth Edition, Oxford University Press, Oxford
9. P. W. Atkins & Julio De Paula, Elements of Physical Chemistry, Fifth Edition, Oxford University Press, Oxford
10. R.G. Mortimer, Physical Chemistry, Third Edition, Elsevier Academic Press.

11. P. Monk, Physical Chemistry Understanding our Chemical World, John Wiley & Sons Ltd.
12. K.L. Kapoor, A Text Book of Physical Chemistry (Vol. 1 – 5), Macmillan India Limited, New Delhi.
13. S. Pahari, Physical Chemistry (Vol. 1 & 2), New Central Book Agency (P) Ltd.
14. Berry, Rice & Ross, Physical Chemistry, Oxford University Press.
15. W. J. Moore, Physical Chemistry, Longman Green and Co. Ltd., 1953.
16. Pahari and Pahari, Problems on Physical Chemistry, New Central Book Agency (P) Ltd.
17. Ghoshal, Numerical Problems on Physical Chemistry, Books and Allied (P) Ltd.
18. J. C. Ghosh, Experiments in Physical Chemistry, Bharati Bhawan Publishers and Distributors, Patna, 1994
19. S. K. Maity and N. K. Ghosh, Physical Chemistry Practical, New Central Book Agency (P) Ltd.
20. A. K. Nad, B. Mahapatra & A. Ghosal, An Advanced Course in Practical Chemistry, New Central, 2007.

COURSE TYPE: MINOR

COURSE NAME: INORGANIC & ORGANIC CHEMISTRY

COURSE CODE: BSCCEMMN301

Course Type: **MINOR**	Course Details: MNC-3			L-T-P: **3-0-4**	
		CA Marks		ESE Marks	
Credit: **5**	Full Marks:	Practical	Theoretical	Practical	Theoretical
3 (Theory) + 2 (Practical)	**100**	**30**	**15**	**20**	**35**

On completion of this course, the students will be able to understand:

Learning objectives:

1. Atomic theory and its evolution.

2. Learning scientific theory of atoms.

3. To understand atomic theory of matter, composition of atom.

4. Identity of given element, relative size, charges of proton, neutron and electrons, and their assembly to form different atoms.

5. Defining isotopes, isobar and isotone.

6. Coordination compounds – Concepts of double salts and complex salts, Werner theory, stereochemistry and isomerism.

7. Reactivity, stability of organic molecules, structure, stereochemistry.

8. Stereochemistry of organic molecules – conformation and configuration, asymmetric molecules and nomenclature.

9. Understandings of Carbohydrates, classification, structure and configuration.

Syllabus:

Theory

Group - A

1. Nuclear Chemistry (10 Lectures)

Nuclear Stability: neutron-proton ratio and Segre's chart, modes of decay and neutron-proton ratio, packing fraction, mass defect and nuclear binding energy, magic number; Radioactive decay, units of radioactivity, different modes of decay, half-life and average-life of radioelements, radioactive equilibrium, natural radioactive disintegration series, principles of

determination of age of rocks and minerals, radiocarbon dating, group displacement law, artificial radioactivity, types of nuclear reactions (n, p, α, d and γ), reaction cross section, nuclear fission, fusion reaction and spallation, nuclear energy and power generation, application of radioactivity in analytical chemistry.

2. Coordination Chemistry (13 Lectures)

Double and complex salts, Werner's Coordination theory, different types of ligands, metal chelates, IUPAC nomenclature of coordination compounds (upto two metal centers), electronic theory of complex compounds, effective atomic number (EAN) and its limitations, Valence bond theory in coordination compounds: different geometry, outer and inner orbital complexes, magnetic criterion of bond type, Principle of electroneutrality of atoms, limitations of VBT. Stereochemistry, Coordination number, factors favouring low and high coordination numbers, isomerism (ionization, hydrate, ligand, linkage, coordination, geometrical, optical isomerism in square planar and octahedral complex etc.) in coordination compounds, chelate effect, application of coordination complexes in chemical analysis

Group - B

3. Stereochemistry II (11 Lectures)

A) Optical isomerism: Optical activity of organic compounds: optical rotation, specific rotation and molar rotation, racemic compounds, racemisation (through cationic, anionic, radical intermediates and through reversible formation of stable achiral intermediates), resolution of acids, bases and alcohols via diastereomeric salt formation.

B) Cycloalkanes and Conformational Analysis:

Types of cycloalkanes and their relative stability, Bayer's strain theory, Methods of formation of cycloalkanes: Conformation analysis of cycloakanes, Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms - Relative stability with energy diagrams.

4. Carbohydrate chemistry (11 Lectures)

Classification, Structure and configuration of D- arabinose, D – ribose, D- glucose, D – fructose and Sucrose (Fischer and Haworth projection): Structure determination of D-glucose: Epimers and Anomers; Mutarotation Osazone formation, Oxidation and reduction of

D – glucose; Stepping up and stepping down of monosaccharides; Conversion of aldose to ketose and vice – versa; Elementary idea about starch and cellulose.

Practical

Inorganic Qualitative analysis

Qualitative analysis of mixtures containing not more than three radicals from among the following:

1. Basic Radicals: Lead, bismuth, copper, arsenic, iron, aluminium, manganese, chromium, nickel, cobalt, zinc, calcium, strontium, barium, sodium, potassium

2. Acid Radicals: Chloride, bromide, iodide, fluoride, arsenite, arsenate, phosphate, nitrite, nitrate, sulphide, sulphate, borate.

Recommended Books:

1. R. L. Dutta and G. S. De, Inorganic Chemistry, Part – I, The New Book Stall, 7th Edn, 2013.
2. P. K. Dutt, General and Inorganic Chemistry, (Vol- I & II).
3. S. N. Poddar & S. Ghosh, General & Inorganic Chemistry (Vol I & II), Book Syndicate Pvt Ltd.
4. S. Sengupta, Organic Chemistry.
5. Bahl and Bahl, Organic Chemistry, S. Chand Publications.
6. R. K. Bansal, Organic Chemistry.

SEMESTER – IV

COURSE TYPE: MAJOR

COURSE NAME: ORGANIC CHEMISTRY–I

COURSE CODE: BSCCEMMJ401

Course Type: **MAJOR**	Course Details: MJC-5			L-T-P: **3-0-4**	
		CA Marks		ESE Marks	
Credit: **5**	Full Marks:	Practical	Theoretical	Practical	Theoretical
3 (Theory) + 2 (Practical)	**100**	**30**	**15**	**20**	**35**

On completion of this course, the students will be able to understand:

Learning objectives:

1. Thermodynamic criteria for reactivity, stability of organic molecules, structure, stereochemistry.

2. Reaction mechanism of substitution, elimination and addition reaction

3. Mechanism of organic reactions (effect of nucleophile/leaving group, solvent), substitution vs. elimination.

4. Electrophile, nucleophiles, free radicals, electronegativity, resonance, and intermediates along the reaction pathways.

5. Stereochemistry and concept of different types of isomerism.

6. Preparation, properties and reaction of some functional groups.

7. Understanding different types of name reaction.

Syllabus:

Theory

1. Reaction Mechanism II (18 Lectures)

Reaction thermodynamics: Free energy and equilibrium, enthalpy and entropy factor, calculation of enthalpy change via Bond dissociation Energy, intermolecular & intramolecular reactions

Reaction kinetics: Rate constant and free energy of activation; free energy profiles for one-step, and two-step reactions; catalyzed reactions, principle of microscopic reversibility; Hammond's postulate. Method of determination of reaction mechanism.

Substitution and Elimination Reactions: Nucleophilic substitution reactions

Substitution at sp^3 carbon centre [alkyl halides, allyl halides, benzyl halides, alcohols, ethers, epoxides, α-halocarbonyls: mechanisms (with evidence)], relative rates & stereochemical features: SN^1, SN^2, $SN^{2'}$, $SN^{1'}$ (allylic rearrangement) and SN^i reactions, effects of solvent, substrate structure, leaving group and nucleophiles (including ambident nucleophiles: cyanide & nitrite); substitutions involving Neighbouring Group Participation.

Elimination reactions

E1, E2, E1cB and Ei (pyrolytic *syn*e limitations); formation of alkenes and alkynes; mechanisms (with evidence), reactivity, regioselectivity (Saytzeff/Hofmann) and stereoselectivity; comparison between substitution and elimination reactions, comparison between nucleophilicity and basicity.

Addition reactions to C-C unsaturated bonds

Alkenes: Electrophilic additions to alkenes and alkynes with mechanisms (Markownikoff / Anti-Markownikoff addition), Oxymercuration-demercuration, Hydroboration-oxidation, Ozonolysis, Reduction (catalytic and chemical), syn and anti-hydroxylation. 1,2- and 1,4-addition reactions in conjugated dienes, addition of HX to allenes, addition of 1,3-dipolarions to alkenes and alkynes.

Alkynes: Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes.

2. Stereochemistry II (15 Lectures)

Optical isomerism: Optical activity of organic compounds: optical rotation, specific rotation and molar rotation, racemic compounds, racemisation (through cationic, anionic, radical intermediates and through reversible formation of stable achiral intermediates), resolution of acids, bases and alcohols via diastereomeric salt formation, optical purity and enantiomeric excess.

Concept of prostereoisomerism

Prostereogenic centre; concept of prochirality: topicity of ligands and faces (elementary idea); pro-R/pro-S, pro- E/pro-Z and Re/Si descriptors; pro-*r* and pro-*s* descriptors of ligands on propseudo asymmetric centre.

Conformational Analysis

Meaning of conformational analysis, difference between configuration and conformation, concept of dihedral and torsion angle, conformation of ethane, propane, n-butane, halohydrins and 1,2-diols; Baeyer strain theory, conformation of cyclic molecules with special reference of cyclohexane and its derivatives.

3. Functional Group Chemistry I (12 Lectures)

Alcohols: Preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, Bouvaelt-Blanc Reduction; Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement.

Phenols: Preparation and properties; Acidity and factors, Ring substitution reactions, Reimer–Tiemann Reactions, Kolbe's–Schmidt Reactions, Fries rearrangement, Claisen Rearrangement, Houben-Hoesch reaction, Leaderer-Manasse Reaction, Gattermann Reaction.

Ethers and Epoxides: Preparation and reactions. Acid and base catalysed ring opening of epoxides, Orientation and stereochemistry of epoxide ring opening, Reactions with Grignard reagents and Organolithium compounds, Reactions of epoxides with alcohols, ammonia derivatives and $LiAlH_4$.

Practical

Identification of single organic compound with general reaction and tests of the following compounds:

1. Liquid organic compounds

a) Methyl alcohol, b) Ethyl alcohol, c) Acetone, d) Formic acid, e) Acetic acid, f) Aniline,

2. Solid organic compounds

g) Urea, h) Tartaric acid, i) Succinic acid, j) Salicylic acid, k) Glucose, l) Resorcinol

Recommended Books:

1. E.L. Eliel, S.H. Wilen and L.N. Mander, Stereochemistry of Organic Compounds, John Wiley & Sons, New York, 1994.

2. S. Sengupta, Basic Stereochemistry of Organic Molecules, 2009.
3. D. Nasipuri, Stereochemistry of Organic Compounds, 2nd Edn., Wiley Eastern, New Delhi, 1993.
4. J. March, Advanced Organic Chemistry: Reactions, Mechanisms and Structure, 5th Edn., John Wiley, New York, 1999.
5. S. P. McManus, Organic Reactive Intermediates, Academic Press, New York, 1973.
6. F.A. Carey and R.J. Sundberg, Advanced Organic Chemistry Part A and Part B, 4th Edn., Plenum Press, New York, 2001.
7. T. L. Gilchrist and C. W. Rees, Carbenes, Nitrenes and Arynes, Nelson, New York, 1973.
8. T. H. Lowry and K.C. Richardson, Mechanism and Theory in Organic Chemistry, 3rd Edn., Harper and Row, New York, 1998.
9. H. Neurath, The Proteins: Composition, Structure and Function, Vols. 1-5, Academic Press, New York, 1963.
10. T. W. G. Solomons, Organic Chemistry,
11. G. M. Loudon, Organic Chemistry
12. J. Clayden, N. Greeves, S. Warren and P. Wothers, Organic Chemistry, Oxford University Press, Oxford, 2001.
13. I. Fleming, Frontier Orbitals and Organic Chemical Reactions, John Wiley, 1980.
14. W. Caruthers, Modern Methods of Organic Synthesis, 3rd Edn., Low Price Edition, Cambridge University Press, 1996.
15. H. O. House, Modern Synthetic Reactions, 2nd Edn., Benjamin, 1971.
16. P. Sykes: A Guide to Mechanism in Organic Chemistry.
17. R. T. Morrison and R. N. Boyd: Organic Chemistry
18. R. O. C. Norman and J. M. Coxon: Principle of organic synthesis
19. I. L. Finar, Organic Chemistry, Vol I, 6th Edn., Addison Wesley Longmann, London, 1998.
20. S. Warren, Organic Synthesis: The Disconnection Approach, 1st Edn, Wiley, 2012.

COURSE TYPE: MAJOR

COURSE NAME: PHYSICAL CHEMISTRY–II

COURSE CODE: BSCCEMMJ402

Course Type: **MAJOR**	Course Details: MJC-6			L-T-P: **3-0-4**	
		CA Marks		ESE Marks	
Credit: **5**	Full Marks:	Practical	Theoretical	Practical	Theoretical
3 (Theory) + 2 (Practical)	**100**	**30**	**15**	**20**	**35**

On completion of this course, the students will be able to understand:

Learning objectives:

1. Second Law of thermodynamics and concepts.

2. Understanding the concept of entropy; reversible, irreversible processes.

3. Learn the application of thermodynamics: Joule Thompson effects, partial molar quantities.

4. Understanding the equilibrium on the basis of thermodynamic parameters.

5. Understanding the Le Chatelier's principle from thermodynamics.

6. Concepts of thermodynamic probability and relation with entropy.

7. Calculation of entropy using 3rd law of thermodynamics.

8. Concepts of partition functions.

9. Concepts of four colligative properties, their interrelations and applications

10. Thermodynamic parameters related to mixing for binary solutions.

Syllabus:

Theory

1. Thermodynamics – II (24 Lectures)

Second law of thermodynamics and its need, Kelvin, Planck and Clausius statements and their equivalence, Carnot cycle and refrigerator, Carnot's theorem, thermodynamic scale of temperature

Physical concept of entropy, Clausius inequality, entropy change of system and surroundings for various processes and transformations, entropy change during isothermal mixing of ideal gases, entropy and unavailable work, auxiliary state functions (G and A) and their variations with T, P and V, criteria of spontaneity and equilibrium

Thermodynamic relations, Maxwell relations, thermodynamic equation of state, Gibbs-Helmholtz equation and its consequence, Joule-Thomson (J-T) experiment inversion temperature, J-T coefficient for a van der Waals gas, general heat capacity relations

Additivity rule, partial molar quantities, chemical potential and its variation with T and P, Gibbs-Duhem equation, fugacity of gases and fugacity coefficient.

Nernst heat theorem and its implications, approach to zero Kelvin, Planck's formulation of third law and absolute entropies.

2. Chemical Equilibrium (5 Lectures)

Thermodynamic condition of equilibrium, degree of advancement and Le Chatelier's principle, Van't Hoff isotherm, isobar and isochore.

3. Statistical Thermodynamics (8 Lectures)

Thermodynamic probability, entropy and probability, Boltzmann distribution formula (with derivation), application to barometric distribution, partition function and thermodynamic properties (U, H & P), Einstein's theory of heat capacity of solids and its limitations

4. Colligative properties (8 Lectures)

Chemical potential; ideal and nonideal solutions; Raoult's law and Henry's laws.

Colligative properties: relative lowering of vapour pressure, ebullioscopy, cryoscopy and osmosis (thermodynamic treatment only). inter relationships and abnormal behaviour in solution, van't Hoff *i*-factor. ΔG, ΔS, ΔH and ΔV of mixing for binary solutions, vapour pressure of solution, ideal solutions.

Practical

1. Effect of ionic strength on the rate of persulphate-iodide reaction.
2. Kinetics of saponification of ester by conductometric method.
3. Conductometric verification of Ostwald dilution law.

Recommended Books:

1. G. W. Castellan, Physical Chemistry, Narosa Publishing House, Calcutta, 1995.
2. Ira N. Levine, Physical Chemistry, PHI Learning Pvt. Ltd.
3. R. A. Alberty and R. J. Silbey, Physical Chemistry, John Wiley and Sons, Inc., New York, 1995.
4. S. Glasstone, Text Book of Physical Chemistry, Macmillan and Company Ltd., London, 1951.
5. T. Engel and P. Reid, Physical Chemistry, Pearson Education, New Delhi, 2006.
6. D. A. McQuarrie and J. D. Simon, Physical Chemistry: A Molecular Approach, Viva Books Private Limited.
7. P. C. Rakshit (Revised by S.C. Rakshit), Physical Chemistry, Sarat Book Distributers, Kolkata.
8. P. W. Atkins & Julio De Paula, Physical Chemistry, Eighth Edition, Oxford University Press, Oxford
9. P. W. Atkins & Julio De Paula, Elements of Physical Chemistry, Fifth Edition, Oxford University Press, Oxford
10. R.G. Mortimer, Physical Chemistry, Third Edition, Elsevier Academic Press.
11. P. Monk, Physical Chemistry Understanding our Chemical World, John Wiley & Sons Ltd.
12. K.L. Kapoor, A Text Book of Physical Chemistry (Vol. 1 – 5), Macmillan India Limited, New Delhi.
13. S. Pahari, Physical Chemistry (Vol. 1 & 2), New Central Book Agency (P) Ltd.
14. Berry, Rice & Ross, Physical Chemistry, Oxford University Press.
15. W. J. Moore, Physical Chemistry, Longman Green and Co. Ltd., 1953.
16. Pahari and Pahari, Problems on Physical Chemistry, New Central Book Agency (P) Ltd.
17. A. Ghoshal, Numerical Problems on Physical Chemistry, Books and Allied (P) Ltd.

18. J. C. Ghosh, Experiments in Physical Chemistry, Bharati Bhawan Publishers and Distributors, Patna, 1994
19. S. K. Maity and N. K. Ghosh, Physical Chemistry Practical, New Central Book Agency (P) Ltd.
20. A. K. Nad, B. Mahapatra & A. Ghosal, An Advanced Course in Practical Chemistry, New Central, 2007.

COURSE TYPE: MINOR

COURSE NAME: ORGANIC & PHYSICAL CHEMISTRY

COURSE CODE: BSCCEMMN401

Course Type: **MINOR**	Course Details: MNC-4			L-T-P: **3-0-4**	
		CA Marks		ESE Marks	
Credit: **5**	Full Marks:	Practical	Theoretical	Practical	Theoretical
3 (Theory) + 2 (Practical)	**100**	**30**	**15**	**20**	**35**

On completion of this course, the students will be able to understand:

Learning objectives:

1. Understanding the preparation methods of few organic compounds

2. Understandings of different types of biomolecules, e.g, amino acids. proteins, etc, synthesis and properties of these molecules.

3. Knowledge of Macromolecular chemistry

4. Laws of thermodynamics and concepts.

5. Understanding the concept of system, variables, heat, work, and laws of thermodynamics.

6. Understanding the concept of heat of reactions and use of equations in calculations of bond energy, enthalpy, etc.

7. Understanding the concept of entropy; reversible, irreversible processes.

8. Knowledge of reversible reactions and Chemical Equilibrium.

Syllabus:

Theory

Group - A

1. Organic Synthesis (6 Lectures)

Preparation and synthetic uses of diethyl malonate, ethylacetoacetate and Grignard reagents

Preparation of TNT phenyl acetic acid, salicylic acid, cinnamic acid, sulphanilic acid, phenyl hydrazine, nitrophenols, nitroanilines, picric acid glycerol, allyl alcohol, citric acid.

2. Macromolecules (9 Lectures)

Introduction, definition of macromolecules, natural and synthetic polymers, monomers, polymers, degree of polymerization, simple idea of polymer structure: homopolymer (linear, branched, cross-linked) and copolymer (random, block, graft), polymerization reaction step (growth, addition, ring opening), importance of polymers both natural and synthetic.

Number and weight average molecular weights of polymers – significance, structure and use of natural rubber, synthetic rubber (neoprene), synthetic fibres (Nylon 66, poly ester), plastics like polyethylene and PVC, macromolecules and environment.

3. Amino acid and Protein (7 Lectures)

Essential and non-essential amino acid; Synthesis of glycine and alanine; Isoelectric point; Detection of amino acid (Ninhydrin reaction) Classification of Protein, Geometry of peptide Linkage elementary idea about primary and secondary structure of protein; Denaturation of proteins.

Group - B

4. 1st law and 2nd law of Thermodynamics (18 Lectures)

Thermal equilibrium and zeroth law, First law, reversible and irreversible work, criteria of perfect gas, isothermal and adiabatic expansions, Joule-Thomson effect (derivation excluded); Thermochemistry: Hess's law and its application. Second law and its elementary interpretation, Carnot's cycle and theorems, Clausius inequality, criteria of spontaneity, free energy and entropy.

5. Chemical Equilibrium (5 Lectures)

Conditions of spontaneity and equilibrium, degree of advancement and Le Chatelier principle; Van't Hoff isotherm, isobar and isochore.

Practical

Quantitative analysis of organic compounds.

Estimation of: 1. Glucose by Fehling's solution, 2. Phenol by bromate bromide method

Recommended Books:

1. A. Sangal, Advanced Organic Chemistry, Vol. 1, Krishna Prakashan Media (P) Ltd, Meerut, India, 2012.
2. S. R. Palit, Elementary Physical Chemistry; Book Syndicate Private Limited.
3. P. C. Rakshit, Physical Chemistry; Sarat Book Distributers.
4. Dr. A. K. Mondal, Degree Bhouto O Sadharan Rasayan; Sarat Book Distributers.
5. A. Ghoshal, Sadharan O Bhouto Rasayan; Books and Allied (P) Ltd.
6. S. Sengupta, Organic Chemistry.
7. Bahl and Bahl, Organic Chemistry, S. Chand Publications.
8. R. K. Bansal, Organic Chemistry.

COURSE TYPE: SEC

COURSE NAME: FUEL CHEMISTRY (SEC-3)

COURSE CODE: BSCCEMSE401

Course Type: **SEC**	Course Details: SEC-3			L-T-P: **2-1-0**	
Credit: **3**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
			15		**35**

On completion of this course, the students will be able to understand:

Learning objectives:

1. Concepts of different renewable and non-renewable energy sources

2. Understanding the Coal as a fuel

3. Fractionation of coal tar and coal liquification

4. Other non-petroleum fuels and their production and uses

5. Understanding of various petrochemicals and their uses

6. Concepts of lubricants and their various properties

Syllabus:

Theory

1. Energy Sources (6 Lectures)

Review of energy sources (renewable and non-renewable). Classification of fuels and their calorific value.

Coal: Uses of coal (fuel and nonfuel) in various industries, its composition, carbonization of coal. Coal gas, producer gas and water gas—composition and uses. Fractionation of coal tar,

uses of coal tar bases chemicals, requisites of a good metallurgical coke, Coal gasification (Hydro gasification and Catalytic gasification), Coal liquefaction and Solvent Refining.

2. Petroleum and Petrochemical Industry (10 Lectures)

Composition of crude petroleum, Refining and different types of petroleum products and their applications. Fractional Distillation (Principle and process), Cracking (Thermal and catalytic cracking), Reforming Petroleum and non-petroleum fuels (LPG, CNG, LNG, bio-gas, fuels derived

from biomass), fuel from waste, synthetic fuels (gaseous and liquids), clean fuels. Petrochemicals: Vinyl acetate, Propylene oxide, Isoprene, Butadiene, Toluene and its derivatives Xylene.

3. Lubricants (4 Lectures)

Classification of lubricants, lubricating oils (conducting and non-conducting), solid and semisolid lubricants, synthetic lubricants. Properties of lubricants (viscosity index, cloud point, pore point) and their determination.

Project report on industrial/Academic Institute visit (internal assessment, marks 15)

Recommended Books:

1. B. Shaikia, Fuel Chemistry, Mahaveer Publications, 2021.
2. S. K. Juneja and A. Kumar, Fuel Chemistry & Chemistry of Cosmetics & Perfumes, S. Dinesh & Co. 2021.

SEMESTER – V

COURSE TYPE: MAJOR

COURSE NAME: INORGANIC CHEMISTRY–II

COURSE CODE: BSCCEMMJ501

Course Type: **MAJOR**	Course Details: MJC-7			L-T-P: **3-0-4**	
		CA Marks		ESE Marks	
Credit: **5**	Full Marks:	Practical	Theoretical	Practical	Theoretical
3 (Theory) + 2 (Practical)	**100**	**30**	**15**	**20**	**35**

On completion of this course, the students will be able to understand:

Learning objectives:

1. Coordination compounds – idea of metal-ligand bonding.
2. Idea of different types of bonding in complexes and their effects on oxidation states.
3. Explanation about the origin of colour and magnetism of complexes.
4. Concepts of magnetic properties of the complexes.
5. f-block chemistry including both lanthanides and actinides.
6. Concepts of Lanthanide contraction, abnormal electronic configuration and magnetic properties and their chemistry.
7. Introductory idea about inorganic reaction mechanism, labile-inert complex, reaction mechanism on various substitution reaction, trans-/cis-effect and its consequences etc.

Syllabus:

Theory

1. Coordination Chemistry-II: Crystal Field Theory; Magnetochemistry: Origin of Colours in Transition Metal Compounds (20 Lectures)

Metal-ligand bonding (MO concept, elementary idea), sigma- and pi bonding in octahedral complexes (qualitative pictorial approach) and their effects on the oxidation states of transitional metals (examples). Magnetism and Colour: Orbital and spin magnetic moments,

spin only moments of d^n ions and their correlation with effective magnetic moments, including orbital contribution; quenching of magnetic moment: super exchange and antiferromagnetic interactions (elementary idea with examples only); d-d transitions; L-S coupling; qualitative Orgel diagrams for $3d^1$ to $3d^9$ ions. Selection rules for electronic spectral transitions; nephelauxetic effect, introduction to LFT, spectrochemical series of ligands; charge transfer spectra (elementary idea).

2. f-Block Elements (10 Lectures)

Comparison of the general properties (e.g. electronic configuration, oxidation state, variation in atomic and ionic (3+) radii, complex formation, magnetic and spectral properties) of lanthanides and actinides, f-contraction, similarities between the later actinides and the later lanthanides, spectral properties (in comparison with the d-block elements), isolation and occurrence, use of the metals, principle of separation of lanthanides, chemistry of separation of Np, Pu and Am from U.

3. Reaction Mechanism: Inorganic Substitution Reaction Mechanism (15 Lectures)

Labile and inert complexes; associative, dissociative, interchange reaction mechanism, various factors on reaction rate, substitution reaction on square planer complexes, tetrahedral, octahedral (preliminary concept), trans-effect and its theories, cis-effect (preliminary concept) in square planar complexes; nucleophilicity parameter; Cis-trans isomerism; Oxidation- reduction reactions.

Practical

1. Volumetric analysis: Redox titrations- iodometry and iodimetry

2. Volumetric analysis of mixtures involving not more than two different estimations: Fe + Cu, Fe + Cr, Fe + Ca, Ca + Ba etc.

Recommended Books:

19. R. L. Dutta and G. S. De, Inorganic Chemistry, Pt – I, 7th Edn, 2013, The New Book Stall, 2013.

20. R. Sarkar, General and Inorganic Chemistry, Pt- I, II, 2nd Edn, Books & Allied (P) Ltd, 2009.
21. A. K. Das, Fundamental Concepts of Inorganic Chemistry, (Vol. 1-3), 2nd Edn, CBS Publisher, 2012.
22. A. K. Das, Fundamental Concepts of Inorganic Chemistry, (Vol. 4-7), CBS Publisher, 2014.
23. D. F. Shriver, P. W. Atkins and C. H. Langford, Inorganic Chemistry, Oxford University Press, New York, 1990.
24. Douglas, D. McDaniel and J. Alexander, Concepts and Models of Inorganic Chemistry, 3rd Edn, John Wiley and Sons, Inc., New York, 2001.
25. J. E. Huheey, E. A. Keiter and R. L. Keiter, Inorganic Chemistry: Principles of Structure and Reactivity, 4th Edn, Pearson Education, India, 2006.
26. N. N. Greenwood and A. Earnshaw, Chemistry of the Elements, 2nd Edn, Elsevier, India, 2005.
27. J. D. Lee, Concise Inorganic Chemistry, 5th Edn, Oxford University Press, 1999.
28. F. A. Cotton, G. Wilkinson, C. M. Murillo and M. Bochmann, Advanced Inorganic Chemistry, 6th Edn, John Wiley and Sons, Inc., New York, 1999.
29. J. J. Katz, G. T. Seaborg and L. R. Morss (Eds), The Chemistry of the Actinide Elements, Vols I and II, 2nd Edn, Springer Verlag Gmbh, 1986.
30. R. B. Jordan, Reaction Mechanisms of Inorganic and Organometallic Systems, Oxford University Press, 1998.
31. A. G. Sharpe, Inorganic Chemistry, 3rd Edn, Pearson Education, New delhi, 2004.
32. D. Banerjea, Inorganic Chemistry: A Modern Treatise, Asian Books Private Ltd, 2012.
33. I. Vogel, A Text Book of Quantitative Inorganic Analysis, 3rd Edn, Longmans, 1961.
34. A. K. Nad, B. Mahapatra & A. Ghosal, An Advanced Course in Practical Chemistry, New Central, 2007.

COURSE TYPE: MAJOR

COURSE NAME: ORGANIC CHEMISTRY–II

COURSE CODE: BSCCEMMJ502

Course Type: **MAJOR**	Course Details: MJC-8			L-T-P: **3-0-4**	
		CA Marks		ESE Marks	
Credit: **5**	Full Marks:	Practical	Theoretical	Practical	Theoretical
3 (Theory) + 2 (Practical)	**100**	**30**	**15**	**20**	**35**

On completion of this course, the students will be able to understand:

Learning objectives:

1. *Stereochemistry of organic molecules – conformation and configuration, asymmetric molecules and different types of reaction.*
2. *Basic of organic molecules, structure, bonding, reactivity and reaction mechanisms.*
3. *Basic uses of reaction mechanisms.*
4. *Aromatic compounds and aromaticity, mechanism of aromatic reactions.*
5. *Reactivity, stability of organic molecules, structure, stereochemistry.*
6. *Electrophile, nucleophiles, free radicals, electronegativity, resonance, and intermediates along the reaction pathways.*
7. *Mechanism of organic reactions (effect of nucleophile/leaving group, solvent), substitution vs. elimination.*
8. *Use of reagents in various organic transformation reactions.*

Syllabus:

Theory

1. Stereochemistry III (12 Lectures)

Cycloalkanes and Conformational Analysis

Types of cycloalkanes and their relative stability, Bayer's strain theory, Methods of formation of cycloalkanes: Diel's Alder Reaction, Simmons-Smith Reaction, Demjanov Rearrangement reduction, and addition of carbenes to olefins. Conformation analysis of cycloakanes, Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms - Relative stability with energy diagrams.

2. Reaction Mechanism III (18 Lectures)

A) Electrophilic aromatic substitution

Mechanisms and evidences in favour of it including PKIE; orientation and reactivity; reactions: nitration, nitrosation, sulfonation, halogenation, Friedel-Crafts reaction; one-carbon electrophiles (reactions: chloromethylation, Houben-Hoesch, Vilsmeier-Haack, Reimer-Tiemann, Kolbe-Schmidt); *Ipso* substitution. Diazocoupling reaction

B) Nucleophilic aromatic substitution

Addition-elimination mechanism and evidences in favour of it; SN1 mechanism; *cine* substitution (benzyne mechanism), structure of benzyne.

C) Birch Reduction of benzenoid aromatics

Benzene, Alkylbenzene, Anisole, Benzoic acid (with mechanism).

3. Functional Group Chemistry II (15 Lectures)

A) Carbonyl Compounds: -

Structure, reactivity and preparation: Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisen-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation, α-substitution reactions, oxidations and reductions (Clemmensen, Wolff-Kishner, $LiAlH_4$, $NaBH_4$, and MPV), Michael addition.

B) Carboxylic Acids and their Derivatives:

Preparation, physical properties and reactions of monocarboxylic acids: Typical reactions of

dicarboxylic acids, hydroxy acids and unsaturated acids: succinic/phthalic, lactic, malic, tartaric, citric, maleic and fumaric acids.

Preparation and reactions of acid chlorides, anhydrides, esters and amides; Comparative study of nucleophilic substitution at acyl group-Mechanism of acidic and alkaline hydrolysis of esters,

Claisen condensation, Dieckmann and Reformatsky reactions, Hofmann-bromamide degradation and Curtius rearrangement.

Practical

Quantitative analysis of organic compounds.

Estimation of: 1. Glucose by Fehling's solution, 2. Acetone by iodometric method, 3. Phenol by bromination, 4) acetic acid by sodium hydroxide solution, 5) Vitamin-C by iodometric method 6) Aniline by iodometric method

Recommended Books:

21. E.L. Eliel, S.H. Wilen and L.N. Mander, Stereochemistry of Organic Compounds, John Wiley & Sons, New York, 1994.
22. S. Sengupta, Basic Stereochemistry of Organic Molecules, 2009.
23. D. Nasipuri, Stereochemistry of Organic Compounds, 2nd Edn., Wiley Eastern, New Delhi, 1993.
24. J. March, Advanced Organic Chemistry: Reactions, Mechanisms and Structure, 5th Edn., John Wiley, New York, 1999.
25. S. P. McManus, Organic Reactive Intermediates, Academic Press, New York, 1973.
26. F.A. Carey and R.J. Sundberg, Advanced Organic Chemistry Part A and Part B, 4th Edn., Plenum Press, New York, 2001.
27. T. L. Gilchrist and C. W. Rees, Carbenes, Nitrenes and Arynes, Nelson, New York, 1973.
28. T. H. Lowry and K.C. Richardson, Mechanism and Theory in Organic Chemistry, 3rd Edn., Harper and Row, New York, 1998.
29. H. Neurath, The Proteins: Composition, Structure and Function, Vols. 1-5, Academic Press, New York, 1963.
30. T. W. G. Solomons, Organic Chemistry,
31. G. M. Loudon, Organic Chemistry
32. J. Clayden, N. Greeves, S. Warren and P. Wothers, Organic Chemistry, Oxford University Press, Oxford, 2001.

33. W. Caruthers, Modern Methods of Organic Synthesis, 3rd Edn., Low Price Edition, Cambridge University Press, 1996.
34. H. O. House, Modern Synthetic Reactions, 2nd Edn., Benjamin, 1971.
35. P. Sykes: A Guide to Mechanism in Organic Chemistry.
36. R. T. Morrison and R. N. Boyd: Organic Chemistry
37. R. O. C. Norman and J. M. Coxon: Principle of organic synthesis
38. I. L. Finar, Organic Chemistry, Vol I, 6th Edn., Addison Wesley Longmann, London, 1998.
39. S. Warren, Organic Synthesis: The Disconnection Approach, 1st Edn, Wiley, 2012.

COURSE TYPE: MAJOR

COURSE NAME: PHYSICAL CHEMISTRY–III

COURSE CODE: BSCCEMMJ503

Course Type: **MAJOR**	Course Details: MJC-9			L-T-P: **3-0-4**	
		CA Marks		ESE Marks	
Credit: **5**	Full Marks:	Practical	Theoretical	Practical	Theoretical
3 (Theory) + 2 (Practical)	**100**	**30**	**15**	**20**	**35**

On completion of this course, the students will be able to understand:

Learning objectives:

1. Learn about limitations of classical mechanics and solution in terms of quantum mechanics for atomic/molecular systems.

2. Develop an understanding of quantum mechanical operators, quantization, probability distribution, uncertainty principle.

3. Concepts of phases, components, degrees of freedom, Gibb's phase rule and its applications, construction of phase diagram of different systems, the application of phase diagram.

4. Understanding of phase equilibrium, criteria etc.

5. Knowledge of the laws of absorption of light energy by molecules and the subsequent photochemical reactions.

6. Interpret rotational and vibrational spectra and know about their application.

Syllabus:

Theory

1. Quantum Chemistry – I (15 Lectures)

Summarization of the results of some experiments – black-body radiation, photoelectric effect, Davison and Germer experiment, identification of classical and quantum systems, Wilson-Sommerfeld quantization rule, application to Bohr atom, harmonic oscillator, rigid rotator and particle in 1-d box, de Broglie relation and energy quantization in Bohr atom and box, Heisenberg uncertainty principle and its application in determining size and ground state energy of H atom.
Properties of wave functions, acceptability of wave function, probability interpretation of wave function, operators and related theorems, postulates of quantum mechanics. Schrödinger time independent equation, energy-eigenvalue equation, expectation value.

2. Phase Equilibria – I (8 Lectures)

Definition of phase, component and degree of freedom, phase rule and its derivation, phase diagram, phase equilibria for one-component system: water and carbon dioxide, first order phase transition and Clapeyron equation, Clausius-Clapeyron equation: derivation and applications, Nernst distribution law and its applications to various systems.

3. Atomic Spectroscopy (6 Lectures)

Stern-Gerlach experiment, vector atom model, term symbols (one and two optical electron systems), Alkali metal spectra, multiplicity of spectral lines, idea of spin quantum number, physical idea of spin orbit coupling, normal and anomalous Zeeman effect, Paschenback effect.

4. Molecular Spectroscopy – I (16 Lectures)

Electromagnetic spectrum and molecular processes associated with the regions.
Rotational spectra: classification of molecules into spherical, symmetric and asymmetric tops; diatomic molecules as rigid rotors – energy levels, selection rules and spectral features, isotope effect, intensity distribution, effect of non-rigidity on spectral features.
Vibrational spectra of diatomics: potential energy of an oscillator, Harmonic Oscillator approximation, energy levels and selection rules, anharmonicity and its effect on energy levels and spectral features: overtones and hot bands, vibration-rotation spectra of diatomics: origin; selection rules; P, Q and R branches.
NMR spectra: theory, relaxation process, instrumentation, chemical shift and shielding, factors contributing to magnitude of shielding, spin interactions – its origin, equivalent

protons, qualitative idea of energy levels of AX and A2 systems, a few representative examples.

Practical

1. Colorimetric determination of pK_{in} of methyl red.
2. Determine the ratio of metal and ligand in the Fe^{3+}- Salicylic acid complex by Job's method.
3. Determination of K_{eq} for $KI + I_2 = KI_3$ using partition coefficient between water and CCl_4.

Recommended Books:

1. G. W. Castellan, Physical Chemistry, Narosa Publishing House, Calcutta, 1995.
2. Ira N. Levine, Physical Chemistry, PHI Learning Pvt. Ltd.
3. R. A. Alberty and R. J. Silbey, Physical Chemistry, John Wiley and Sons, Inc., New York, 1995.
4. S. Glasstone, Text Book of Physical Chemistry, Macmillan and Company Ltd., London, 1951.
5. T. Engel and P. Reid, Physical Chemistry, Pearson Education, New Delhi, 2006.
6. D. A. McQuarrie and J. D. Simon, Physical Chemistry: A Molecular Approach, Viva Books Private Limited.
7. P. C. Rakshit (Revised by S.C. Rakshit), Physical Chemistry, Sarat Book Distributers, Kolkata.
8. P. W. Atkins & Julio De Paula, Physical Chemistry, Eighth Edition, Oxford University Press, Oxford
9. P. W. Atkins & Julio De Paula, Elements of Physical Chemistry, Fifth Edition, Oxford University Press, Oxford
10. R.G. Mortimer, Physical Chemistry, Third Edition, Elsevier Academic Press.
11. P. Monk, Physical Chemistry Understanding our Chemical World, John Wiley & Sons Ltd.
12. K.L. Kapoor, A Text Book of Physical Chemistry (Vol. 1 – 5), Macmillan India Limited, New Delhi.
13. S. Pahari, Physical Chemistry (Vol. 1 & 2), New Central Book Agency (P) Ltd.
14. Berry, Rice & Ross, Physical Chemistry, Oxford University Press.
15. W. J. Moore, Physical Chemistry, Longman Green and Co. Ltd., 1953.

16. Pahari and Pahari, Problems on Physical Chemistry, New Central Book Agency (P) Ltd.
17. Ghoshal, Numerical Problems on Physical Chemistry, Books and Allied (P) Ltd.
18. J. C. Ghosh, Experiments in Physical Chemistry, Bharati Bhawan Publishers and Distributors, Patna, 1994
19. S. K. Maity and N. K. Ghosh, Physical Chemistry Practical, New Central Book Agency (P) Ltd.
20. A. K. Nad, B. Mahapatra & A. Ghosal, An Advanced Course in Practical Chemistry, New Central, 2007.
21. S. Ghosh, M. Das Sharma, D. Majumdar and S. Manna, Chemistry in Laboratory, Santra Publications, 2019.

COURSE TYPE: MINOR

COURSE NAME: INORGANIC & PHYSICAL CHEMISTRY

COURSE CODE: BSCCEMMN501

Course Type: **MINOR**	Course Details: MNC-5			L-T-P: **3-0-4**	
		CA Marks		ESE Marks	
Credit: **5**	Full Marks:	Practical	Theoretical	Practical	Theoretical
3 (Theory) + 2 (Practical)	**100**	**30**	**15**	**20**	**35**

On completion of this course, the students will be able to understand:

Learning objectives:

1. Chemistry, reactivity and various properties of s- and p-block elements.
2. Knowledge of noble gas chemistry, their occurrence, preparation and reaction.
3. Knowledge of chemistry reaction and other properties of d block elements.
4. Chemistry of some representative compounds.
5. Basic concept of phase rule in a binary liquid mixture.
6. Basic knowledge about colligative properties of solutions.
7. Introduction on electrochemistry, electrochemical cell formation, electrode potentials.
8. Concepts about conductance, transport number, limiting law.

Syllabus:

Theory

Group - A

1. Chemistry of s and p Block Elements (14 Lectures)

General properties of s- and p-block elements, Comparative account of physical and chemical properties of the s and p-block elements, Relative stability of different oxidation states, diagonal relationship and anomalous behaviour of first member of each group. Allotropy (if any) and catenation (if any), hydrides, halides, oxides, oxy- acids (if any), inert pair effect (if any); Properties and reactions of important compounds (i) Structure, bonding and reactivity of B_2H_6; (SN)x with x=2, 4; phosphazines; interhalogens. (ii) Structure of borates, silicates, polyphosphates, borazole, boron nitride, silicones. (iii) Reactivity of polyhalide ions, pseudohalogens, fluorocarbons, freons and NOx with environmental effects. (iv) Chemistry of hydrazine, hydroxylamine, phosponitrile.

Compounds of Noble Gases: Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation and properties of XeF_2, XeF_4 and XeF_6; Bonding in noble gas compounds, Xenon oxygen compounds. Molecular shapes of noble gas compounds (VSEPR theory).

2. Chemistry of d Block Elements (8 Lectures)

d-Block elements: general comparison of 3d, 4d and 5d elements with special reference to electronic configuration, variable valency, ability to form coordination complexes, spectral magnetic catalytic properties.

Chemistry of some representative compounds: $K_2Cr_2O_7$, $KMnO_4$, Prussian blue, Turnbull's blue, $K_4[Fe(CN)_6]$, $K_2[Ni(CN)_4]$, H_2PtCl_6, $Na_2[Fe(CN)_5NO]$, Millon's Base, Ruthenium red, Magnus green salt, Reinecke's salt.

Group - B

3. Electrochemistry (11 Lectures)

Electrolytic conduction, transport number (experimental determination excluded), velocity of ions: specific, equivalent and molar conductances, determination of equivalent conductivity of solutions, Kohlrausch's law, strong and weak electrolytes, Ion atmosphere; electrophoretic and relaxation effects, Debye-Huckel theory (qualitative) and the limiting law.

Electrochemical cells, half-cells (with types and examples), Nernst equation and standard electrode potentials, standard cells

4. Phase equilibria & Colligative Properties (12 Lectures)

Phase rule equation (derivation excluded); phase diagram of water system, Miscibility (phenol-water) and distillation of completely miscible binary liquid mixtures; azeotropes, Steam distillation

Graphical approach of Raoult's law of vapour pressure and colligative properties: osmosis, lowering of freezing point, elevation of boiling point, experimental methods of determination of molecular weights of substances in dilute solutions, van't Hoff '*i*' factor and abnormal behaviour of electrolytic solutions

Practical

1. Study of kinetics of H_2O_2 decomposition catalysed by $FeCl_3$.
2. Conductometric titration of an acid (strong, weak, monobasic, dibasic, mixture of weak and strong acid) against strong base.

Recommended Books:

1. R. L. Dutta and G. S. De, Inorganic Chemistry, Part – I, The New Book Stall, 7th Edn, 2013.
2. P. K. Dutt, General and Inorganic Chemistry, (Vol- I & II).
3. S. N. Poddar & S. Ghosh, General & Inorganic Chemistry (Vol I & II), Book Syndicate Pvt Ltd.
4. S. Ekambaram, General Chemistry; Pearson.
5. S. R. Palit, Elementary Physical Chemistry; Book Syndicate Private Limited.
6. P. C. Rakshit, Physical Chemistry; Sarat Book Distributers.
7. Dr. A. K. Mondal, Degree Bhouto O Sadharan Rasayan; Sarat Book Distributers.
8. A. Ghoshal, Sadharan O Bhouto Rasayan;: Books and Allied (P) Ltd.

SEMESTER – VI

COURSE TYPE: MAJOR

COURSE NAME: INORGANIC CHEMISTRY–III

COURSE CODE: BSCCEMMJ601

Course Type: **MAJOR**	Course Details: MJC-10			L-T-P: **3-0-4**	
		CA Marks		ESE Marks	
Credit: **5**	Full Marks:	Practical	Theoretical	Practical	Theoretical
3 (Theory) + 2 (Practical)	**100**	**30**	**15**	**20**	**35**

On completion of this course, the students will be able to understand:

Learning objectives:

1. Students acquire knowledge of role of metal ions in our biological systems and mechanisms
of action of drugs in our body system.
2. Knowledge of vitamins and enzymes present in biological system and their roles.
3. Concepts of organometallic compounds, their preparations nomenclature and properties.
4. Acquire knowledge of different types of catalytic inorganic reaction.

Syllabus:

Theory

1. Bio-Inorganic Chemistry (23 Lectures)

Essential metals: role of metal ions in biological systems (specially Na^{+}, K^{+}, Mg^{2+}, Ca^{2+}, $Fe^{3+/2+}$, $Cu^{2+/+}$, and Zn^{2+}) and in different metalloproteins and metalloenzymes, metal ion transport across biological membrane, Na^{+}/K^{+} ion pump, ionophores, biological functions of hemoglobin and myoglobin, heamocyanin, hemerythrin, cytochromes and ferredoxins, carbonate bicarbonate buffering system and metalloenzyme: catalase, carbonic anhydrase; biological nitrogen fixation, photosynthesis: photosystem-I and photosystem-II, Chemistry of respiration; vitamin B_{12} and B_{12} enzyme; metal dependent disease, detoxification by chelation therapy for Pb and As poisoning Important metal complexes in medicines (Examples only), antimicrobial activity, antiarthritic gold complexes, anticancer compounds (Pt-complexes and metallocenes), Anti-AIDS drugs; lithium therapy in psychiatric mind disorder.

2. Organometallic Chemistry (22 Lectures)

Definition, a brief history, nomenclature, classification, importance of organometallic compounds as reagents, additives and catalysts, effective atomic number rule (18 electron rule), counting of electrons; preparation, properties and bonding in - carbonyl, nitrosyl and cyanide complexes; compounds with metal-alkane, -alkene, -alkyne bonds; IR-results as diagnostic tools in the identification of nature of bonding in such -acid complexes, metal-olefin complexes: Zeise's salt (preparation, structure and bonding), Ferrocene: Preparation and reactions (acetylation, alkylation, metalation, Mannich Condensation), heptacity of organometallic ligands and their examples, different types of reaction (elementary idea): oxidative addition, reductive elimination, insertion, transmetallation and cyclisation reactions; fluxional behaviour, isolobal analogy, Agostic interaction.

Catalytic Inorganic Reaction: Wilkinson, Zigler-Natta, Hydroformylation catalyst.

Practical

1. Preparation of a) Chrome alum; b) Mohr's salt; c) Cuprommonium sulphate; d) Sodium nitroprusside; e) hexamine cobalt(III) chloride; f) tris(ethane 1,2-ammine) g) nickel(III) chloride; h) Cuprous Chloride, Cu_2Cl_2; i) Manganese(III) phosphate, $MnPO_4.H_2O$; j) Reinecke's salt, k) $NH_4[Cr(NCS)_4(NH_3)_2]$; l) $[Cu(en)_2(H_2O)_2]SO_4$; m) $[Co(en)_3]^{3+}$ optically active; n) $[Mn(acac)_3]$/ $Mn(OAc)_3$

2. Preparation of acetylacetanato complexes of Cu^{2+}/Fe^{3+} (find out the λ_{max} of the prepared complex using instrument).

Recommended Books:

1. R. L. Dutta and G. S. De, Inorganic Chemistry, Pt – I, 7th Edn, 2013, The New Book Stall, 2013.
2. R. Sarkar, General and Inorganic Chemistry, Pt- I, II, 2nd Edn, Books & Allied (P) Ltd, 2009.
3. A. K. Das, Fundamental Concepts of Inorganic Chemistry, (Vol. 1-3), 2nd Edn, CBS Publisher, 2012.
4. A. K. Das, Fundamental Concepts of Inorganic Chemistry, (Vol. 4-7), CBS Publisher, 2014.
5. D. F. Shriver, P. W. Atkins and C. H. Langford, Inorganic Chemistry, Oxford University Press, New York, 1990.
6. Douglas, D. McDaniel and J. Alexander, Concepts and Models of Inorganic Chemistry, 3rd Edn, John Wiley and Sons, Inc., New York, 2001.
7. J. E. Huheey, E. A. Keiter and R. L. Keiter, Inorganic Chemistry: Principles of Structure and Reactivity, 4thEdn, Pearson Education, India, 2006.
8. A. Das and G. N. Mukherjee, Elements of Bioinorganic Chemistry, 2nd Edn, U. N. Dhur and Sons, Kolkata, 2002.
9. N. N. Greenwood and A. Earnshaw, Chemistry of the Elements, 2nd Edn, Elsevier, India, 2005.
10. J. D. Lee, Concise Inorganic Chemistry, 5thEdn, Oxford University Press, 1999.
11. F. A. Cotton, G. Wilkinson, C. M. Murillo and M. Bochmann, Advanced Inorganic Chemistry, 6th Edn, John Wiley and Sons, Inc., New York, 1999.

12. R. B. Jordan, Reaction Mechanisms of Inorganic and Organometallic Systems, Oxford University Press, 1998.
13. A. G. Sharpe, Inorganic Chemistry, 3rdEdn, Pearson Education, New Delhi, 2004.
14. D. Banerjea, Inorganic Chemistry: A Modern Treatise, Asian Books Private Ltd, 2012.
15. I. Vogel, A Text Book of Quantitative Inorganic Analysis, 3rd Edn, Longmans, 1961.
16. A. K. Nad, B. Mahapatra & A. Ghosal, An Advanced Course in Practical Chemistry, New Central, 2007.

COURSE TYPE: MAJOR

COURSE NAME: INORGANIC CHEMISTRY–IV

COURSE CODE: BSCCEMMJ602

Course Type: **MAJOR**	Course Details: MJC-11			L-T-P: **3-0-4**	
		CA Marks		ESE Marks	
Credit: **5**	Full Marks:	Practical	Theoretical	Practical	Theoretical
3 (Theory) + 2 (Practical)	**100**	**30**	**15**	**20**	**35**

On completion of this course, the students will be able to understand:

Learning objectives:

1. Knowledge of Polymer chemistry.
2. Concepts of different sphere and and layers of earths atmosphere.
3. To make students aware of different toxic chemicals and how they spoils the environment.
4. Knowledge of toxicity of different chemicals and impact on environment.
5. Understandings of radioactivity and stability of any nucleus.
6. Knowledge of radio carbon dating.

Syllabus:

Theory

1. Polymer Chemistry (12 Lectures)

Basic concept, definition of polymers, natural and synthetic polymers, monomers, degree of polymerization, simple idea of polymer structure: homopolymer (linear, branched, cross-linked) and copolymer (random, block, graft), vulcanization of rubber, polymerization reaction step (growth, addition, ring opening), importance of polymers both natural and synthetic, Criteria for polymer solubility, Thermodynamics of polymer solutions, Biodegradable polymers. Number and weight average molecular weights of polymers – significance, structure, properties and use of natural rubber, synthetic rubber (neoprene), synthetic fibres (Nylon 66, polyester), plastics like polyethylene and PVC, macromolecules and environment.

2. Environmental Chemistry (20 Lectures)

The Atmosphere

Characteristics of atmosphere, ozone layer and its role; major air pollutants: CO, SO_2, NO and particulate matters –their origins and harmful effects, problems of ozone layer depletion, green house effect, acid rain and photochemical smog, air quality standard, air pollution control measures: cyclone collector, electrostatic precipitator, catalytic converter,

Aspects of Environmental Inorganic Chemistry

Atmospheric stability and temperature inversion, greenhouse effect, global warming and cooling, ozone depletion and involved chemical reactions, eutrophication in natural water bodies, Minamata disease, hazard of nuclear disaster (Chernobyl and Fukushima Daiichi), nuclear disaster management.

The Hydrosphere

Water pollutants: action of soaps and detergents, phosphates, industrial effluents, agricultural runoff, domestic wastes; thermal pollution radioactive pollution and their effects on animal and plant life, waste water treatment: chemical treatment and microbial treatment; water quality standards: DO, BOD, COD, TDS and hardness parameters, desalination of sea water: reverse osmosis, electro dialysis, Water purification methods.

The Lithosphere and Pollution control

Soil pollution and control measures, biochemical effects of As, Pb, Cd, Hg, Cr, and their monitoring and remedial measures; noise pollution, agricultural and industrial pollution, green solution to various environmental hazards.

3. Nuclear Chemistry (13 Lectures)

Neutron-proton ratio and Segre's chart, modes of decay and neutron-proton ratio, packing fraction, mass defect and nuclear binding energy, magic number; Radioactive decay, units of radioactivity, different modes of decay, half-life and average-life of radioelements, radioactive equilibrium, natural radioactive disintegration series, principles of determination of age of rocks and minerals, radio carbon dating, group displacement law, artificial radioactivity, types of nuclear reactions (n, p, α, d and γ), reaction cross section, compound nucleus theory and nuclear reactions, nuclear fission, fusion reaction and spallation, nuclear energy and power generation, application of radioactivity in analytical chemistry, radiometric titrations.

Radiation chemistry: Elementary ideas of radiation chemistry, radiolysis of water and aqueous solutions, unit of radiation chemical yield (G-value), radiation dosimetry (Fricke's dosimeter), units of radiation energy (Rad, Gray, Sievert).

Practical

1. Complexometric Titration: $CaCO_3$ and $MgCO_3$ in mixture; Mg^{2+} and Zn^{2+} in mixture.
2. Estimation of Mn and Cr by colorimetric method.

Recommended Books:

1. R. L. Dutta and G. S. De, Inorganic Chemistry, Pt – I, 7th Edn, 2013, The New Book Stall, 2013.
2. R. Sarkar, General and Inorganic Chemistry, Pt- I, II, 2nd Edn, Books & Allied (P) Ltd, 2009.
3. A. K. Das, Fundamental Concepts of Inorganic Chemistry, (Vol. 1-3), 2nd Edn, CBS Publisher, 2012.
4. A. K. Das, Fundamental Concepts of Inorganic Chemistry, (Vol. 4-7), CBS Publisher, 2014.
5. D. F. Shriver, P. W. Atkins and C. H. Langford, Inorganic Chemistry, Oxford University Press, New York, 1990.

6. J. E. Huheey, E. A. Keiter and R. L. Keiter, Inorganic Chemistry: Principles of Structure and Reactivity, 4th Edn, Pearson Education, India, 2006.
7. A. Das and G. N. Mukherjee, Elements of Bioinorganic Chemistry, 2nd Edn, U. N. Dhur and Sons, Kolkata, 2002.
8. N. N. Greenwood and A. Earnshaw, Chemistry of the Elements, 2nd Edn, Elsevier, India, 2005.
9. J. D. Lee, Concise Inorganic Chemistry, 5th Edn, Oxford University Press, 1999.
10. F. A. Cotton, G. Wilkinson, C. M. Murillo and M. Bochmann, Advanced Inorganic Chemistry, 6th Edn, John Wiley and Sons, Inc., New York, 1999.
11. A. G. Sharpe, Inorganic Chemistry, 3rdEdn, Pearson Education, New Delhi, 2004.
12. D. Banerjea, Inorganic Chemistry: A Modern Treatise, Asian Books Private Ltd, 2012.
13. I. Vogel, A Text Book of Quantitative Inorganic Analysis, 3rd Edn, Longmans, 1961.
14. M. Kolthoff, P. J. Elving and E. B. Sandell, Treatise on Analytical Chemistry, Pt-I, II, III, The Interscience Encyclopedia, Inc., New York. 1959.
15. A. K. Nad, B. Mahapatra & A. Ghosal, An Advanced Course in Practical Chemistry, New Central, 2007.

COURSE TYPE: MAJOR

COURSE NAME: ORGANIC CHEMISTRY–III

COURSE CODE: BSCCEMMJ603

Course Type: **MAJOR**	Course Details: MJC-12			L-T-P: **3-0-4**	
		CA Marks		ESE Marks	
Credit: **5**	Full Marks:	Practical	Theoretical	Practical	Theoretical
3 (Theory) + 2 (Practical)	**100**	**30**	**15**	**20**	**35**

On completion of this course, the students will be able to understand:

Learning objectives:

1. Will have knowledge about Nitrogen containing functional groups and their reactions in various aspects.

2. Familiarization with polynuclear hydrocarbons and their reactions.

3. Understanding reactions and reaction mechanism of nitrogen containing functional groups.
4. Understanding the reactions and mechanisms of diazonium compounds.
5. Understanding the structure and their mechanism of reactions of selected polynuclear hydrocarbons.
6. Understanding the structure, mechanism of reactions of selected heterocyclic compounds.
7. Name reactions, uses of various reagents and the mechanism of their action.
8. Various organometallic chemistry in organic transformations.
9. Knowledge of carbohydrate chemistry mostly monosaccharides and few examples of disaccharides and polysaccharides.

Syllabus:

Theory

1. Nitrogen Containing Functional Groups (10 Lectures)

Preparation and important reactions of aliphatic and aromatic nitro compounds, nitriles and isonitriles; Amines: Basicity; Preparations: Gabriel's phthalimide synthesis, Carbylamine reaction, Mannich reaction, Hofmann bromoamide degradation, reductive amination; Properties: Hoffmann's exhaustive methylation, Hofmann-elimination reaction; Distinction between 1°, 2° and 3° amines with Hinsberg reagent and nitrous acid; nitrophenols, amionophenols, nitro anilines, amino carboxylic acids. Diazomethane, Diazonium salts: Preparation and synthetic applications.

2. Rearrangement Reaction (13 Lectures)

Rearrangement to electron-deficient carbon: Wagner-Meerwein rearrangement, pinacol rearrangement, dienone-phenol; Wolff rearrangement, Arndt-Eistert synthesis, benzil-benzilic acid rearrangement, Demjanov rearrangement, Tiffeneau–Demjanov rearrangement.

Rearrangement to electron-deficient nitrogen: rearrangements: Hofmann, Curtius, Lossen, Schmidt and Beckmann.

Rearrangement to electron-deficient oxygen: Baeyer-Villiger oxidation, cumene hydroperoxidephenol rearrangement and Dakin reaction.

Rearrangement in Aromatic system: Fries rearrangement and Claisen rearrangement.

Migration from nitrogen to ring carbon: Hofmann-Martius**,** Sommelet Houser**,** Fischer-Hepp, Bamberger, Orton and benzidine rearrangement.

3. Organometallics (10 Lectures)

Preparation and reactions: Grignard reagent; Organolithiums; addition of Grignard and organolithium to carbonyl compounds; abnormal behavior of Grignard reagents; *ortho*

lithiation of arenes; Gilman cuprates: substitution on -COX; conjugate addition by Gilman cuprates; Corey-House synthesis; Reformatsky reaction; Blaise reaction.

4. Biomolecules I (Carbohydrates Chemistry) (12 Lectures)

Occurrence, classification and their biological importance. Monosaccharides – Constitution and absolute configuration of glucose and fructose, epimers and anomers, mutarotation, determination of ring size of glucose and fructose, Haworth projections and conformational structures; Inter-conversions of aldoses and ketoses; Killiani-Fischer synthesis and Ruff degradation. Disaccharides – Structure elucidation of maltose, lactose and sucrose.

Practical

A. Organic synthesis-
1. Preparation of dibenzylacetone by condensation of acetone and benzaldehyde

2. Preparation of P-bromo acetanilide by bromate bromide method

3. Preparation of acetyl/benzoyl-P-toluidine (acetylation/benzoylation of P-toluidine)

4. Preparation of 1-phenylazo-2-naphthol/methyl red/ methyl orange by diazo coupling reaction

5. Preparation of 1,3,5-tribromobenzene from 2,4,6-tribromoaniline

6. Preparation of dihydropyrimidine by multicomponent reaction of urea, aromatic aldehyde and ethylacetoacetate using P-TSA

B. Purification of crude product by crystallization using the following solvents:

a. Water b. Alcohol c. Alcohol-Water

Recommended Books:

1. J. March, Advanced Organic Chemistry: Reactions, Mechanisms and Structure, 5th Edn., John Wiley, New York, 1999.
2. S. P. McManus, Organic Reactive Intermediates, Academic Press, New York, 1973.
3. F.A. Carey and R.J. Sundberg, Advanced Organic Chemistry Part A and Part B, 4th Edn., Plenum Press, New York, 2001.
4. T. L. Gilchrist and C. W. Rees, Carbenes, Nitrenes and Arynes, Nelson, New York, 1973.
5. T. H. Lowry and K.C. Richardson, Mechanism and Theory in Organic Chemistry, 3rd Edn., Harper and Row, New York, 1998.

6. H. Neurath, The Proteins: Composition, Structure and Function, Vols. 1-5, Academic Press, New York, 1963.
7. T. W. G. Solomons, Organic Chemistry,
8. G. M. Loudon, Organic Chemistry
9. J. Clayden, N. Greeves, S. Warren and P. Wothers, Organic Chemistry, Oxford University Press, Oxford, 2001.
10. Fleming, Frontier Orbitals and Organic Chemical Reactions, John Wiley, 1980.
11. W. Caruthers, Modern Methods of Organic Synthesis, 3rd Edn., Low Price Edition, Cambridge University Press, 1996.
12. H. O. House, Modern Synthetic Reactions, 2nd Edn., Benjamin, 1971.
13. P. Sykes: A Guide to Mechanism in Organic Chemistry.
14. R. T. Morrison and R. N. Boyd: Organic Chemistry
15. R. O. C. Norman and J. M. Coxon: Principle of organic synthesis
16. L. Finar, Organic Chemistry, Vol I, 6th Edn., Addison Wesley Longmann, London, 1998.
17. S. Warren, Organic Synthesis: The Disconnection Approach, 1st Edn, Wiley, 2012.

COURSE TYPE: MAJOR

COURSE NAME: PHYSICAL CHEMISTRY–IV

COURSE CODE: BSCCEMMJ604

Course Type: **MAJOR**	Course Details: MJC-13			L-T-P: **3-0-4**	
		CA Marks		ESE Marks	
Credit: **5**	Full Marks:	Practical	Theoretical	Practical	Theoretical
3 (Theory) + 2 (Practical)	**100**	**30**	**15**	**20**	**35**

On completion of this course, the students will be able to understand:

Learning objectives:

1. Understand the collision theory and transition state theory for any reaction.
2. Understanding about electrodes, EMF measurement, chemical cells and their function.
3. Learn the working of electrochemical cells, galvanic cell.
4. Qualitative idea about potentiometric titrations and their applications.
5. Understanding of phase equilibrium, criteria, CST, Duhem-Margules equation.
6. Understanding the symmetry and group theory.

Syllabus:

Theory

1. Chemical Kinetics – II (12 Lectures)

Collision theory of bimolecular reactions, unimolecular reactions, Lindemann theory, transition state theory, free energy and entropy of activation, pressure-dependence of rate constant, primary kinetic salt effect.
Homogeneous catalysis, with reference to acid base and enzyme catalyses, heterogeneous catalysis.

2. Quantum Chemistry – II (10 Lectures)

Particle in a box, setting up of Schrödinger's equation of 1-d box, its solution and application, degeneracy, Bohr's correspondence principle and its applications to Bohr atom and particle in 1-d, 2-d and 3-d box, degeneracy. Preliminary idea of tunneling.

3. Phase Equilibria -II (7 Lectures)

Liquid-vapour equilibrium for two-component systems, Duhem-Margules equation, Henry's law, Konowaloff's rule, deviation from ideal behavior, azeotropic solution, liquid-liquid phase diagrams for phenol-water, triethylamine-water and nicotine-water systems, solid-liquid phase diagram, eutectic mixture, principle of solvent extraction.

4. Electrochemistry – II (10 Lectures)

Electrochemical cells, half cells/electrodes with types and examples, cell reactions and thermodynamics of cell reactions, Nernst equation, standard cells, calomel, Ag/AgCl, quinhydrone and glass electrodes: features and applications, potentiometric titrations (acid base and redox), concentration cells, liquid junction potential.

5. Symmetry & Group Theory (6 Lectures)

Introduction, symmetry elements and operations with illustrations, symmetry elements and physical properties, group and symmetry group, group multiplication table, point group.

Practical

1. Acid-base titration by Potentiometric method.
2. Redox titration by Potentiometric method.
3. Study of phenol-water phase diagram, determination of CST and effect of impurities on it.

Recommended Books:

1. G. W. Castellan, Physical Chemistry, Narosa Publishing House, Calcutta, 1995.
2. Ira N. Levine, Physical Chemistry, PHI Learning Pvt. Ltd.
3. R. A. Alberty and R. J. Silbey, Physical Chemistry, John Wiley and Sons, Inc., New York, 1995.
4. S. Glasstone, Text Book of Physical Chemistry, Macmillan and Company Ltd., London, 1951.
5. T. Engel and P. Reid, Physical Chemistry, Pearson Education, New Delhi, 2006.
6. D. A. McQuarrie and J. D. Simon, Physical Chemistry: A Molecular Approach, Viva Books Private Limited.
7. P. C. Rakshit (Revised by S.C. Rakshit), Physical Chemistry, Sarat Book Distributers, Kolkata.
8. P. W. Atkins & Julio De Paula, Physical Chemistry, Eighth Edition, Oxford University Press, Oxford
9. P. W. Atkins & Julio De Paula, Elements of Physical Chemistry, Fifth Edition, Oxford University Press, Oxford
10. A.K. Mukherjee & B. C. Ghosh, Group Theory in Chemistry, Universities Press, 2018.
11. S. C. Rakshit, Molecular Symmetry Group and Chemistry, Sarat Book House.
12. R.G. Mortimer, Physical Chemistry, Third Edition, Elsevier Academic Press.
13. K.L. Kapoor, A Text Book of Physical Chemistry (Vol. 1 – 5), Macmillan India Limited, New Delhi.
14. S. Pahari, Physical Chemistry (Vol. 1 & 2), New Central Book Agency (P) Ltd.
15. Berry, Rice & Ross, Physical Chemistry, Oxford University Press.
16. W. J. Moore, Physical Chemistry, Longman Green and Co. Ltd., 1953.

17. M..K. Bagde, K. Singh, S. P. Singh, Quantum Mechanics, S Chand & Company Ltd.
18. Pahari and Pahari, Problems on Physical Chemistry, New Central Book Agency (P) Ltd.
19. Ghoshal, Numerical Problems on Physical Chemistry, Books and Allied (P) Ltd.
20. J. C. Ghosh, Experiments in Physical Chemistry, Bharati Bhawan Publishers and Distributors, Patna, 1994
21. S. K. Maity and N. K. Ghosh, Physical Chemistry Practical, New Central Book Agency (P) Ltd.
22. A. K. Nad, B. Mahapatra & A. Ghosal, An Advanced Course in Practical Chemistry, New Central, 2007.
22. S. Ghosh, M. Das Sharma, D. Majumdar and S. Manna, Chemistry in Laboratory, Santra Publications, 2019.

SEMESTER – VII

COURSE TYPE: MAJOR

COURSE NAME: INORGANIC CHEMISTRY–V

COURSE CODE: BSCCEMMJ701

Course Type: **MAJOR**	Course Details: MJC-14			L-T-P: **3-0-4**	
		CA Marks		ESE Marks	
Credit: **5**	Full Marks:	Practical	Theoretical	Practical	Theoretical
3 (Theory) + 2 (Practical)	**100**	**30**	**15**	**20**	**35**

On completion of this course, the students will be able to understand:

Learning objectives:

1. Concept of analytical chemistry including error, precision, random error standard deviation.

2. Learn to draw straight line using least square method.

3. Understanding of different instrumental methods such as electroanalytical method, thermal methods for separation of elements.

Syllabus:

Theory

Unit I: Introduction to Analytical Chemistry (05 Lectures)

Errors in chemical analysis: accuracy, precision; determinate, indeterminate, systematic and random errors; source, effect and detection of systematic errors; distribution of random errors; standard deviation of calculated results - sum or difference, product or quotient, logarithm or antilogarithm; significant figures; rounding and expressing results of chemical computations; least square method for calibration plots.

Unit II: Separation Techniques (17 Lectures)

Classification, principle and efficiency of the techniques. Mechanism of separation: adsorption, partition & ion exchange; Chromatography: mathematical relations of capacity, selectivity factor; distribution constant and retention time; chromatogram; elution in column chromatography: band broadening and column efficiency; column resolution; qualitative and quantitative aspects of chromatographic methods of analysis using LC, GC, TLC, HPLC (Normal and reverse phase); size-exclusion chromatography; Ion chromatography and capillary electrophoresis: principles, methods and applications. Solvent extraction, distribution ratio, principle of solvent extraction, extraction equilibrium and effect of pH; application in analytical chemistry.

Unit III: Electroanalytical Methods (18 Lectures)

Fundamentals, electrochemical cell, reference and indicator electrodes, supporting electrolyte, electrolytic process, Dropping Mercury Electrode (DME), Ilkovich equation, DC and AC polarography, Cyclic Voltammetry (CV), Cottrell equation, amperometric, conductometric and coulometric titration.

Unit IV: Thermal Analysis (05 Lectures)

Different methods of analysis: TGA, DTA, DSC; thermogram, applications; thermal stability of covalent and non-covalent bonds, thermal degradation, different types of titrations and their applications.

Practical

1. Ion-exchanger
2. Solvent extraction
3. Ore / Alloy analysis.

Recommended Books:

1. R. L. Dutta and G. S. De, Inorganic Chemistry, Pt – I, 7th Edn, 2013, The New Book Stall, 2013.
2. R. Sarkar, General and Inorganic Chemistry, Pt- I, II, 2nd Edn, Books & Allied (P) Ltd, 2009.
3. A. K. Das, Fundamental Concepts of Inorganic Chemistry, (Vol. 1-3), 2ndEdn, CBS Publisher, 2012.
4. A. K. Das, Fundamental Concepts of Inorganic Chemistry, (Vol. 4-7), CBS Publisher, 2014.
5. D. F. Shriver, P. W. Atkins and C. H. Langford, Inorganic Chemistry, Oxford University Press, New York, 1990.
6. D. A. Skoog, D. M. West, F. J. Holler & S. R. Crouch, Fundamentals of Analytical Chemistry, Thomson, 8th Edition.
7. Douglas, D. McDaniel and J. Alexander, Concepts and Models of Inorganic Chemistry, 3rd Edn, John Wiley and Sons, Inc., New York, 2001.
8. J. E. Huheey, E. A. Keiter and R. L. Keiter, Inorganic Chemistry: Principles of Structure and Reactivity, 4th Edn, Pearson Education, India, 2006.
9. R. P. Budhiraja, Separation Chemistry, New Age International (P) Ltd, New Delhi.
10. N. N. Greenwood and A. Earnshaw, Chemistry of the Elements, 2nd Edn, Elsevier, India, 2005.
11. C. E. Meloan, Techniques in Analytical Chemistry, John Wiley & Sons.
12. F. A. Cotton, G. Wilkinson, C. M. Murillo and M. Bochmann, Advanced Inorganic Chemistry, 6th Edn, John Wiley and Sons, Inc., New York, 1999.

13. A. G. Sharpe, Inorganic Chemistry, 3rdEdn, Pearson Education, New delhi, 2004.
14. D. Banerjea, Inorganic Chemistry: A Modern Treatise, Asian Books Private Ltd, 2012.
15. A. I. Vogel, A Text Book of Quantitative Inorganic Analysis, 3rd Edn, Longmans, 1961.
16. M. Kolthoff, P. J. Elving and E. B. Sandell, Treatise on Analytical Chemistry, Pt-I, II, III, The Interscience Encyclopedia, Inc., New York. 1959.
17. G. D. Christia, P. K. Dasgupta & K. A. Schug, Analytical Chemistry, Wiley,7th Edition.

COURSE TYPE: MAJOR

COURSE NAME: ORGANIC CHEMISTRY–IV

COURSE CODE: BSCCEMMJ702

Course Type: **MAJOR**	Course Details: MJC-15			L-T-P: **3-0-4**	
		CA Marks		ESE Marks	
Credit: **5**	Full Marks:	Practical	Theoretical	Practical	Theoretical
3 (Theory) + 2 (Practical)	**100**	**30**	**15**	**20**	**35**

On completion of this course, the students will be able to understand:

Learning objectives:

1. Understanding of retrosynthesis for different types of reaction.

2. Synthesis, nomenclature and reactions of different types of heterocyclic compounds.

3. Concepts of polynuclear hydrocarbons.

4. Understanding of preparation of Amino acids and their reactions.

Syllabus:

Theory

Unit I: Retrosynthesis (15 lectures)

Features of organic synthesis*, Retrosynthetic analysis:* disconnections; concept of synthons and synthetic equivalents, donor and acceptor synthons; illogical electrophiles and nucleophiles, natural reactivity and *umpolung*; synthesis involving umpolung strategy, latent polarity in bifunctional compounds: consonant and dissonant polarity; interconversion and addition of functional groups (FGI and FGA); functional group removal (FGR); C-C disconnections and synthesis: one-group and two-group (1,2- to 1,5-dioxygenated compounds), reconnection (1,6-dicarbonyl. synthesis involving enolates and enamines with special reference to diethyl malonate and ethyl acetoacetate; Robinson annulation; synthesis through protection of functional groups (alcohol, amine, carbonyl, acid): Strategy of ring synthesis, thermodynamic and kinetic factors; synthesis of large rings, application of high dilution technique. concept and examples of cascade reaction.

Unit II: Heterocycles (16 lectures)

Classification and nomenclature, structure, aromaticity in 5-membered and 6-membered rings containing one heteroatom;

Saturated heterocycles: Synthetic approaches, reactivity of oxiranes, aziridines, oxaziridines, diaziridine and diazirines, oxitanes, azetidines and thietanes.

Five-membered aromatic heterocyclic compounds: Synthesis, reactions and mechanism of substitution reactions of: furan, pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), and thiophene.

Six-membered aromatic heterocyclic compounds: General synthetic approaches, properties and reaction of pyridine and its derivative

Fused aromatic heterocyclic compounds: Synthetic approach of indole (Fischer indole synthesis and Madelung synthesis), quinoline and isoquinoline, (Skraup synthesis, Friedlander's synthesis, Knorr quinoline synthesis, Doebner-Miller synthesis, Bischler-

Napieralski reaction, Pictet-Spengler reaction, Pomeranz-Fritsch reaction) properties and reactions.

Unit III: Polynuclear hydrocarbon (5 lectures)

Reactions of naphthalene, phenanthrene and anthracene; structure, preparation and structure elucidation, Important derivatives of naphthalene and anthracene.

Unit-IV: Amino acids (9 lectures)

Classification, physical properties, concept of isoelectric point and its determination, electrophoresis, synthesis with mechanistic details: Strecker, Gabriel, acetamido malonic ester, azlactone, Bücherer hydantoin, chemical properties (with mechanism): ninhydrin reaction, Dakin-West reaction; resolution of racemic amino acids; Estimation of amino acids by Sorensen formol titration.

Practical

Separation (chemical) of binary mixtures of solid-solid/liquid-solid/liquid-liquid organic samples and identification of individual components

Recommended Books:

1. J. March, Advanced Organic Chemistry: Reactions, Mechanisms and Structure, 5th Edn., John Wiley, New York, 1999.
2. F.A. Carey and R.J. Sundberg, Advanced Organic Chemistry Part A and Part B, 4th Edn., Plenum Press, New York, 2001.
3. P. G. M. Wuts and T. W. Greene, Greene's Protective Groups in Organic Synthesis, 4th Edn, Wiley-VCH, 2006.
4. S. Warren and P. Wyatt, Organic Synthesis: The Disconnection Approach, 2nd Edn, Wiley-VCH, 2008.
5. E. J. Corey and X.-M. Chelg, The Logic of Organic Synthesis, John Wiley & Sons, 1995.
6. T.L. Gilchrist and R.C. Storr, Organic Reactions and Orbital Symmetry, 2nd Edn., Cambridge University Press, 1979.
7. R. K. Bansal, Heterocyclic Chemistry: Syntheses, Reactions and Mechanisms, Wiley Eastern Limited, New Delhi, 1999.
8. T. L. Gilchrist, Heterocyclic Chemistry, Pearson Education, 2008.

9. T. Eicher, S. Hauptmann and A. Speicher, The Chemistry of Heterocycles, Wiley-VCH, 2012.
10. G. Brahmachari, Green Synthetic Approaches for Biologically Relevant Heterocycles, Elsevier, 2014.
11. A. I. Meyers, Heterocycles in Synthesis, John Wiley & Sons, 1974.
12. A.R. Katritzky, Comprehensive Heterocyclic Chemistry, Elsevier Book series.
13. G. Brahmachari, Green Synthetic Approaches for Biologically Relevant Heterocycles, Elsevier, 2014.
14. T. H. Lowry and K.C. Richardson, Mechanism and Theory in Organic Chemistry, 3rd Edn., Harper and Row, New York, 1998.
15. H. Neurath, The Proteins: Composition, Structure and Function, Vols. 1-5, Academic Press, New York, 1963.
16. J. Clayden, N. Greeves, S. Warren and P. Wothers, Organic Chemistry, Oxford University Press, Oxford, 2001.
17. W. Caruthers, Modern Methods of Organic Synthesis, 3rd Edn., Low Price Edition, Cambridge University Press, 1996.
18. H. O. House, Modern Synthetic Reactions, 2nd Edn., Benjamin, 1971.
19. R. O. C. Norman and J. M. Coxon: Principle of organic synthesis
20. S. Warren, Organic Synthesis: The Disconnection Approach, 1st Edn, Wiley, 2012.

COURSE TYPE: MAJOR

COURSE NAME: ORGANIC CHEMISTRY–V

COURSE CODE: BSCCEMMJ703

Course Type: **MAJOR**	Course Details: MJC-16			L-T-P: **3-0-4**	
		CA Marks		ESE Marks	
Credit: **5**	Full Marks:	Practical	Theoretical	Practical	Theoretical
3 (Theory) + 2 (Practical)	**100**	**30**	**15**	**20**	**35**

On completion of this course, the students will be able to understand:

Learning objectives:

1. Understanding of some organic name reactions.

2. Concepts of mechanism, stereochemistry, regioselectivity of Pericyclic reactions.

3. Study of chemistry of functional groups of natural products.

4. Concept of drug design (physiochemical principles) and basis of drug design, quantitative description, physicochemical approach of drug molecules.

5. Thermodynamic approach of drug design and drug delivery in biological systems.

Reaction mechanism of substitution, elimination and addition reaction

Syllabus:

Theory

Unit I: Organic name reactions (10 lectures)

Baeyer-Villiger oxidation; Barton reaction; Beckmann rearrangement; Birch reduction; Claisen rearrangement; Favorskii reaction; Fries rearrangement; Heck reaction; Mannich reaction; McMurry reaction; Michael addition; Perkin reaction; Sharpless asymmetric epoxidation; Stile coupling; Strecker reaction; Suzuki coupling; Wittig reaction; Yamaguchi esterification

Unit II: Introduction to Pericyclic Reactions (10 lectures)

Mechanism, stereochemistry, regioselectivity in case of

Electrocyclic reactions: FMO approach involving 4π- and 6π-electrons (thermal & photochemical) and corresponding cyclo-reversion reactions, Woodward-Hofmann selection rules and stereochemistry of electrocyclic reaction

Cycloaddition reactions: FMO approach, selection rules and stereochemistry of cycloaddition. Diels-Alder reaction, Alder ene reaction, photochemical [2+2] cycloadditions.

Unit-III: Chemistry of natural products: Chemistry and function (15 lectures)

Chemistry and function of some major groups of natural products such as terpenoids (*monoterpenoids*: geraniol, alpha-pinene, camphor, menthol, carvone; *sesquiterpenoids*: farnesol, zingiberine, caryophyllene, santonin; *diterpenoids*: abietic acid, taxol; *triterpenoids*: beta-amyrene, oleanolic acid, ursolic acid), alkaloids (papaverine, emitene, morphine, quinine, nicotine, ephedrine) and carbohydrates (monosaccharides and disaccharides); concepts on biosynthetic pathways (*mevalonic acid*, *geranyl pyrophosphate*, *shikimic acid*) for natural products

Unit-IV: Medicinal chemistry (10 lectures)

Concept of drug design (physiochemical principles and basis of drug design, quantitative description, physicochemical approach of drug molecules, different methods of drug design, Free Wilson method and its application to extra thermodynamic approach); pharmacodynamic and pharmacokinetic (drug absorption, distribution, metabolism and excretion) aspects; drug targets (enzymes, receptors, nucleic acids); membranes and receptors (drug transport mechanism and absorption processes, prodrugs and bioactivation, receptor theories and receptor models, drug receptor interactions); concept on lead compounds and lead modifications; pharmacophore; structure-activity relationship (SAR); clinical trials; bioavailability; computer-aided drug design (*de novo* design), docking procedures and molecular modelling; discussion with suitable examples of choice.

Practical

Chromatography

1. Determination of Rf values and identification of organic compounds (amino acids/dye/Sugars) by thin layer chromatography (TLC)
2. Determination of Rf values and identification of organic compounds (2/3 sugars) by Paper chromatography

Recommended Books:

1. J. March, Advanced Organic Chemistry: Reactions, Mechanisms and Structure, 5th Edn., John Wiley, New York, 1999.
2. F.A. Carey and R.J. Sundberg, Advanced Organic Chemistry Part A and Part B, 4th Edn., Plenum Press, New York, 2001.
3. T. L. Gilchrist and C. W. Rees, Carbenes, Nitrenes and Arynes, Nelson, New York, 1973.

4. T. H. Lowry and K.C. Richardson, Mechanism and Theory in Organic Chemistry, 3rd Edn., Harper and Row, New York, 1998.
5. H. Neurath, The Proteins: Composition, Structure and Function, Vols. 1-5, Academic Press, New York, 1963.
6. J. Clayden, N. Greeves, S. Warren and P. Wothers, Organic Chemistry, Oxford University Press, Oxford, 2001.
7. W. Caruthers, Modern Methods of Organic Synthesis, 3rd Edn., Low Price Edition, Cambridge University Press, 1996.
8. P. Sykes, A Guide to Mechanism in Organic Chemistry.
9. R. T. Morrison and R. N. Boyd: Organic Chemistry
10. R. O. C. Norman and J. M. Coxon: Principle of organic synthesis
11. L. Finar, Organic Chemistry, Vol I, 6th Edn., Addison Wesley Longmann, London, 1998.
12. S. Warren, Organic Synthesis: The Disconnection Approach, 1st Edn, Wiley, 2012.
13. T.L. Gilchrist and R.C. Storr, Organic Reactions and Orbital Symmetry, 2nd Edn., Cambridge University Press, 1979.
14. R. B. Woodward and R. Hoffman, The Conservation of Orbital Symmetry, Academic Press, 1970.
15. S. Sankararaman, Pericyclic Reactions – A Textbook, Wiley-VCH Verlag, 2005.
16. I. Fleming, Pericyclic Reactions, Oxford University Press, 1996.
17. X.-T. Liang and W.-S. Fang, Medicinal Chemistry of Bioactive Natural Products, John Wiley & Sons, 2006.
18. S. K. Talapatra and B. Talapatra, Chemistry of Plant Natural Products, Springer, 2012.
19. S. V. Bhat, B. A. Nagasampagi and M. Sivakumar, Chemistry of Natural Products, Narosa Publishing House, New Delhi, 2005.
20. K. Chatterjee and E. J. Topol, Cardiac Drugs, 1 edition,Jaypee Brothers Medical Pub., 2013.
21. W. H. Frishman and D. A. Sica, Cardiovascular Pharmacotherapeutics - 3rd Edition, CardioText, 2011.
22. Atta-ur-Rahman and M.I. Choudhary, Frontiers in Cardiovascular Drug Discovery, Bentham Publications, 2010.

COURSE TYPE: MAJOR

COURSE NAME: PHYSICAL CHEMISTRY–V

COURSE CODE: BSCCEMMJ704

Course Type: **MAJOR**	Course Details: MJC-17			L-T-P: **3-0-4**	
		CA Marks		ESE Marks	
Credit: **5**	Full Marks:	Practical	Theoretical	Practical	Theoretical
3 (Theory) + 2 (Practical)	**100**	**30**	**15**	**20**	**35**

On completion of this course, the students will be able to understand:

Learning objectives:

1. Concepts of electrical properties of molecules and different types of intermolecular forces.

2. Understanding of Photophysical and photochemical process.

3. Basic concepts of polymers, their classifications, nomenclature and molecular weight determination.

4. Concepts of partition functions.

5. Adsorption – theory and significance.

6. Langmuir, Freundlich – adsorption isotherms, significance.

7. Understand the colloids and different types of electrokinetic phenomena, concept of micelles.

Syllabus:

Theory

Unit-I: Electric & Magnetic Properties of atoms & Molecules (7 lectures)

Electrical properties of molecules, polarizability, induced and orientation polarization, Debye and Clausius-Mossotti equations (without derivation) and their applications, Origin and types of intermolecular forces, different types of potential and their diagrams.

Unit-II: Photochemistry (8 lectures)

Primary photophysical processes, potential energy diagram, Franck-Condon principle and vibrational structure of electronic spectra, bond dissociation, decay of excited state by radiative and nonradiative paths, fluorescence and phosphorescence, Jablonsky diagram. laws of photochemistry, quantum yield, photochemical equilibrium, photosensitized reactions, kinetics of HI decomposition.

Unit-III: Chemistry of Polymers (8 lectures)

Basic Concepts, classification, nomenclature, molecular weights, molecular weight distribution Methods for determination of Molecular weights, viscosity molecular weight, intrinsic viscosity, mark-Houwink relationships, Glass transition temperature, Polymerization reaction, kinetics of free radical and condensation polymer. Graft polymerization.

Unit-IV: Statistical Thermodynamics (10 lectures)

Motivation for study, Entropy and Probability, Stirling approximations, Maxwell-Boltzmann Distribution, concept of partition functions, translational, rotational, vibrational and electronic partition functions, Thermodynamic properties in terms of partition functions, Equilibrium constant.

Unit-V: Surface Chemistry (12 lectures)

Special feature of interfaces, physical and chemical adsorptions, Langmuir and Freundlich adsorption isotherms, surface excess and Gibbs adsorption isotherms, heterogeneous catalysis (single reactant), Electrical double layers, zeta potential, overvoltage, Stern double layer (qualitative idea), Tyndall effect, electrokinetic phenomena (qualitative idea), colloids and electrolytes, micelle and reverse micelle, critical micelle constant (CMC)

Practical

1. Kinetics of charge transfer complex (Naphthalene-I_2)
2. Determination of CMC by measuring molar conductance with gradual addition of concentrated surfactant solution in water Conductometrically.
3. Determination of Ionisation constant of dibasic/tribasic acid using pH meter.

Recommended Books:

1. G. W. Castellan, Physical Chemistry, Narosa Publishing House, Calcutta, 1995.
2. Ira N. Levine, Physical Chemistry, PHI Learning Pvt. Ltd.
3. R. A. Alberty and R. J. Silbey, Physical Chemistry, John Wiley and Sons, Inc., New York, 1995.
4. S. Glasstone, Text Book of Physical Chemistry, Macmillan and Company Ltd., London, 1951.
5. T. Engel and P. Reid, Physical Chemistry, Pearson Education, New Delhi, 2006.

6. D. A. McQuarrie and J. D. Simon, Physical Chemistry: A Molecular Approach, Viva Books Private Limited.
7. P. C. Rakshit (Revised by S.C. Rakshit), Physical Chemistry, Sarat Book Distributers, Kolkata.
8. P. W. Atkins & Julio De Paula, Physical Chemistry, Eighth Edition, Oxford University Press, Oxford
9. P. W. Atkins & Julio De Paula, Elements of Physical Chemistry, Fifth Edition, Oxford University Press, Oxford
10. R.G. Mortimer, Physical Chemistry, Third Edition, Elsevier Academic Press.
11. P. Monk, Physical Chemistry Understanding our Chemical World, John Wiley & Sons Ltd.
12. K.L. Kapoor, A Text Book of Physical Chemistry (Vol. 1 – 5), Macmillan India Limited, New Delhi.
13. P. A. Cox, The Electronic Structure & Chemistry of Solids, Oxford University Press, Oxford, 1987.
14. S. Pahari, Physical Chemistry (Vol. 1 & 2), New Central Book Agency (P) Ltd.
15. Berry, Rice & Ross, Physical Chemistry, Oxford University Press.
16. W. J. Moore, Physical Chemistry, Longman Green and Co. Ltd., 1953.
17. Pahari and Pahari, Problems on Physical Chemistry, New Central Book Agency (P) Ltd.
18. K. K. Rohatgi-Mukherjee, Fundamentals of Photochemistry, New Age International Pvt. Ltd., 2021.
19. A. Ghoshal, Numerical Problems on Physical Chemistry, Books and Allied (P) Ltd.
20. J. C. Ghosh, Experiments in Physical Chemistry, Bharati Bhawan Publishers and Distributors, Patna, 1994
21. S. K. Maity and N. K. Ghosh, Physical Chemistry Practical, New Central Book Agency (P) Ltd.
22. A. K. Nad, B. Mahapatra & A. Ghosal, An Advanced Course in Practical Chemistry, New Central, 2007.
23. S. Ghosh, M Das Sarma, D Majumdar & S Manna, Chemistry in Laboratory, Santra Publication, 2019.

COURSE TYPE: MINOR

COURSE NAME: ADVANCED PHYSICAL CHEMISTRY

COURSE CODE: BSCCEMMN701

Course Type: **MINOR**	Course Details: MNC-6			L-T-P: **3-0-4**	
		CA Marks		ESE Marks	
Credit: **5**	Full Marks:	Practical	Theoretical	Practical	Theoretical
3 (Theory) + 2 (Practical)	**100**	**30**	**15**	**20**	**35**

On completion of this course, the students will be able to understand:

Learning objectives:

1. Understanding of Photophysical and photochemical process.

2. Concept of supramolecular chemistry, their landscape, building blocks, orbitals.

3. Understand the collision theory and transition state theory for any reaction.

4. Concepts of different kind of catalysis.

Syllabus:

Theory

Unit I: Photochemistry (10 lectures)

Absorption, Lambert-Beer's law, photochemical laws, primary photophysical processes, potential energy diagram, Franck-Condon principle, fluorescence and phosphorescence, Jablonsky diagram.

Unit II: Supramolecular Chemistry (20 lectures)

Concept and language, scientific/technological landscape, building block, atomic and molecular valences, supramolecular orbitals, pallet of non-covalent forces and their harnessing towards crystal engineering, structure directed supramolecular arrays, crystal synthesis, deliberate isolation of different functional materials

Unit III: Chemical Kinetics – II (15 lectures)

Collision theory of bimolecular reactions, unimolecular reactions, Lindemann theory, transition state theory, free energy and entropy of activation, pressure-dependence of rate constant, primary kinetic salt effect. Homogeneous catalysis, with reference to acid base and enzyme catalyses, heterogeneous catalysis.

Practical

Verification of Lambert Beers' law.

Recommended Books:

1. G. W. Castellan, Physical Chemistry, Narosa Publishing House, Calcutta, 1995.
2. Ira N. Levine, Physical Chemistry, PHI Learning Pvt. Ltd.
3. R. A. Alberty and R. J. Silbey, Physical Chemistry, John Wiley and Sons, Inc., New York, 1995.
4. K. K. Rohatgi-Mukherjee, Fundamentals of Photochemistry, New Age International Pvt. Ltd., 2021.
5. T. Engel and P. Reid, Physical Chemistry, Pearson Education, New Delhi, 2006.
6. D. A. McQuarrie and J. D. Simon, Physical Chemistry: A Molecular Approach, Viva Books Private Limited.
7. K. J. Laidler, Chemical Kinetics, Tata McGraw-Hill Publishing Company Ltd, New Delhi, 1988.
8. P. C. Rakshit (Revised by S.C. Rakshit), Physical Chemistry, Sarat Book Distributers, Kolkata.
9. P. W. Atkins & Julio De Paula, Physical Chemistry, Eighth Edition, Oxford University Press, Oxford
10. P. W. Atkins & Julio De Paula, Elements of Physical Chemistry, Fifth Edition, Oxford University Press, Oxford
11. K.L. Kapoor, A Text Book of Physical Chemistry (Vol. 1 – 5), Macmillan India Limited, New Delhi.
12. S. Pahari, Physical Chemistry (Vol. 1 & 2), New Central Book Agency (P) Ltd.
13. Berry, Rice & Ross, Physical Chemistry, Oxford University Press.
14. W. J. Moore, Physical Chemistry, Longman Green and Co. Ltd., 1953.
15. Pahari and Pahari, Problems on Physical Chemistry, New Central Book Agency (P) Ltd.
16. A. Ghoshal, Numerical Problems on Physical Chemistry, Books and Allied (P) Ltd.
17. F. Vogtle, Supramolecular Chemistry: An Introduction, Wiley, Chichester, 1991.
18. B. Dietrich, P. Viout and J. -M. Lehn, Macrocyclic Chemistry – Aspects of Organic and Inorganic Supramolecular Chemistry, VCH, Weinheim, 1993.
19. J. -M. Lehn, Supramolecular Chemistry: Concepts and Perspectives, VCH, Weinheim, 1995.
20. S. K. Maity and N. K. Ghosh, Physical Chemistry Practical, New Central Book Agency (P) Ltd.

21. A. K. Nad, B. Mahapatra & A. Ghosal, An Advanced Course in Practical Chemistry, New Central, 2007.

SEMESTER – VIII

COURSE TYPE: MAJOR

COURSE NAME: ADVANCED GENERAL CHEMISTRY–I

COURSE CODE: BSCCEMMJ801

Course Type: **MAJOR**	Course Details: MJC-18			L-T-P: **3-0-4**	
		CA Marks		ESE Marks	
Credit: **5**	Full Marks:	Practical	Theoretical	Practical	Theoretical
3 (Theory) + 2 (Practical)	**100**	**30**	**15**	**20**	**35**

On completion of this course, the students will be able to understand:

Learning objectives:

1. To inspire the students about the chemistry which is good for human health and environment.
2. To make students aware of how chemical processes can be designed, developed and run in a sustainable way.
3. To acquire the knowledge of the twelve principles of green chemistry and how to apply in green synthesis.
4. To make students aware about the benefits of using green chemistry.
5. Knowledge of synthesis of nanomaterials.
6. Concepts of some special types of nanomaterials.
7. Characterisations of nanomaterials by using different instrumental techniques.
8. Concepts of Photoelectron spectroscopy and CD/ORD Spectroscopy.

Syllabus:

Theory

Unit I: **Green Chemistry: (10 Lectures)**

Sustainable development, twelve principles of green chemistry and implementations, atom economy, environmental E-factor, role of catalysts, microwave and ultrasound irradiation in green synthesis, traditional and alternative commercial syntheses of ibuprofen, paracetamol, adipic acid and maleic acid etc,; green chemistry in action developing foam, whitening agent, detergent builders, green insecticides; biosynthesis of synthetic chemical, photochemical reactions in atmosphere, photochemical smog and stratospheric ozone depletion; chemicals from renewable feedstock.

Unit II: Nano chemistry (12 Lectures)

Basics of nanoscience, nanotechnology and nanoparticles; Preparation of nano particles, top down and bottom up approach; electrochemical, chemical, photochemical and biochemical

synthesis of nano particles. Characterization techniques, Properties of nano particles, variation of properties with size; Applications of nano particles. Synthesis and properties of carbon nanotubes; Organic conductors, liquid crystals.

Unit III: Photoelectron spectroscopy (11 Lectures)

ESCA, UPS, Auger, XRF and EXFAS; spectroscopic and other tools in structure elucidation.

Unit IV: CD/ORD Spectroscopy and AES, AAS (12 Lectures)

Methods, molecular dissymmetry and chiroptical properties, Cotton effect, Faraday effect in magnetic circular dichroism (MCD) and application.

Practical

Synthesis and characterization of Nanomaterials.

Analysis of waste water (pH, BOD, COD, turbidity, viscosity, conductance).

Recommended Books:

1. S. Warren, Organic Synthesis: The Disconnection Approach, 1st Edn, Wiley, 2012.
2. A. K. Das, Environmental with Green Chemistry, Books & Allied (P) Ltd, 2004.
3. Ahluwalia, Green Chemistry Environmentally Benign Reactions, Ane Books-New Delhi, 2012.
4. G. Cao, Nanostructures & Nanomaterials, Synthesis, Properties & Applications, Imperial College Press, London, 2004.
5. L. Cademartiri and G. A. Ozin, Concepts of Nanochemistry, Wiley-VCH, Weinheim, 2009.
6. D. W. Turner, C. Baker and C. R. Bundle, Molecular Photoelectron Spectroscopy, Wiley Interscience, New York, 1970.
7. J. H. D Eland, Photoelectron Spectra, Butterworth, London, 1984.
8. T. L. Barr, Modern ESCA: the Principles and Practice of X-ray Photoelectron Spectroscopy, CRC Press, Boca Raton, FL, 1994.
9. G.A. Ozin, A. C. Arsenault and L. Cadematiri, Nanochemistry: A Chemical approach to Nanomaterials, Royal Society of Chemistry, London, 2009.

COURSE TYPE: MAJOR

COURSE NAME: ADVANCED INORGANIC CHEMISTRY–I

COURSE CODE: BSCCEMMJ802

Course Type: **MAJOR**	Course Details: MJC-19			L-T-P: **2-0-4**	
		CA Marks		ESE Marks	
Credit: **4**	Full Marks:	Practical	Theoretical	Practical	Theoretical
2 (Theory) + 2 (Practical)	**100**	**30**	**15**	**20**	**35**

On completion of this course, the students will be able to understand:

Learning objectives:

1. Coordination compounds – Crystal field theory, and some preliminary idea about Ligand Field Theory.

2. Concept of Jahn-Teller Distortion and application.

3. Explanation about the origin of colour of complexes.

4. Concepts of magnetic properties of the complexes.

5. Understanding of reaction mechanism.

6. Concepts of mechanism of different types of inorganic reaction.

7. Understanding of Molecular magnetism.

Syllabus:

Unit I: Coordination chemistry – stereochemistry, bonding and structure (12 lectures)

Preamble, Orgel/Tanabe-Sugano diagram, ligand symmetry orbital, molecular orbital, Angular overlap model, spectral features, Nephelauxetic effect, Racah parameter, Franck Condon principle, vibronic coupling, band broadening, spin-orbit coupling, spin-forbidden transition, intensity stealing, magnetic properties, cooperative, anomalous and subnormal magnetic moments, lowering of symmetry, electronic, steric and Jahn-Teller effects on energy levels, conformation of chelator/congregator/macrocycle, structural equilibrium and implication.

Unit II: Inorganic reaction mechanism II (10 lectures)

Preamble, factors affecting the rate of a chemical reaction, analysis of rate data, complex rate laws, kinetically indistinguishable schemes, nucleophilicity and rate scales: Edward scale, nPt scale, Gutmann donor number, Drago E & C scale, trans- and cis- effects, water exchange rates, proton ambiguity, mechanistic simulation; associative, dissociative,

interchange, nucleophilic, electrophilic, insertion pathways; Hammett relation, application of LFER in chemical kinetics.

Unit III: Molecular magnetism I (08 lectures)

Classification of magnetic materials, van Vleck equation and its application, Curie-Weiss law and its implication, Lande interval rule, microstates, multiplet, multiplet width, hole formalism, zero-field splitting, spin-orbit coupling, quenching of orbital contribution, Fermi contact and pseudo-contact shifts, chemical shift reagent.

Practical

Synthesis and characterization of Schiff base ligands and their complexes.

Recommended Books:

1. R. L. Dutta and G. S. De, Inorganic Chemistry, Pt – I, 7th Edn, 2013, The New Book Stall, 2013.
2. R. Sarkar, General and Inorganic Chemistry, Pt- I, II, 2nd Edn, Books & Allied (P) Ltd, 2009.
3. A. K. Das, Fundamental Concepts of Inorganic Chemistry, (Vol. 1-3), 2nd Edn, CBS Publisher, 2012.
4. A. K. Das, Fundamental Concepts of Inorganic Chemistry, (Vol. 4-7), CBS Publisher, 2014.
5. D. F. Shriver, P. W. Atkins and C. H. Langford, Inorganic Chemistry, Oxford University Press, New York, 1990.
6. Douglas, D. McDaniel and J. Alexander, Concepts and Models of Inorganic Chemistry, 3rd Edn, John Wiley and Sons, Inc., New York, 2001.
7. J. E. Huheey, E. A. Keiter and R. L. Keiter, Inorganic Chemistry: Principles of Structure and Reactivity, 4thEdn, Pearson Education, India, 2006.
8. N. N. Greenwood and A. Earnshaw, Chemistry of the Elements, 2nd Edn, Elsevier, India, 2005.
9. J. D. Lee, Concise Inorganic Chemistry, 5thEdn, Oxford University Press, 1999.
10. F. A. Cotton, G. Wilkinson, C. M. Murillo and M. Bochmann, Advanced Inorganic Chemistry, 6th Edn, John Wiley and Sons, Inc., New York, 1999.

11. R. B. Jordan, Reaction Mechanisms of Inorganic and Organometallic Systems, Oxford University Press, 1998.
12. S. Asperger, Chemical Kinetics and Inorganic Reaction Mechanisms, 2nd Edn, Springer, London, 2012.
13. F. Basolo and R. G. Pearson, Mechanism of Inorganic Reactions, 2nd Edn, Wiley, New York, 1967.
14. D. Katakis and G. Gordon, Mechanisms of Inorganic Reactions, John Wiley & Sons, New York, 1987.
15. R. G. Wilkinns, Kinetics and Mechanism of Reactions of Transition Metal Complexes, 2nd Edn, VCH, Weinheim, 1991.
16. I. Vogel, A Text Book of Quantitative Inorganic Analysis, 3rd Edn, Longmans, 1961.
17. C. J. F. Böttcher, Theory of Electric Polarisation, Vols 1 and 2, Elsevier Scientific Publishing Co, New York, 1973.
18. D. W. Davies, The Electric and Magnetic Properties of Molecules.

COURSE TYPE: MAJOR

COURSE NAME: ADVANCED ORGANIC CHEMISTRY–I

COURSE CODE: BSCCEMMJ803

Course Type: **MAJOR**	Course Details: MJC-20			L-T-P: **2-0-4**	
		CA Marks		ESE Marks	
Credit: **4**	Full Marks:	Practical	Theoretical	Practical	Theoretical
2 (Theory) + 2 (Practical)	**100**	**30**	**15**	**20**	**35**

On completion of this course, the students will be able to understand:

Learning objectives:

1. Knowledge of stereoselective and stereospecific reactions.

2. Concepts of stereochemical aspects of some organic reactions.

3. Understanding of asymmetric synthesis and asymmetric induction.

4. Stereochemistry of some reaction.

5. Knowledge of conformation and reactivity for alicyclic compounds.

6. Knowledge of stereochemical change of substitution, elimination and NGP reactions.

7. Application of UV-VIS, IR, NMR, MASS Spectroscopy for organic molecules.

Syllabus:

Theory

Unit I: Dynamic Stereochemistry (15 lectures)

A) General Introduction

Regioselective, regiospecific and chemoselective reactions; stereoselectivity and stereospecificity; stereoselective reactions: classification, terminology and principles;

Curtin-Hammett principle and Wenstein-Eliel equations; conformation, reactivity & mechanism (*viz*. acyclic and cyclic system focusing on nucleophilic substitution reaction, formation and cleavage of epoxide ring, addition reactions to double bonds, elimination reactions, pyrolytic *syn*-elimination, oxidation of cyclohexanols, *etc*.); elementary idea about asymmetric synthesis

B) Synthetic Approach

Asymmetric synthesis and asymmetric induction; diastereoselective synthesis: asymmetric synthesis with chiral substrates, cram's rule – its application and deviation, Felkin-Anh Model Prelog's rule, enantioselective synthesis.

C) Stereochemical Aspects of a few Organic Reactions

Polar addition reactions to alkene, Prevost and Woodward hydroxylation, hydroxylation by OsO_4 followed by reductive cleavage, catalytic reductions of alkenes and alkynes, nucleophilic substitution on saturated carbon, E_1 and E_2 reaction, stereo convergent elimination, stereochemical aspects of a few molecular rearrangement – Pinacol-Pinacolone rearrangement, Beckmann rearrangement, Claisen rearrangement and Cope rearrangement.

D) Alicyclic system

Conformation and reactivity in cyclohexanes; steric effect and steroelectronic effect; neighbouring group effects, effects of conformation on rearrangement and transannular reactions in alicyclic system; diastereo selection in cyclic system. reactions of cyclohexane derivatives; hydrolysis of ester of cyclohexane carboxylic acids, esterification reaction of cyclohexane carboxylic acids, S_N1, S_N2, E_1, E_2, NGP, reactions. Hydride reduction of cyclohexanones to cyclohexanols, oxidation of cyclohexanols with chromic acid, merged substitution – elimination reaction, reaction of 2-aminocyclohexanol by nitrous acid, Pinacol-Pinacolone rearrangement in cyclohexanediols.

Unit II: Spectroscopy (15 lectures)

A) UV Spectroscopy

Introduction to absorption and emission spectroscopy, types of electronic transitions, effect of solvent polarity on electronic transitions, chromophores and auxochromes, absorption and intensity shift; bathochromic and hypsochromic shifts, hyperchromic and hypochromic shifts. Application of Fieser-Woodward rules for calculation of λ_{max} for conjugated dienes and α, β – unsaturated carbonyls, distinction between cis and trans isomers.

B) IR Spectroscopy

Fundamental and non-fundamental molecular vibrations, IR absorption positions of O, N and S containing functional groups, effect of H-bonding, conjugation, resonance and ring size on IR absorptions, fingerprint region and its significance, application in functional group analysis.

C) NMR Spectroscopy

Basic principles of PMR spectroscopy, nuclear shielding and deshielding phenomenon, chemical shift and factors influencing it, spin-spin coupling and coupling constant, anisotropic effect. Interpretation of PMR spectra of simple organic compounds such as ethyl bromide, ethanol, acetaldehyde, ethyl acetate and toluene.

Carbon-13 NMR spectroscopy - general considerations; chemical shift values (aliphatic, olefinic, alkyne, aromatic, heteroaromatic and carbonyl carbon); coupling constant; two

dimensional NMR Spectroscopy - COSY, NOESY, DEPT, INEPT, APT and INADEQUATE techniques.

D) **Mass Spectrometry**

Elementary idea and fragmentation rule in characterization of organic compounds.

E) **Combined spectral applications**

Applications of all the spectroscopic techniques (UV, FT-IR, NMR and Mass) in a combined manner to solve structural problems of unknown organic compounds.

Practical

1. Chromatographic separation

Column chromatographic separation of mixture of organic compounds

2. Identification of simple organic compounds by IR and NMR (spectra to be provided)

Aliphatic system-

Diethyl fumarate; Mesityl oxide; Pent-1-yn-3-ol; ethanol, 2-butene, 1-butene, acetaldehyde

Mono substituted aromatic system-

Benzylacetate; Toluene, phenol, benzoic acid, benzaldehyde, ethyl benzene, nitro benzene, N-methylaniline

Disubstituted aromatic system-

4-Bromoacetanilide; 2-Bromo-4'-methylacetophenone; 2-Methoxyacetophenone; 4-Aminobenzoic acid; Salicylamide; 2-Hydroxyacetophenone; 1,3-Dinitrobenzene; trans-4-Nitrocinnamaldehyde; 4-Nitrobenzaldehyde; 4-Methylacetanilide; 2-Hydroxybenzaldehyde; 4-Nitroaniline; 3-Nitrobenzaldehyde; 2-Methoxybenzaldehyde; Methyl 4-hydroxybenzoate; Methyl 3-hydroxybenzoate; 3-Aminobenzoic acid; Ethyl 3-aminobenzoate; Ethyl 4-aminobenzoate; 3-nitroanisole; 3-Methylacetanilide.

Trisubstituted aromatic system-

Vanillin; 2-Hydroxy-3-nitrobenzaldehyde; 2,3-Dimethylbenzonitrile; 3-Ethoxy-4-hydroxybenzaldehyde; 5-Methyl-2-nitroanisole, 1,3,5-trimethyl benzene.

Recommended Books:

1. E.L. Eliel, S.H. Wilen and L.N. Mander, Stereochemistry of Organic Compounds, John Wiley & Sons, New York, 1994.
2. S. Sengupta, Basic Stereochemistry of Organic Molecules, 2009.

3. D. Nasipuri, Stereochemistry of Organic Compounds, 2nd Edn., Wiley Eastern, New Delhi, 1993.
4. E.L. Eliel, N.L. Allinger, S. J. Angyal and G.A Morrison, Conformational Analysis,John Wiley & Sons, Inc., 1967.
5. J. Eames and J. Peach, Stereochemistry at a Glance, Blackwell Science, 2003.
6. K. Mislow and W. A. Benjamin, Introduction to Stereochemistry New York, 1965.
7. B. Testa, Principles of Organic Stereochemistry, Marcel Dekker, New York, 1979.
8. E. Juaristi, Stereochemistry & Conformational Analysis, John Wiley & Sons, Inc., 1991.
9. M. Nogradi, Stereochemistry: Concepts and Applications, Pergamon Press, New York, 1981.
10. William Kemp, Organic Spectroscopy, 3rdEdn., Macmillan Press Ltd., 1991.
11. D. L. Pavia, G. M. Lampman and G.S. Kriz, Introduction to Spectroscopy, 3rd Edn., Harcourt, Inc., 2001.
12. R. M. Silverstein, G. C. Bassler and T. C. Morrill, Spectroscopic Identification of Organic Compounds, 5th Edn., John Wiley & Sons, Inc., 1991.
13. D. H. Williams and I. Fleming, Spectroscopic Methods in Organic Chemistry, 5th Edn., Tata McGraw-Hill Edition, New Delhi, 2004.
14. J. March, Advanced Organic Chemistry: Reactions, Mechanisms and Structure, 5th Edn., John Wiley, New York, 1999.
15. F.A. Carey and R.J. Sundberg, Advanced Organic Chemistry Part A and Part B, 4th Edn., Plenum Press, New York, 2001.
16. J. Clayden, N. Greeves, S. Warren and P. Wothers, Organic Chemistry, Oxford University Press, Oxford, 2001.
17. I. Fleming, Frontier Orbitals and Organic Chemical Reactions, John Wiley, 1980.
18. W. Caruthers, Modern Methods of Organic Synthesis, 3rd Edn., Low Price Edition, Cambridge University Press, 1996.
19. H. O. House, Modern Synthetic Reactions, 2nd Edn., Benjamin, 1971.
20. R. O. C. Norman and J. M. Coxon: Principle of organic synthesis
21. S. Warren, Organic Synthesis: The Disconnection Approach, 1stEdn, Wiley, 2012.

COURSE TYPE: MAJOR

COURSE NAME: ADVANCED PHYSICAL CHEMISTRY–I

COURSE CODE: BSCCEMMJ804

Course Type: **MAJOR**	Course Details: MJC-21			L-T-P: **2-0-4**	
		CA Marks		ESE Marks	
Credit: **4**	Full Marks:	Practical	Theoretical	Practical	Theoretical
2 (Theory) + 2 (Practical)	**100**	**30**	**15**	**20**	**35**

On completion of this course, the students will be able to understand:

Learning objectives:

1. Understanding the symmetry and group theory. Reducible, irreducible representations.

2. Concepts of Great Orthogonality Theorem and its application.

3. Understanding of Raman spectroscopy and application.

4. Concepts of Transition State Theory, Potential energy diagram, Hammet's acidity function.

5. Quantum mechanical approach of rotational and vibrational motion of particles.

6. Understanding of partial molar quantities, excess functions, activity coefficients.

Syllabus:

Theory

Unit I: Symmetry and Group Theory (12 lectures)

Concept of symmetry, symmetry elements and symmetry operations, optical activity, concept of groups, point symmetry groups, class, group multiplication tables, matrix representation, equivalent and reducible representations, irreducible representations, great orthogonality theorems statement (without derivation) and interpretation, proof of its corollaries, character table and its construction, number of times an irreducible representation occurs in a reducible one; the reduction of reducible representations, notation of irreducible representations.

Unit II: Advanced Molecular Spectroscopy – II (4 lectures)

Raman spectroscopy: Classical and quantum theories of Raman Effect; Pure rotational, Vibrational and vibrational-rotational Raman spectra; Selection rules; Mutual exclusion principle, Resonance Raman; Surface Enhanced Raman Scattering (SERS).

Unit III: Chemical Kinetics- III (5 lectures)

Transition state theory, potential energy surfaces, concept of imaginary frequency, thermodynamic treatment of reaction rates, energy of activation, volume of activation, reactions in solutions, diffusion and activation controlled reactions, influence of solvent dielectric constant and ionic strength on reaction rates, linear free energy relationship, effect of substituents, Hammett's and Taft's constants, Hammet's acidity functions, Oscillatory reactions.

Unit IV Quantum Chemistry – III (4 lectures)

Free particle system – position, momentum, energy and uncertainty relation, motion of three dimension, degeneracy, potential barrier, Vibrational motion of a particle, classical mechanical treatment, Rotational motion of a particle – Schrodinger equation and wave function.

Unit V: Solutions Thermodynamics and Electrochemistry (5 lectures)

Partial molar quantities, significance and the determination of partial molar quantities, Thermodynamics of ideal and non-ideal binary solutions, excess functions and their determination, Activity co-efficients, Experimental determination of activity coefficients of electrolytes and non-electrolytes,

Practical

1. Study of kinetics of $K_2S_2O_8$ + KI reaction by spectroscopic method.
2. Determination of solubility product of AgCl by potentiometric titration of $AgNO_3$ solution against standard KCl solution
3. Determination of CMC of a surfactant measuring optical density of a probe .
4. Determination of ground state acidity constant (pK)of a suitable organic molecule (eg. Picric acid) measuring optical density.

Recommended Books:

1. G. W. Castellan, Physical Chemistry, Narosa Publishing House, Calcutta, 1995.
2. Ira N. Levine, Physical Chemistry, PHI Learning Pvt. Ltd.
3. R. A. Alberty and R. J. Silbey, Physical Chemistry, John Wiley and Sons, Inc., New York, 1995.

4. S. C. Rakshit, Molecular Symmetry Group and Chemistry, The New Book Stall, Kolkata, 1988.
5. D. M. Bishop, Group Theory and Chemistry, Oxford University Press, Oxford, 1993.
6. A. Vincent, Molecular Symmetry and Group Theory, John Wiley & Sons, New York, 1998.
7. F. A. Cotton, Chemical Applications of Group Theory, 3rd Edn, John Wiley & Sons, New York, 1999.
8. T. Engel and P. Reid, Physical Chemistry, Pearson Education, New Delhi, 2006.
9. D. A. McQuarrie and J. D. Simon, Physical Chemistry: A Molecular Approach, Viva Books Private Limited.
10. P. C. Rakshit (Revised by S.C. Rakshit), Physical Chemistry, Sarat Book Distributers, Kolkata.
11. F. L. Pilar, Elementary Quantum Chemistry, Tata McGraw-Hill, New Delhi, 1990.
12. K. J. Laidler, Chemical Kinetics, Tata McGraw-Hill Publishing Company Ltd, New Delhi, 1988.
13. P. W. Atkins & Julio De Paula, Physical Chemistry, Eighth Edition, Oxford University Press, Oxford
14. P. W. Atkins & Julio De Paula, Elements of Physical Chemistry, Fifth Edition, Oxford University Press, Oxford
15. R.G. Mortimer, Physical Chemistry, Third Edition, Elsevier Academic Press.
16. P. Monk, Physical Chemistry Understanding our Chemical World, John Wiley & Sons Ltd.
17. K.L. Kapoor, A Text Book of Physical Chemistry (Vol. 1 – 5), Macmillan India Limited, New Delhi.
18. S. Pahari, Physical Chemistry (Vol. 1 & 2), New Central Book Agency (P) Ltd.
19. Berry, Rice & Ross, Physical Chemistry, Oxford University Press.
20. W. J. Moore, Physical Chemistry, Longman Green and Co. Ltd., 1953.
21. Pahari and Pahari, Problems on Physical Chemistry, New Central Book Agency (P) Ltd.
22. Ghoshal, Numerical Problems on Physical Chemistry, Books and Allied (P) Ltd.
23. J. C. Ghosh, Experiments in Physical Chemistry, Bharati Bhawan Publishers and Distributors, Patna, 1994
24. S. K. Maity and N. K. Ghosh, Physical Chemistry Practical, New Central Book Agency (P) Ltd.
25. A. K. Nad, B. Mahapatra & A. Ghosal, An Advanced Course in Practical Chemistry, New Central, 2007.

26. S. Ghosh, M Das Sarma, D Majumdar & S Manna, Chemistry in Laboratory, Santra Publication, 2019.

COURSE TYPE: MINOR

COURSE NAME: ADVANCED INORGANIC & ORGANIC CHEMISTRY

COURSE CODE: BSCCEMMN801

Course Type: **MINOR**	Course Details: MNC-7			L-T-P: **3-0-4**	
		CA Marks		ESE Marks	
Credit: **5**	Full Marks:	Practical	Theoretical	Practical	Theoretical
3 (Theory) + 2 (Practical)	**100**	**30**	**15**	**20**	**35**

On completion of this course, the students will be able to understand:

Learning objectives:

1. Students acquire knowledge of role of metal ions in our biological systems and mechanisms of action of drugs in our body system.

2. Basic knowledge of analytical chemistry.

3. Concept of extraction and purification process of compounds.

4. Knowledge of different chromatography techniques.

5. To make students aware of how chemical processes can be designed, developed and run in a sustainable way.

6. To acquire the knowledge of the twelve principles of green chemistry and how to apply in green synthesis.

7. Understanding of heterocyclic compounds and polynuclear compounds.

8. Concepts of drug and pharmaceuticals.

Syllabus:

Theory

Unit I: Basic Analytical Chemistry (8 lectures)

a) General principle: Accuracy and precision in analysis, types of errors, data analysis and curve fitting (linear Y=mX + C type), numerical problems, mean, mode and variant.

b) Chromatography: Definition, general introduction on principles of chromatography, paper chromatography, TLC etc., column chromatography, ion-exchange chromatography, etc., determination of ion exchange capacity of anion /cation exchange resin.

Unit II: Bioinorganic Chemistry (Elementary concept) (7 lectures)

Elements of life: essential and beneficial elements, major, trace and ultratrace elements. Role of metal ions (specially Na^+ , K^+ , Mg^{2+}, Ca^{2+}, $Fe^{3+/2+}$, $Cu^{2+/+}$ and Zn^{2+}) in biological systems. toxic metal ions and their effects, chelation therapy (examples only), Pt and Au complexes as drugs (examples only), metal dependent diseases.

Unit III: **Basic Principles of Green Chemistry (7 lectures)**

Tools of green chemistry including the use of alternative feed stocks or starting materials, reagents, solvents, target molecules, and catalysts (homogeneous, heterogeneous and biocatalysis), green chemistry as the alternative chemistry for protection of environment.

Unit IV: **Heterocycles (10 lectures)**

Structures of furan, pyrrole, thiophene, pyridine, pyrimidine, pyrimidine derivatives like uracil, thymine and cytosine, purine, purine derivatives like adenine, guanine & uric acid; Reactivity and basicity comparison between pyrrole and pyridine.

Unit V: Polynuclear Hydrocarbons (5 lectures)

Preparations, Properties and Reactions of naphthalene, phenanthrene and anthracene

Unit VI: Drugs and Pharmaceuticals (8 lectures)

Drug discovery, design and development; Concept on lead compounds and lead modifications; pharmacophore, Synthesis of the representative drugs of the following classes: analgesics agents, antipyretic agents, anti-inflammatory agents (Aspirin, paracetamol, lbuprofen); antilaprosy (Dapsone), HIV-AIDS related drugs (AZT- Zidovudine).

Practical

Organic preparation:

1. Condensation: preparation of phthalimide
2. Nitration: acetanilide
3. Hydrolysis: hydrolysis of amides/Esters

Calculate percentage yield, based upon isolated yield (crude) and theoretical yield.

Recommended Books:

1. S. Warren, Organic Synthesis: The Disconnection Approach, 1st Edn, Wiley, 2012.
2. Ahluwalia, Green Chemistry Environmentally Benign Reactions, Ane Books-New Delhi, 2012.
3. S. J. Lippard and J. M. Berg, Principles of Bioinorganic Chemistry, University Science Books, Mill Valley, CA, 1993.
4. A. K. Das, Environmental with Green Chemistry, Books & Allied (P) Ltd, 2004

5. W. Kaim and B. Schwederski, Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life, Wiley, New York, 1994.
6. I. Bertini, H. B. Gray, S. J. Lippard and J. S. Valentine, Bioinorganic Chemistry, Viva Books Pvt. Ltd., New Delhi, 1998.
7. D. A. Skoog, D. M. West, F. J. Holler & S. R. Crouch, Fundamentals of Analytical Chemistry, Thomson, 8th Edition.
8. A. I. Vogel, A Text Book of Quantitative Inorganic Analysis, 3rd Edn, Longmans, 1961.
9. M. Kolthoff, P. J. Elving and E. B. Sandell, Treatise on Analytical Chemistry, Pt-I, II, III, The Interscience Encyclopedia, Inc., New York. 1959.
10. G. D. Christia, P. K. Dasgupta & K. A. Schug, Analytical Chemistry, Wiley,7th Edition.
11. G. Thomas, Fundamentals of Medicinal Chemistry, 5th Edn, Oxford University Press, 2013.
12. R. B. Silverman, The Organic Chemistry of Drug Design and Drug Action,3rd Edn, Academic Press, 2014.
13. M. P. S. Ishar and A Faruk, Syntheses of Organic Medicinal Compounds, Alpha Science, 2006.
14. D. R. Budman,A. H. Calvert and E. K. Rowinsky, Handbook of Anticancer Drug Development, Lippincott Williams & Wilkins, Philadelphia, PA, USA, 2003.
15. E. Garrett-Meyer, Principles of Anticancer Drug Development, Springer, 2010.

COURSE TYPE: RP

COURSE NAME: RESEARCH METHODOLOGY AND ETHICS

COURSE CODE: BSCCEMRP801

Course Type: **RP**	Course Details: RPC-1			L-T-P: **4-0-0**	
Credit: **4 (Theory)**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		00	**30**	**00**	**70**

Course Objective: *The objective is to impart into the students the theoretical idea and understanding on research and its methodology particularly of reviewing and surveying literature, writing research report with required format; testing of hypotheses and sampling for analysis and quantification research outputs, etc in maintaining research ethics.*

Course outcome: After completion of the course the students will be able to

- *describe important ideas, concepts, and research styles, such as mixed, qualitative, and quantitative approaches*
- *create testable hypotheses or research questions, outline research challenges, and identify research gaps*
- *create a well-thought-out research plan that includes sampling strategies, data gathering procedures, and the right instruments for data processing*
- *use citing tools correctly, synthesize current research findings, and critically evaluate academic literature*
- *plan and carry out investigations involving human or animal subjects by applying ethical principles and comprehending the ethical issues in research*
- *evaluate data and interpret the findings in a meaningful way by using fundamental statistical or thematic analysis and approaches*
- *compose well-organized research papers or reports and explain their findings either orally or visually as well as to gain the capacity to evaluate research papers and procedures critically for validity, reliability, and limitations*
- *maintain research ethics although his/her research activities*

Introduction to Research Methodology 15 Hours

Meaning of Research, Objectives of Research, Motivations in Research, Types of Research, Criteria of good Research, What is Research Problem? Basic and Applied research

Review of Literature and Literature survey 15 Hours

Meaning and Purpose of the Literature Review & Literature Survey, Identification of the related Literature.

The Research Report 15 Hours

General format of the Research report, style and formatting of writing, typing of the research report.

Testing of Hypotheses and Sampling design 15 Hours

Definition, Concepts Concerning Testing of Hypotheses, Formulation of hypotheses and related difficulties; Needs of sampling, Sampling for chemical analysis, Random sampling

Research ethics 15 Hours

Research Ethics: Ethical principles and responsible conduct of research (RCR); integrity, transparency, and accountability in scientific research. Scientific misconduct (fabrication, falsification, plagiarism), publication ethics, authorship, peer review, and data management. Ethical issues in human and animal research, informed consent, confidentiality, IEC/IRB approval, conflict of interest, and researcher responsibilities

Quantification of research output 15 Hours

Impact Factor, *h*-index, *i10*-index and *i20*-index, *G*-index

Recommended books/ Journals:

- C R Kothari, Research Methodology: Methods and Techniques, New Age International (P)Ltd. (2010), New Delhi Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers.
- Handbook of Communication and Social Interaction Skills by John O. Greene, Brant Raney Burleson.
- W. M. K. Trochim, 2005. Research Methods: the concise knowledge base, Atomic Dog Publishing. 270p.
- Ranjit Kumar, Research Methodology: A Step-by-Step Guide for Beginners, SAGE Publications
- Inderpal Singh, Research Methodology and Statistical Methods, Kalyani Publishers, Ludhiana.
- G Kanji, 100 statistical tests, Sage Publications.
- R. A. Day (1992) How to write and publish a scientific paper. Cambridge University press. London.

COURSE TYPE: RP

COURSE NAME: RESEARCH PROJECT / DISSERTATION

COURSE CODE: BSCCEMRP802

Course Type: **RP**	Course Details: RPC-2			L-T-P: **0-0-16**	
Credit: **8 (Practical)**	Full Marks: **200**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		120	**00**	**80**	**00**

Course Objective: *The objective is to impart into the students a research oriented logical mind such that they can choose research problem(s) on their own and develop required theoretical methods/theory and/or design experiment with necessary instrumental set up and thereby to achieve the goal (solution).*

Course outcome:

- *On completion of the course the students will be able to:*
- *Search literatures and choose scientific problems*
- *Use required tools with necessary modifications/extensions/ for arriving solving solutions*
- *Design experiment with necessary as per the research problem(s)*
- *Set up instrument as per experimental requirement*
- *Analyze and interpret the outcomes of theory/experiments and come to the final conclusions*
- *Write research papers/articles*
- *Present and defend the work at the seminar*