# Syllabus of Integrated B.Sc.- M.Sc. in Chemistry

**JIS UNIVERSITY,**
81, Nilgunj Road,Agarpara
Kolkata -700109

# INTEGRATED B.Sc.-M.Sc. CHEMISTRY SYLLABUS

## FIRST SEMESTER

| SUBJECT CODE | SUBJECT NAME | L | T | P | CREDIT |
|---|---|---|---|---|---|
| BCH-101 | Inorganic Chemistry I | 2 | 1 | 0 | 3 |
| BCH-102 | Physical Chemistry I | 2 | 1 | 0 | 3 |
| BPY-101 | Mathematical Physics I | 2 | 1 | 0 | 3 |
| BPY-102 | Acoustics and General Properties of Matter | 2 | 1 | 0 | 3 |
| BMTH-101 | Mathematics I | 3 | 0 | 0 | 3 |
| BHU-101 | English | 2 | 1 | 0 | 3 |
| BCH-191 | Chemistry Lab I | 0 | 0 | 3 | 2 |
| BPY-191 | Physics Lab I | 0 | 0 | 3 | 2 |
| BSD-181 | Project & Seminar | 0 | 0 | 0 | 1 |
| TOTAL | | 13 | 6 | 6 | 23 |

# INTEGRATED B.Sc.-M.Sc. CHEMISTRY SYLLABUS

## SECOND SEMESTER

| SUBJECT CODE | SUBJECT NAME | L | T | P | CREDIT |
|---|---|---|---|---|---|
| BCH-201 | Organic Chemistry I | 2 | 1 | 0 | 3 |
| BCH-202 | Physical Chemistry II | 2 | 1 | 0 | 3 |
| BPY-201 | Classical Mechanics I | 2 | 1 | 0 | 3 |
| BPY-202 | Thermal Physics | 2 | 1 | 0 | 3 |
| BMTH-201 | Mathematics II | 3 | 0 | 0 | 3 |
| BCS-201 | Computer Applications in Physics and Chemistry | 2 | 0 | 2 | 3 |
| BCH-291 | Chemistry Lab II | 0 | 0 | 3 | 2 |
| BPY-291 | Physics Lab II | 0 | 0 | 3 | 2 |
| BSD-281 | Project & Seminar | 0 | 0 | 0 | 1 |
| BSD-282 | Skill Development | 0 | 0 | 0 | 1 |
| TOTAL | | 13 | 5 | 8 | 24 |

# INTEGRATED B.Sc.-M.Sc. CHEMISTRY SYLLABUS

## THIRD SEMESTER

| SUBJECT CODE | SUBJECT NAME | L | T | P | CREDIT |
|---|---|---|---|---|---|
| BCH-301 | Inorganic Chemistry II | 2 | 1 | 0 | 3 |
| BCH-302 | Organic Chemistry II | 2 | 1 | 0 | 3 |
| BCH-303 | Physical Chemistry III | 2 | 1 | 0 | 3 |
| BPY-303 | Optics I | 2 | 1 | 0 | 3 |
| BMTH-301 | Mathematics III | 3 | 0 | 0 | 3 |
| BCH-391 | Chemistry Lab III | 0 | 0 | 6 | 4 |
| BPY-391 | Physics Lab III | 0 | 0 | 6 | 4 |
| BSD-381 | Project & Seminar | 0 | 0 | 0 | 1 |
| TOTAL | | 11 | 5 | 12 | 24 |

# INTEGRATED B.Sc.-M.Sc. CHEMISTRY SYLLABUS

## FOURTH SEMESTER

| SUBJECT CODE | SUBJECT NAME | L | T | P | CREDIT |
|---|---|---|---|---|---|
| BCH-401 | Inorganic Chemistry III | 2 | 1 | 0 | 3 |
| BCH-402 | Organic Chemistry III | 2 | 1 | 0 | 3 |
| BCH-403 | Physical Chemistry IV | 2 | 1 | 0 | 3 |
| BPY-401 | Quantum Mechanics I | 2 | 1 | 0 | 3 |
| BMTH-401 | Mathematics IV | 3 | 0 | 0 | 3 |
| BCH-491 | Chemistry Lab IV | 0 | 0 | 9 | 6 |
| BSD-481 | Project & Seminar | 0 | 0 | 0 | 1 |
| BSD-482 | Skill Development | 0 | 0 | 0 | 1 |
| TOTAL | | 11 | 5 | 9 | 23 |

# INTEGRATED B.Sc.-M.Sc. CHEMISTRY SYLLABUS

## FIFTH SEMESTER

| SUBJECT CODE | SUBJECT NAME | L | T | P | CREDIT |
|---|---|---|---|---|---|
| BCH-501 | Inorganic Chemistry IV | 2 | 1 | 0 | 3 |
| BCH-502 | Organic Chemistry IV | 2 | 1 | 0 | 3 |
| BCH-503 | Quantum Mechanics | 2 | 1 | 0 | 3 |
| BCH-504 | Molecular Spectroscopy | 2 | 1 | 0 | 3 |
| BCH-505 | Biomolecules | 2 | 1 | 0 | 3 |
| BES-501 | Environmental Science | 2 | 1 | 0 | 3 |
| BCHD-591 | Project I | 0 | 0 | 9 | 6 |
| BSD-581 | Project & Seminar | 0 | 0 | 0 | 1 |
| TOTAL | | 12 | 6 | 9 | 25 |

# INTEGRATED B.Sc.-M.Sc. CHEMISTRY SYLLABUS

## SIXTH SEMESTER

| SUBJECT CODE | SUBJECT NAME | L | T | P | CREDIT |
|---|---|---|---|---|---|
| BCH-601 | Inorganic Chemistry V | 2 | 1 | 0 | 3 |
| BCH-602 | Organic Chemistry V | 2 | 1 | 0 | 3 |
| BCH-603 | Physical Chemistry V | 2 | 1 | 0 | 3 |
| BCH-604 | Analytical & Environmental Chemistry | 2 | 1 | 0 | 3 |
| BCH-605 | Polymer Chemistry & Nanotechnology | 2 | 1 | 0 | 3 |
| BCH-606 | Application of Spectroscopy | 2 | 1 | 0 | 3 |
| BCHD-691 | Project II | 0 | 0 | 9 | 6 |
| BSD-681 | Project & Seminar | 0 | 0 | 0 | 1 |
| BSD-682 | Skill Development | 0 | 0 | 0 | 1 |
| TOTAL | | 12 | 6 | 9 | 26 |

## Detailed Syllabus of First Semester

### BCH-101: Inorganic Chemistry I

**L-T-P: 2-1-0** **Credit: 3**

**Unit-1: Atomic structure**

X-ray spectra and atomic number, Bohr's theory of hydrogen atom, Sommerfeld's extension of Bohr's theory, Wave mechanics: de Broglie equation, Heisenberg's uncertainty principle and its significance, Schrödinger wave equation, spectrum of hydrogen atom, radial and angular wave functions, Quantum numbers and concept of orbitals, shape of s, p, d, f- orbitals, Aufbau principle, Pauli's exclusion principle, Hund's rule, effective nuclear charge, Slater rule.

**Unit-2: Chemical periodicity**

Periodic classification of elements, modern form of Periodic table, periodicity of properties: atomic radii, ionic radii, covalent radii, van der Waals radii, ionisation energy, electron affinity, electronegativity (Pauling, Mulliken-Jaffe, Allred and Rochow scales), ionic potential. Applications in predicting the chemical behaviour of different elements, and inert pair effect.

**Unit-3: Chemical bonding**

***Ionic bond:*** Types of ionic solids, radius ratio rule and coordination number, limitations of radius ratio, lattice defects, lattice energy and Born-Haber cycle, solvation energy and solubility of ionic solids, polarizing power and polarizability, Fajan's rules.

***Covalent bond:*** Lewis structures, formal charge, Valence Bond theory, directional character of covalent bonds, Bent's rule. VSEPR theory: shapes of molecules and ions containing lone pairs and bond pairs, dipole moment, partial ionic character of covalent bonds, resonance. Molecular orbital theory of homonuclear and heteronuclear diatomic molecules, weak intermolecular forces.

**Recommended Books**

1.Concise Inorganic Chemistry, J. D. Lee, 5th Edition (1996), Chapman & Hall, London.
2 Inorganic Chemistry, J.E. Huheey, E.A. Keiter and R.L. Keiter.
3. Inorganic Chemistry, Asim K. Das
4. Basic Inorganic Chemistry, F. A Cotton, G. Wilkinson, and Paul L. Gaus, 3rd Edition (1995),John Wiley & Sons, New York.
5. Inorganic Chemistry, A. G. Sharpe, 3rd International Student Edition (1999), ELBS / Longman, U.K.
6.Inorganic Chemistry, D. F. Shriver and P. W. Atkins, 3rd Edition (1999), ELBS, London.
7. Inorganic Chemistry, R. P. Sarkar
8. Inorganic Chemistry, R. L. Dutta

## BCH-102: Physical Chemistry I

**L-T-P: 2-1-0** **Credit: 3**

### Unit-1: Gaseous state

The gas laws, equation of state, concept of molar volume, vapour density, limiting density and abnormal density. Kinetic theory of gas: postulates and derivation of the kinetic gas equation, concept of pressure and temperature, different gas laws from kinetic theory, idea of distribution functions, properties of Gamma functions, Maxwell's distribution of speeds and their significance, kinetic energy, calculations of average, root mean square and most probable values, principle of equipartition of energy, molar heat capacity of gases, binary collision among gas molecules of similar/different molecules, collision frequency, collision diameter, mean free path. Viscosity of gases, its variation with temperature and pressure, relation between mean free path and coefficient of viscosity. Real gas: deviations from ideal gas, causes of its deviation, compressibility factor ($Z$), Andrew's and Amagot's plots, van der Waals equation and its characteristic features, other equations of state (Dietrici, Berthelot, etc.), critical phenomena: critical constants of a gas and their determination, continuity of state, the van der Waals equation and critical state, law of corresponding states.

### Unit-2: Liquid state

Physical properties of liquids: vapour pressure, surface tension, viscosity, parachor and their dependence on temperature, principles of determination of vapour pressure (Ramsay and Young method), surface tension (capillary-rise and drop-weight methods), and viscosity (Ostwald viscometer and falling sphere viscometer). Fluidity, Reynolds number.

### Unit-3: Chemical Equilibrium

Law of mass action, criteria of thermodynamic equilibrium, degree of advancement of reaction and Le-Chatelier's principle, various equilibrium constants *($K_p$, $K_c$* and *$K_x$)* from thermodynamics and their quantitative dependence on temperature, pressure and concentration, van't Hoff isotherm, isobar and isochore.

### Recommended Books


1. P. W. Atkins, & J. de Paula, Physical Chemistry 8th Ed., Oxford University Press (2006).
2. G. W. Castellan, Physical Chemistry 4th Ed. Narosa (2004).
3. R. G. Mortimer, Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).
4. P.C. Rakshit, Physical Chemistry 7th Ed. Sarat book distributors, Calcutta (2001)
5. Rastogi, R.P. Mishra, An Introduction to Chemical Thermodynamics
6. K. L. Kapoor, A Textbook of Physical Chemistry

## BCH-191: Chemistry Lab I

**L-T-P: 0-0-3** **Credit: 2**

### Group A: Inorganic chemistry practical

- Determination of carbonate and hydroxide content in a mixture
- Determination of carbonate and bicarbonate content in a mixture
- Determination of free alkali present in different detergents

### Group B: Physical chemistry practical

- Determination of viscosity coefficient of given glycerol solution by Ostwald's viscometer
- Study the effect of addition of solutes [alcohol and NaCl] on the viscosity of water
- Determination of surface tension using stalagmometer

### Recommended Books


1. A.I. Vogel, A Textbook of Quantitative Inorganic Analysis, ELBS
2. Ghosal, Mahaparta and Nad, An Advanced Course in Practical chemistry
3. G. N. Mukherjee, Handbook of Practical Chemistry

# Detailed Syllabus of Second Semester

## BCH-201: Organic Chemistry I

**L-T-P: 2-1-0** **Credit: 3**

**Unit-1: Fundamental of organic chemistry**

Classification, and nomenclature, hybridization, shapes of molecules, influence of hybridization on bond properties. Localised and delocalised bonds, inductive effect, field effect, electromeic effect, conjugation, resonance, hyperconjugation, steric assistance and steric inhibition of resonance, tautomerism.

**Unit-2: Stereochemistry-I**

Concept of constitution, stereochemical representation: Fischer, Newman, Sawhorse, Flying-wedge and their interconversions, molecular symmetry: plane, centre, simple and alternating axes; symmetry operations, stereogenicity, chirotopicity, achirotopicity; Axial chirality. Enantiomerism & Diastereoisomerism, Stereogenic centers involving C=C, C=N; D/L, R/S, E/Z, syn/ anti, cis/trans, meso/dl,threo/erythro nomenclature.

**Unit-3: Reaction Intermediates**

Formation, structure, stability and reactions of classical and non-classical carbocations, carbanions, carbenes, benzynes. Classification of reactions: substitution, elimination, addition, rearrangement.

**Unit-4: Aliphatic Substitution reaction**

Free radical and nucleophilic substitutions at $sp^3$ carbon: $S_N1$, $S_N2$, $S_Ni$, $S_N1'$, $S_N2'$, $S_Ni'$ reactions; NGP Factors affecting rates of $S_N1$ and $S_N2$ reactions, phase transfer catalyst and its use in organic reaction, functional group transformations using $S_N2$ reactions, reactivity of aryl, vinyl, allyl and benzyl halides.

**Recommended Books**


1. Peter Sykes, A guidelines to mechanism in organic Chemistry
2. Clayden, Greeves, Warren, Woothers, Organic Chemistry
3. F.A. Carey, R.J. Sundberg, Advanced Organic Chemistry
4. Michael B. Smith, Jerry March, March's Advanced Organic Chemistry. Reactions, Mechanisms, and Structure
5. Subrata Sengupta, Basic Stereochemistry of Organic Molecules
6. D.S. Nassipuri, Stereochemistry of Organic Compounds
7. Morrison, & Boyd, Organic Chemistry, Dorling Kindersley, Pearson
8. I. L. Finar, Organic Chemistry (Volume 1&2), Dorling Kindersley, Pearson
9. Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds; Wiley: London,1994.

## BCH-202: Physical Chemistry II

**L-T-P: 2-1-0** **Credit: 3**

**Unit-1: Thermodynamics-I**

Introduction of different terms and processes in thermodynamics : systems (isolated, closed, open) and surrounding, diathermal and adiabatic wall, extensive and intensive properties, different processes, state function and path function, concept of thermal equilibrium and the zeroth law of thermodynamics.

*First law of thermodynamics:* concept of heat, work, internal energy and statement of first law, IUPAC sign convention of heat and work, nature of work: reversible, irreversible, isothermal and adiabatic, Joule's experiment and its consequences, enthalpy, heat capacities, relation between $C_P$ and $C_V$ for ideal gas, van der Wall's gas, and for all state of matter.

*Thermochemistry:* heat changes during physicochemical processes at constant pressure/volume, Kirchoff's equations, bond dissociation energies and resonance energy from thermochemical data, changes of thermodynamic properties in different chemical changes, adiabatic flame temperature, explosion temperature.

**Unit-2: Thermodynamics-II**

*Second law of thermodynamics:* limitation of first law, spontaneous processes and statement of the second law of thermodynamics, Carnot cycle and refrigeration, Carnot's theorem, thermodynamic scale of temperature, concept of entropy, Clausius inequality, entropy changes of an ideal gas in different processes, entropy of an ideal gas, entropy changes in mixture of ideal gases, entropy and unavailable work, Joule-Thomson's experiment and its consequences, inversion temperature, Joule-Thomson coefficient for a van der Waal's gas, Gibbs and Helmholtz energy, Gibbs-Helmholtz equation, criteria for spontaneity and equilibrium, free energy of mixing, Maxwell's relations, thermodynamic equation of state, Clapeyron-Clausius equation and its applications, chemical potential, Gibbs-Duhem relations, partial molar quantities, activity and activity coefficients, fugacity of gases and fugacity coefficient.

**Unit-3: Ionic Equilibria**

Electrolytes, Ostwald's dilution law, ionic product of water ($K_w$), concept of pH, salt hydrolysis, buffer solution and buffer capacity, indicators (acid base).

**Recommended Books**


1. P. W. Atkins, & J. de Paula, Physical Chemistry 8th Ed., Oxford University Press (2006).
2. G. W. Castellan, Physical Chemistry 4th Ed. Narosa (2004).
3. R. G. Mortimer, Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).
4. P.C. Rakshit, Physical Chemistry 7th Ed. Sarat book distributors, Calcutta (2001)
5. Rastogi, R.P. Mishra, An Introduction to Chemical Thermodynamics
6. K. L. Kapoor, A Textbook of Physical Chemistry

## BCH-291: Chemistry Lab II

**L-T-P: 0-0-3** **Credit: 2**

### Group A: Inorganic chemistry practical

- Determination of hardness of water
- Estimation of Fe(II) with $KMnO_4$ solution
- Estimation of Fe(II) with $K_2Cr_2O_7$ solution

### Group B: Organic chemistry practical

- Detection of elements (N, S, Cl/Br) and functional groups (-$CO_2H$, phenolic-OH, -CHO/CO, -$NO_2$, -$NH_2$, -$CONH_2$) in organic compounds

### Group C: Physical chemistry practical

- pH-metric titrations of strong acid vs strong base and weak acid vs strong base
- Preparation of different buffer solution
- Determination of hydrolytic constant of ($K_h$) of $NH_4Cl$ pH-metrically

### Recommended Books


1. A.I. Vogel, A Textbook of Quantitative Inorganic Analysis, ELBS
2. Ghosal, Mahaparta and Nad, An Advanced Course in Practical chemistry
3. G. N. Mukherjee, Handbook of Practical Chemistry

## Detailed Syllabus of Third Semester

### BCH-301: Inorganic Chemistry II

**L-T-P: 2-1-0** **Credit: 3**

**Unit-1: Redox reaction**

Complementary/non-complementary redox reactions, standard/formal electrode potentials, influence of pH, complex formation and precipitation reaction on formal potential, Latimer/Forst/Pourbaix diagram, electrochemical series and its implication towards metal extraction principle, basis of redox titration, redox indicator, disproportionation, comproportionation.

**Unit-2: Coordination Chemistry-I**

Nomenclature, Werner's theory, isomerism, Sidgwick's EAN concept and Valence Bond theory, stereochemistry of coordination compounds with coordination no. 4, 5 and 6.

*Theories of metal ligand bonding:* Limitations of valence bond theory, crystal-field theory and crystal-field splitting in octahedral, tetrahedral and square planar complexes, Jahn-Teller distortion, factors affecting the crystal-field splitting.

**Unit-3: Chemistry of s, p-block elements**

*Comparative study of s-block elements:* Group trends in electronic configuration, modification of pure elements, common oxidation states, inert pair effect, chemical properties and reactions in respect of the following group elements: i) Li-Na-K; ii) Be-Mg-Ca-Sr-Ba

Extraction and purification of elements from natural sources: Li, Cr, Ni, Ag, Au, electroplating, galvanizing and anodizing.

*Comparative study of p-block elements:* Group trends in electronic configuration, modification of pure elements, common oxidation states, inert pair effect, and their important compounds in respect of the following groups of elements: i) B-Al-Ga-In-Tl; ii) C-Si-Ge-Sn-Pb; iii) N-P-As-Sb-Bi; iv) O-S-Se-Te; v) F-Cl-Br-I.

**Recommended Books**

1.Concise Inorganic Chemistry, J. D. Lee, 5th Edition (1996), Chapman & Hall, London.
2 Inorganic Chemistry, J.E. Huheey, E.A. Keiter and R.L. Keiter.
3. Inorganic Chemistry, Asim K. Das
4. Basic Inorganic Chemistry, F. A Cotton, G. Wilkinson, and Paul L. Gaus, 3rd Edition (1995),John Wiley & Sons, New York.
5. Inorganic Chemistry, A. G. Sharpe, 3rd International Student Edition (1999), ELBS / Longman, U.K.
6. Inorganic Chemistry, D. F. Shriver and P. W. Atkins, 3rd Edition (1999), ELBS, London.

## BCH-302: Organic Chemistry II

**L-T-P: 2-1-0** **Credit: 3**

**Unit-1: Molecular Orbital theory**

Sketch the π MOs (with HOMO and LUMO in groundstate and excited state) of butadiene, hexatriene, allylic system, pentadienyl system, cyclobutadiene and benzene, Frost diagram, Huckel'srules for aromaticity, antiaromaticity and homoaromaticity.

**Unit-2: Physical properties**

Bond length, bond strength (bond dissociation energy and bond energy) bond angle, inter and intra molecular forces-Van der Waals force and hydrogen bonding, polar and nonpolar molecules, dipole moment of organic molecules.

**Unit-3: Organic acids and bases**

Bronsted and Lewis concept, acidity of hydrocarbons, alcohols, phenols and carboxylic acids; basicity of amines, effect of structure, subtituent and solvent on acidity and basicity.

**Unit-4: Stereochemistry-II**

*Alicyclic compounds:* Chirality, elements of symmetry – simple axis of symmetry ($C_n$), plane of symmetry ($\sigma_v$, $\sigma_d$, $\sigma_h$), centre of symmetry (i), alternating axis of symmetry ($S_n$, $n \geq 2$).

*Optical activity of chiral compounds:* specific rotation, optical purity (enantiomeric excess), recemic compounds, racemisation (through cationic, anionic and radical intermediates), resolution of acids, bases and alcohols via diastereomeric salt formation. Homotopic, enatiotopic and diastereotopic ligands, prochirality, Pro-R/Pro-S descriptors, homotopic, enatiotopic and diastereotopic faces, Re/Si descriptors.

*Conformation:* Staggered and eclipsed conformations, dihedral angle, torsion angle, energy barrier of rotation, relative stability of conformers on the basis of steric effect, dipole-dipole interaction, hydrogen bonding; conformational analysis of ethane, propane, n-butane, 1,2-dihaloethane,1,2-glycols, 1,2-halohydrin, invertomerism of trialkyl amines.

*Static stereochemistry:* Bayer strain theory, energy profile of ring inversion of cyclohexane, symmetry properties of chair, boat and twist boat form. Conformational analysis of methyl cyclohexane 1,2-,1,3-,and1,4 dimethyl cyclohexane, Conformational energy of substituents in cyclohexane, Preferred conformations of disubstituted derivatives of cyclohexane (1-methyl-1-phenyl cyclohexane, cis and trans-1,3- and -1,4- ditertiary butylcyclohexane, cis and trans-1,2-dibromo cyclohexane, cis and transcyclohexane-1,3-diol). Physical properties with respect to dipole moment and acid strength in cyclohexane system.

**Recommended Books**


1. Peter Sykes, A guidelines to mechanism in organic Chemistry
2. Clayden, Greeves, warren, woothers, Organic Chemistry
3. Subrata Sengupta, Basic Stereochemistry of Organic Molecules
4. D.S. Nassipuri, Stereochemistry of Organic Compounds
5. Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds; Wiley: London

## BCH-303: Physical Chemistry III

**L-T-P: 2-1-0** **Credit: 3**

### Unit-1: Thermodynamics of Solution

Lewis-Randall rule, thermodynamic functions of mixing ($\Delta G_{mix}$, $\Delta S_{mix}$, $\Delta V_{mix}$, $\Delta H_{mix}$), Henry's and Raoult's laws, Konowaloff's rule, ideal solutions and their characteristic properties, positive and negative deviations from ideal behavior, Duhem-Margules equation and its application,

Thermodynamics of colligative properties: relative lowering of vapor pressure, elevation of boiling point, freezing point depression, Osmotic pressure, inter relationships, van't Hoff equation, applications in calculating molar masses of normal, dissociated and associated solutes in solution.

### Unit-2: Phase Equilibria

Concept of phases, components and degrees of freedom, thermodynamic derivation of Gibbs phase rule for non-reactive and reactive systems, phase diagrams of one-component system (water, $CO_2$), two component systems (phenol-water, triethylamine-water, nicotine-water and lead-silver), three component systems (water-chloroform-acetic acid), CST, steam distillation, azeotropic solution, eutectic mixture, Nernst distribution law: its derivation and applications.

### Unit-3: Chemical Kinetics & Catalysis

Rate law, integrated rate law, advancement of reaction, order and molecularity, kinetics of zero, first, second and fractional order reactions, determination of order by half-life and differential method, opposing, consecutive and parallel reactions, concept of steady state and rate determining step, chain reactions, temperature dependence of reaction rates, Arrhenius equation, activation energy, collision theory of bimolecular reactions, Lindemann theory, theory of absolute reaction rate and its thermodynamic formulation, primary kinetic salt effect.

Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces, effect of particle size and efficiency of nanoparticles as catalysts, acid-base catalysis, and Enzyme catalysis: Properties of enzymes, Michaelis–Menten equation, Lineweaver–Burk equation, turnover frequency, catalytic efficiency, effect of temperature and pH.

### Recommended Books


1. P. W. Atkins, & J. de Paula, Physical Chemistry 8th Ed., Oxford University Press (2006).
2. G. W. Castellan, Physical Chemistry 4th Ed. Narosa (2004).
3. R. G. Mortimer, Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).
4. P.C. Rakshit, Physical Chemistry 7th Ed. Sarat book distributors, Calcutta (2001)
5. Rastogi, R.P. Mishra, An Introduction to Chemical Thermodynamics
6. K. L. Kapoor, A Textbook of Physical Chemistry
7. K.J. Lailder, Chemical Kinetics, 3rd Edition, Pearson

## BCH-391: Chemistry Lab III

**L-T-P: 0-0-6** **Credit: 4**

### Group A: Inorganic chemistry practical

- Qualitative analysis of inorganic samples (acid,basic radicals and interfering radicals) having at least four radicals

### Group B: Organic chemistry practical

- Identification of a solid unknown organic compound
  i) Physical characteristics
  ii) Solubility test with preliminary conclusion
  iii) Detection of elements (N,S and Cl) in a given solid sample
  iv) Determination of melting point of the organic sample
  v) Detection of the following functional groups in organic samples
  Carbonyl-keto, aldehyde, carboxylic acid, phenolic hydroxyl, unsaturation, aromatic (nitro, amino), amido
  vi) Preparation of a suitable derivative of the supplied organic sample and determine the melting point of derivative

### Group C: Physical chemistry practical

- Experiments based on Chemical Kinetics
- Experiments based on Phase Equilibria
- Experiments based on Colligative properties

### Recommended Books


1. A.I. Vogel, A Textbook of Quantitative Inorganic Analysis, ELBS
2. Ghosal, Mahaparta and Nad, An Advanced Course in Practical chemistry
3. G. N. Mukherjee, Handbook of Practical Chemistry

## BCH-401: Inorganic Chemistry III

**L-T-P: 2-1-0** **Credit: 3**

### Unit-1: Coordination Chemistry-II

*Stereochemistry, bonding, geometric and electronic structures of coordination compounds:* term symbol, Laporte selection rules, charge transfer spectra, Orgel diagram, Tanabe-Sugano diagram, ligand symmetry orbital, molecular orbital, spectral properties, Nephelauxetic effect, Racah parameter, vibronic coupling, band broadening, spin-orbit coupling, spin-forbidden transition, intensity stealing, magnetic properties, anomalous and subnormal magnetic moments, lowering of symmetry, electronic, steric, Jahn-Teller and Renner-Teller effects on energy levels, conformation of chelator/congregator, structural equilibrium and implications.

*Thermodynamics and kinetics of metal complex:* A brief outline of thermodynamic and kinetic stabilities of metal complexes and factors affecting the stability. Substitution reactions of square-planar complexes–Trans effect.

*Chemistry of second and third transition series:* A general comparative treatment of 4d and 5d elements with their 3d analogues in respect of ionic radii, oxidation states, magnetic behaviour and electronic spectral properties.

### Unit-2: Acid base and Non aqueous

Acid-base reactions**,** Arrhenius concept, theory of solvent system (in $H_2O$, $NH_3$, $SO_2$ and HF), Bronsted-Lowry's concept, relative strength of acids, Pauling rules, amphoterism, Lux-Flood concept, Lewis concept, Superacids, HSAB principle, acidbase equilibria in aqueous solution and pH Acid-base neutralisation curves, indicator, choice of indicators.

Physical properties of a non aqueous solvent for functioning as an effective reaction medium, types of solvents and their general characteristics, liquid $NH_3$ as a non-aqueous solvent.

### Unit-3: Chemistry of d and f-block elements

General comparison of 3d, 4d and 5d elements in term of electronic configuration, elemental forms, metallic nature, atomization energy, oxidation states, redox properties, coordination chemistry, spectral and magnetic properties. f-Block elements: electronic configuration, ionization energies, oxidation states, variation in atomic and ionic (3+) radii, magnetic and spectral properties of lanthanides and actinides, separation of lanthanides (by ion-exchange method), chemistry of some representative compounds: $K[Ni(CN)_4]$, $H_2PtCl_6$, $Na_2[Fe(CN)NO]$.

### Recommended Books

1.Concise Inorganic Chemistry, J. D. Lee, 5th Edition (1996), Chapman & Hall, London.
2 Inorganic Chemistry, J.E. Huheey, E.A. Keiter and R.L. Keiter.
3. Inorganic Chemistry, Asim K. Das
4. Basic Inorganic Chemistry, F. A Cotton, G. Wilkinson, and Paul L. Gaus, 3rd Edition (1995),John Wiley & Sons, New York.
5. Inorganic Chemistry, A. G. Sharpe, 3rd International Student Edition (1999), ELBS, U.K.

## BCH-402: Organic Chemistry III

**L-T-P: 2-1-0** **Credit: 3**

### Unit-1: Reaction energetic & Kinetics

ΔG, ΔH and ΔS terms in relation to reaction equilibrium with particular reference to the following: halogenations ofalkane and alkene, keto-enol tautomerism, intermolecular and intramolecular reactions.

Rate equation, TS theory-rate constant and free energy of activation, free energy profiles for one-step, two-step reactions. Hammond postulates, principle of microscopic reversibility, kinetic control vs thermodynamic control, catalysed reaction, isotope effect, tprimary kinetic isotope effect (KH/KD).

### Unit-2: Addition reactions

*Addition to carbon-carbon multiple bond:* electrophilic and free radical mechanism, stability of alkenes-heat of hydrogenation and heat of combustion.

*Mechanism of the following reactions*: Halogenation, hydrohalogenation (regioselectivity, peroxide effect), hydration of alkene (including oxymercuration-demercuration, hydraboration-oxidation), epoxidation, hydroxylation, ozonolysis (involving 1, 3-dipolar mechanism), hydration of alkyne, stereochemistry of bromination, hydroxylation and carbine addition. Electrophilic addition to allene and butadiene, dissolving metal reduction of alkynes and benzenoid aromatics (Birch).

*Dynamic stereochemistry:* Conformations and reactivity in cyclohexane system, E2 elimination, nucleophilic substitution ($S_N1$, $S_N2$, NGP), rearrangement (pinacol-pinacolone and related rearrangements, Favorski rearrangement), Oxidation of cyclohexanol, esterification, saponification and lactonization.

### Unit-3: Carbonyl chemistry

*Nucleophilic addition to carbonyl group- Aldehydes and ketones:* Addition to HCN, $NaHSO_3$, water, alcohol, thioalcohol (Umpolung), derivatives of ammonia, ylides (Wittig reaction), nucleophilic addition to α,β-unsaturated carbonyl compounds (general principles). Quinones, reactions of p-benzoquinone, Hydride addition ($LiAlH_4$, $NaBH_4$ reduction), MPV reduction, Wolff-Kishner, dissolving metal (Clemenson reduction, Bouveaultr-Blanc reduction).

*Acidity of α-Hydrogen*: reaction via enols and enolate ion (carbanions), aldol condensation, Knovenagel reaction, Claisenester condensation, Perkin reactions, Darzen's reaction, halogenations of ketones, α-halogenation of acids (HVZ reaction). Nucleophilic substitution at the acyl carbon- carboxylic acids and theirderivatives: Esterification and hydrolysis (BAC2,

AAC2, AAC1, AAl1-mechanism, non-kinetic use of isotope labels), amides (formation and hydrolysis).

*Carbonyl compounds without α-Hydrogen:* Cannizaro reaction, Tischenko reaction, benzoin condensation.

*Stereoselectivity and asymmetric synthesis:* enentoselectivity/diastereoselectivity; asymmetric synthesis involving achiral and chiral reagent, chiral substrate and achiral reagent (Cram's rule and Felkin-Anh model).

**Recommended Books:**


1. Peter Sykes, A guidelines to mechanism in organic Chemistry
2. Clayden, Greeves, Warren, Woothers, Organic Chemistry
3. F.A. Carey, R.J. Sundberg, Advanced Organic Chemistry
4. Michael B. Smith, Jerry March, March's Advanced Organic Chemistry. Reactions, Mechanisms, and Structure
5. Subrata Sengupta, Basic Stereochemistry of Organic Molecules
6. D.S. Nassipuri, Stereochemistry of Organic Compounds
7. I. L. Finar, Organic Chemistry (Volume 1&2), Dorling Kindersley, Pearson
8. Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds; Wiley: London, 1994.

## BCH-403: Physical Chemistry IV

**L-T-P: 2-1-0** **Credit: 3**

### Unit-1: Electrochemistry-I

Arrhenius theory of electrolytic dissociation, conductance and its measurement, cell constant, specific, equivalent and molar conductances, their variation with respect to dilution; temperature; viscosity; etc, Kohlrausch's law of independent migration of ions, ion conductance and ionic mobility, transport number, determination of transport number by Hittorf and moving boundary methods, various applications of conductance measurement.

Qualitative idea of Debye-H*ü*ckel theory of solution without derivation, qualitative idea of electrophoretic and relaxation effects, Debye-H*ü*ckel-Onsager equation, effect of high frequency and high field on conductance.

### Unit-2: Surface Chemistry & Interfaces

*Adsorption*-Physical and chemical adsorptions, Langmuir, Freundlich, and Gibbs adsorption isotherms, surface excess and BET equation.

*Colloidal state*-Definition, colloids classification, properties, Tyndall effect, electrokinetic phenomena, zeta potential, iso-electric point, Schulze-Hardy rule, protective colloids, gold number, Perrin method for determination of Avogadro number, colloidal electrolytes, micelle and reverse micelle, critical micelle constant, emulsions, gels, thixotropy.

### Unit-3: Solid State

Crystal lattices, space lattice, Bravais lattice, unit cell, crystal systems, law of rational indices, Miller indices, Bragg's equation and its applications, crystal structure of NaCl, graphite, and diamond, types of crystal, imperfection in crystals: point defect-Schottky and Frankel defects.

### Recommended Books


1. Samuel Glasstone, An Introduction To Electrochemistry, Affiliated East-West Press Pvt. Ltd.New Delhi (2000)
2. J. O'M. Bockris, A. K. N. Reddy, Modern Electrochemistry, Vol. 2 A & B, 2nd Edition, Plenum Press, New York (1998)
3. P. W. Atkins, & J. de Paula, Physical Chemistry 8th Ed., Oxford University Press (2006).
4. G. W. Castellan, Physical Chemistry 4th Ed. Narosa (2004).
5. P.C. Rakshit, Physical Chemistry 7th Ed. Sarat book distributors, Calcutta (2001)
6. K. L. Kapoor, A Textbook of Physical Chemistry

## BCH-491: Chemistry Lab IV

**L-T-P: 0-0-9** **Credit: 6**

### Group A: Inorganic chemistry practical

- Quantitative analysis of inorganic samples volumetrically and gravimetrically
- Synthesis and characterization some representative coordination compounds

### Group B: Organic chemistry practical

- **Preparation:** m-Dinitrobenzene, aspirin, methyl orange, p-bromo acetanilide, phthalimide from phthalic anhydride, benzanilide, anthranillic acid from phthalimide, benzilic acid from benzil, benzil from benzoin, benzoic acid by oxidation of benzene derivative(ph-CHO/ph-$CH_2OH$/ph-$CH_3$).

### Group C: Physical chemistry practical

- Experiments based on Electrochemistry
- Experiments based on Adsorption
- Synthesis of Nanomaterials

### Recommended Books


1. A.I. Vogel, A Textbook of Quantitative Inorganic Analysis, ELBS
2. Ghosal, Mahaparta and Nad, An Advanced Course in Practical chemistry
3. G. N. Mukherjee, Handbook of Practical Chemistry

## BCH-501: Inorganic Chemistry IV

**L-T-P: 2-1-0** **Credit: 3**

**Unit-1: Inorganic reaction mechanism**

Reaction mechanism Factors governing 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 pathways; Hammett relation, application of LFER in chemical kinetics.

**Unit-2: Organometallic chemistry**

18-electron rule and its applications to carbonyls (including carbonyl hydrides and carbonylates), nitrosyls, cyanides, and nature of bonding involved therein, Metal-olefin complexes: Zeises salt, Ferrocene, hapticity(η) of organometallic ligands, examples of mono tri and penta-hapto cyclopentadienyl complexes, fluxional molecules, coordinative unsaturation: oxidative addition and insertion reactions, homogeneous catalysis by $K_4[Fe(CN)_6]$, organometallic compounds: hydrogenation, hydroformylation and polymerization of alkenes (Ziegler-Natta catalysis).

**Unit-3: Nuclear chemistry**

Nucleus and its classification, nuclear forces, nuclear binding energy, stability of nucleus, Radioactivity: radioactive elements, general characteristics of radioactive decay, decay kinetics. Nuclear reactions: Bethe notation, types of nuclear reactions, conservation of quantities (mass-energy and linear momentum) in nuclear reactions, reaction cross-section, compound nucleus theory and nuclear reactions, nuclear fission: the process, fragments, mass distribution, and fission energy, nuclear reactor: the natural uranium reactor, classification of reactors, breeder reactor, nuclear fusion and stellar energy, 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 in Rad, Gray, Rontgen, RBE, Rcm, Sievert.

**Recommended Books**

1. Concise Inorganic Chemistry, J. D. Lee, 5th Edition (1996), Chapman & Hall, London.
2. Inorganic Chemistry, J.E. Huheey, E.A. Keiter and R.L. Keiter.
3. Inorganic Chemistry, Asim K. Das
4. Basic Inorganic Chemistry, F. A Cotton, G. Wilkinson, and Paul L. Gaus, 3rd Edition (1995), John Wiley & Sons, New York.
5. Inorganic Chemistry, A. G. Sharpe, 3rd International Student Edition (1999), ELBS, U.K.
6. H.J. Arnikar, Essentials of Nuclear Chemistry, 4th Edition, Wiley-Eastern Ltd, New Delhi.

## BCH-502: Organic Chemistry IV

**L-T-P: 2-1-0** **Credit: 3**

**Unit-1: Aromatic substitution**

*Electrophilic aromatic substitution:* Mechanism orientation and reactivity (including free energy profiles) of halogenations, nitration, sulfonation, Friedel-Craft reactions, chloromethylation, formylation (Gatterman-Koch, Gatterman, Reimer-Tiemann and Vilsmeyer-Haack), Kolbe-Schmidt reaction, Houben-Hoesch reaction, IPSO substitution.

Synthesis of naphthalene, anthracene and their derivatives, Pthenenthrene (Bardhan-Sengupta synthesis), orientation and reactivity in polynuclear hydrocarbons (naphthalene and anthracene).

*Nucleophilic aromatic substitution:* Addition-elimination mechanism, reactivity and orientation in activated aromatic substitutions, elimination-addition, mechanism, benzyne intermediate, $S_N1$ mechanism, *Chemoselectivity:* different reactivity of $-NH_2$ and –OH in aromatic system.

**Unit-2: Chemistry of nitrogen containing compounds**

Aliphatic and aromatic amines (preparation, separation and identification of primary, secondary and tertiary amines), alkylation including Hoffmann's exhaustive methylation, reactions of aliphatic and aromatic amines with nitrous acid, carbyl amine reaction, Mannich reaction, Eschweiler Clarke reaction, enamines, diazomethane, diazoacetic ester, aromatic nitro compounds, aromatic diazonium salts, nitriles andisonitriles, Ritter reaction.

**Unit-3: Organometallics**

Preparation of Grignard reagent and organolithium. Reactions: addition of Grignard and organolithium to carbonyl compounds, substitution on –COX, conjugate addition by Gilman cuprates, Reformatsky reaction.

**Unit-4: Molecular rearrangements**

Intramolecular versus intermolecular rearrangements, crossover experiment, 1,2-shift

*Migration to electron deficient carbon:* Wagner-Meerwein, pinacol-pinacolone, dienenone-phenone, Wolff rearrangement, Arndt-Eistert synthesis, Benzil-benzillic acid rearrangement.

*Migration to electron deficient nitrogen:* Beckmann, Schmidt (carbonyl compound), Hofmann, Lossen, Curtious, Schmidt (carboxylic acid).

*Migration to electron deficient oxygen*: Baeyer-Villeger, Dakin, Hydroperoxide rearrangement, Aromatic rearrangements.

*Migration from oxygen to ring carbon:* Fries, Claisen rearrangement

*Migration from nitrogen to ring carbon:* Hofmann-Mertious, Fischer-Hepp, N-azo to C-azo, Bamberger, Orton, Benzidine-Semidine rearrangement.

**Recommended Books**


1. Clayden, Greeves, Warren, Woothers, Organic Chemistry
2. F.A. Carey, R.J. Sundberg, Advanced Organic Chemistry
3. Michael B. Smith, Jerry March, March's Advanced Organic Chemistry. Reactions, Mechanisms, and Structure

## BCH-503: Quantum Mechanics

**L-T-P: 2-1-0** **Credit: 3**

**Unit-1:** Drawback of classical mechanics, black body radiation, photoelectric effect, Compton effect, wave particle duality, Wilson-Sommerfeld quantization rule, its application to Bohr atom, harmonic oscillator, rigid rotator and particle in 1-d box, de Broglie hypothesis, Heisenberg's uncertainty principle, Bohr's correspondence principle and its applications.

Concept of operators, different types of operators, hermitian operator and its properties, normalization, orthogonality, probability distribution of wave functions, eigen function, eigen values, commutation of operators.

**Unit 2:** Postulates of quantum mechanics, time-independent Schrödinger equation, stationary state, stationary state wave function, probabilistic interpretation of wave functions, applications of Schrödinger equation to free particles, particle in 1-d, 2-d & 3d box, and harmonic oscillators to generate respective acceptable wave functions and corresponding energy, concept of degeneracy, expectation values of x, $x^2$, $p_x$, $p_x^2$ and their significance in relation to the uncertainty principle.

**Unit 3:** Stationary Schrödinger equation for the H-atom in polar coordinates, separation of radial and angular ($\theta$, $\phi$) parts, solution of $\phi$ part and emergence of magnetic quantum number, energy expression, hydrogenic wave functions up to n = 2 (only expressions), real wave functions, concept of orbitals and shapes of s and p orbitals.

**Recommended Books**


1. I. N. Levine, Quantum Chemistry, 5th Edition (2000), Pearson Educ., Inc. New Delhi
2. Donald A McQuarrie, Quantum Chemistry, Viva Student Edition, Viva Books, NewDelhi
3. K. L. Kapoor, A Textbook of Physical Chemistry
4. P. W. Atkins, & J. de Paula, Physical Chemistry 8th Ed., Oxford University Press (2006).
5. A. K. Chandra, Quantum Chemistry
6. R. K. Prasad, Quantum Mechanics

## BCH-504: Molecular Spectroscopy

**L-T-P: 2-1-0** **Credit: 3**

**Unit-1: Fundamentals**

Interaction of electromagnetic radiation with molecules and various types of spectra, Born-Oppenheimer approximation.

**Unit-2: Rotation spectroscopy of diatomic molecules**

Rigid rotor model, selection rules, spectrum, spacing and intensities of spectral lines, determination of bond length, effect of isotopic substitution.

**Unit-3: Vibrational spectroscopy of diatomic molecules**

Simple harmonic oscillator model, selection rules, spectra, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands. *Vibration-rotation spectroscopy:* diatomic vibrating rotator, P, Q, R branches.

**Unit-4: Raman spectroscopy**

Characteristic features and conditions of Raman activity, qualitative treatment of rotational Raman spectrs, effect of nuclear spin. V*ibrational Raman spectra*: Stokes and anti-Stokes lines, their intensity difference, rule of mutual exclusion.

**Unit-5: Electronic spectroscopy**

Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation.

**Unit-6: Nuclear Magnetic Resonance (NMR) spectroscopy**

Principle, Larmor precession, chemical shift and low resolution spectra, different scales, spin-spin coupling and high resolution spectra, interpretation of PMR spectra of organic molecules.

**Unit-7: Electron Spin Resonance (ESR) spectroscopy**

Principle, hyperfine structure, ESR of simple radicals.

**Recommended Books**


1. J. M. Hollas, Modern Spectroscopy, 4th edition (2004) John Wiley & Sons, Ltd., Chichester.
2. C. N. Banwell and E.M. Mc Cash, Fundamentals of Molecular Spectroscopy, 4th edition (1994), Tata McGraw Hill, New Delhi.
3. K. L. Kapoor, A Textbook of Physical Chemistry
4. T. Engel, P. Reid, Physical Chemistry

## BCH-505: Biomolecules

**L-T-P: 2-1-0** **Credit: 3**

### Unit-1: Carbohydrate

Classification, structure and reactions of glucose and fructose, mutarotation, anomeric effect, inter conversion reactions-aldose to ketose, ketose to aldose, chain elongation and chain degradation, epimerization. *Disaccharides:* glycosidic linkages, sucrose, lactose, reducing and non-reducing sugars, inversion of sugar. *Polysaccharide:* starch, glycogen, cellulose and chitin, analysis of carbohydrates.

### Unit-2: Amino acids and Nucleic acids

*Natural and synthetic amino acids:* synthesis, structures, reactions, and importance, synthetic methodology of peptides and polypeptides, peptide-linkage, configuration, general characteristic, structures and properties of protein, isoelectric point, ninhydrin test.

*Nucleic acids:* structure of nucleosides and nucleotides, pyrimidine and purine bases (structure and nomenclature only), elementary idea of RNA and DNA, Watson-Crick model, complimentary base-pairing in DNA.

### Unit-3: Enzymes, Vitamins and Hormones

Classifications, general characteristics and different properties of enzyme, co-enzymes, vitamins and hormones, enzyme kinetics, enzyme inhibition, oxygen and carbon dioxide transport by hemoglobin. Chemical constitution and physiological functions of vitamins A, Riboflavin ($B_2$), Ascorbic acid (C), origin and function of thyroxin and estrone.

### Unit-4: Drugs

Classification, preparation and mechanism of action of the following drugs-

(i) Antipyretics and Analgesics : Aspirin, Paracetamol

(ii) Sulpha drugs: Sulphanilamide, Sulphaguanidine

(iii) Antimalarials: Chloroquine

(iv) Antibiotics: Chloramphenicol

### Recommended Books

1. Principles of Biochemistry, D. L. Nelson M.M. Cox, Lehninger, 3rd edition (2002) McMillan North Publication.

2. Biochemistry, L. Stryer, 5th edition (2002) Freeman & Co New York.

3. Organic Chemistry, I. L. Finar, Vol. II, 5th Edition (1975), Reprinted in1996, ELBS and Longman Ltd., New Delhi.

4. Organic Chemistry, S. M. Mukherji , S. P. Singh, and R. P. Kapoor, 1st Edition (1985), 5th Reprint (1999), New Age International (P) Ltd.Publishers, New Delhi.

5. Organic Chemistry, R. T. Morrison and R. N. Boyd, 6th Edition (1992), Prentice-Hall of India (P) Ltd., New Delhi.

## BCH-601: Inorganic Chemistry V

**L-T-P: 2-1-0** **Credit: 3**

### Unit-1: Bioinorganic

Elements of life: essential major, trace and ultra trace elements, basic chemical reactions in the biological systems and the role of metal ions (specially $Na^+$, $K^+$, $Mg^{2+}$, $Ca^{2+}$, $Fe^{3+}/2^+$, $Cu^{2+}/^+$, and $Zn^{2+}$), metal ion transport across biological membrane: $Na^+$-ion pump, ionophores, biological functions of haemoglobin, myoglobin, cytochromes, ferredoxins, and carbonicanhydrase, biological nitrogen fixation, photosynthesis: Photosystem-I and Photosystem-II, toxic metal ions and their effects, chelation therapy, Pt and Au complexes as drugs, metal dependent diseases.

### Unit-2: Solid State

Structure and properties of solids, ionic, covalent, hydrogen and molecular bonded solids, perovskite, ilmenite and rutile; spinel and inverse spinel, diamond cubic, silicates: single/double chain, 3D network, pyroxene, amphibole, talc, mica, clay, zeolite; crystal defects, non-stoichiometric compounds; electronic properties of solids, F-centre, conductors, insulators, semiconductors, superconductors; ferroelectricity, antiferroelectricity, pyroelectricity, piezoelectricity, liquid crystals, cooperative magnetism.

### Unit-3: Instrumental Methods of Analysis

Basic principles, instrumentations and simple applications of conductometry, potentiometry, UV-Visible, IR, and Raman spectroscopy, TEM, SEM, and XRD.

### Recommended Books


1.Concise Inorganic Chemistry, J. D. Lee, 5th Edition (1996), Chapman & Hall, London.
2 Inorganic Chemistry, J.E. Huheey, E.A. Keiter and R.L. Keiter.
3. Inorganic Chemistry, Asim K. Das
4. Basic Inorganic Chemistry, F. A Cotton, G. Wilkinson, and Paul L. Gaus, 3rd Edition (1995),John Wiley & Sons, New York.
5. Inorganic Chemistry, A. G. Sharpe, 3rd International Student Edition (1999), ELBS, U.K.
6. Bioinorganic Chemistry, A. K Das.
7. D. A. Skoog, D.M. West, F.J. Holler, S.R. Crouch, *Analytical Chemistry - An Introduction*, 7th Edition (2000), Saunders College Publishing, Philadelphia, London.
8. Instrumental Methods of Analysis, Hobart H. Willard. Lynne L. Merritt, John A. Dean, and Frank A. Settle, Jr., Wadsworth Publishing Company, Belmont, CA, 1981.

## BCH-602: Organic Chemistry V

**L-T-P: 2-1-0** **Credit: 3**

### Unit-1: Retrosynthesis

General synthetic strategy, dsconnection approach- target molecule, retrosynthetic analysis, function group interconversion,disconnection, synthons, electrophilic and nuclephilic synthons, synthetic equivalent, latent polarity.

*Methodologies of ring synthesis:* (i) C-C disconnection involving carbanion chemistry (ethyl acetoacetate, diethyl malonate), (ii) carbonyl condensation-two group disconnection: α,β-unsaturated carbonyl compounds, 1,3- dicarbonyl compounds, 1,5-dicarbonyl compounds, Robinson annulations, (iii) *Large ring synthesis:* high dilution technique, Acyloin condensation (use of trimethylsilyl chloride).

### Unit-2: Heterocyclic compounds

Reactivity, orientation and important reactions of furan, pyrrole, thiophene, pyridine, indole. Furan: Paal-Knoor synthesis, Feist-Benary synthesis, Pyrrole: Knoor synthesis, Hantzsch synthesis, Thiophene: Hinsberg synthesis, Pyridine: Hantzsch synthesis, Indole: Fischer, Madelung, Reissert synthesis, Quinoline: Skaurp, Friedlander synthesis, Isoquinoline: Bischler-Napieralski synthesis.

### Unit-3: Pericyclic reaction

Definition and classification of pericyclic reactions, thermal and photochemical electrocyclic reactions of neutral species involving 4 and 6 electrons- FMO approach, Cycloaddition reactions [2+2] and [4+2], Diels-Alder reaction-FMO approach.

### Recommended Books

1. Clayden, Greeves, Warren and Wothers, Organic Chemistry, Oxford University Press, 2001.
2. M.B. Smith & Jerry March, March's Advanced Organic Chemistry, 5th Edition (2001), John Wiley & Sons, New York.
3. Advanced Organic Chemistry, Part-A, F.A. Carey and R.J. Sundburg
4.Advanced Organic Chemistry, Part-B, F.A. Carey and R.J. Sundburg
5.S.M. Mukherjee and S.P. Singh, Pericyclic Reactions &Photochemistry, MacMillan India, New Delhi.
6. I. Fleming, Pericyclic Reactions, Oxford University Press, Oxford (1999)

## BCH-603: Physical Chemistry V

**L-T-P: 2-1-0** **Credit: 3**

### Unit-1: Electrochemistry-II

Types of cell: electrolytic, electrochemical, and fuel cells, electrode potential, standard cells, cell reactions, electromotive force (EMF) of a cell and its measurement, Nernst equation, concentration cells with and without transference, liquid junction potential and its elimination, applications of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell, (ii) equilibrium constants, (iii) pH, and (iv) potentiometric titrations (acid-base, redox, precipitation) etc.

### Unit-2: Photochemistry

Characteristics of electromagnetic radiation, Jablonsky diagram, Lambert-Beer's law and its limitations, physical significance of absorption coefficients, Grotthus-Draper law, Stark-Einstein law of photochemical equivalence, quantum yield and its measurement for a photochemical process, actinometry, photostationary state, chemiluminescence, photosensitized reactions, quenching, role of photochemical reactions in biochemical processes, and properties of excited state.

### Unit-3: Molecular Statistics

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

Microstates, thermodynamic probability, entropy and probability, Boltzmann distribution law, concept of partition function, thermodynamic parameters from partition function.

### Recommended Books


1. P. W. Atkins, & J. de Paula, Physical Chemistry 8th Ed., Oxford University Press (2006)
2. G. W. Castellan, Physical Chemistry 4th Ed. Narosa (2004)
3. P.C. Rakshit, Physical Chemistry 7th Ed. Sarat book distributors, Calcutta (2001)
4. K. L. Kapoor, A Textbook of Physical Chemistry
5. T. Engel, P. Reid, Physical Chemistry
6. Samuel Glasstone, An Introduction To Electrochemistry, Affiliated East-West Press Pvt. Ltd.New Delhi (2000)
7. Statistical Mechanics(1988), B.K. Agarwal and M. Eisner, Wiley Eastern, New Delhi
8. Statistical Mechanics(2000), D.A. Mcquarrie, California University Science Books
9. Statistical Mechanics and Properties of Matter, E. S. R. Gopal, Ellis Horwood, England, 1974.
10. Statistical Mechanics, B.B. Laud

## BCH-604: Analytical & Environmental Chemistry

**L-T-P: 2-1-0** **Credit: 3**

### Unit-1: Statistical evaluation

Determinate and indeterminate errors, accuracy and precision, relative and standard deviation, methods for minimizing errors, significant figures.

### Unit-2: Solvent extraction, Chromatography & Spectrophotometry

Distribution law, Craig concept of counter-current distribution, important solvent extraction systems, Ellingham diagram for metal extraction, and zone melting.

Classification of chromatographic methods, general principle and application of adsorption, partition, ion-exchange, thin layer and paper chromatography.

Lambert-Beer's law, spectrophotometric determination of one component (iron, chromium, manganese, nickel, titanium and phosphorus).

### Unit-3: Experiments related to Electrochemistry

Principles, instrumentations and applications of polarography and cyclic voltammetry.

### Unit-4: Air and Water Pollution

Composition and structure of the atmosphere: troposphere, stratosphere, mesosphere and thermosphere, major air pollutants, ozone layer and its role, depletion of ozone layer, green house effect, acid rain and photochemical smog, different air quality standards.

Environmental role of water, natural water sources, water treatment for industrial, domestic and laboratory uses, water pollutants, water quality standards: DO. BOD, COD, TDS and hardness parameters, desalination of sea water: reverse osmosis, electro dialysis.

### Recommended Books

1. Analytical Chemistry, G. D. Christian, 4th Edition (1986), John Wiley & Sons, New York.
2. Modern Methods of Chemical Analysis, R. L. Pecsock, L. D. Shields, T. Cairns, and I. C. Mc William, 2nd Edition (1976), John Wile
3. Principles of Instrumental Analysis, D.A. Skoog, 5th Edition (1998), Saunders College Publishing, Philadelphia, London.y, New York.
4. Basic Concepts of Analytical Chemistry, S. M. Khopkar, 2nd Edition (1998), New Age International Publications, New Delhi.
5. Environmental Chemistry, A. K. De, 3rd Edition (1994), Wiley Eastern, New Delhi.
6. Instrumental Methods of Analysis, H. H. Willard, L. L. Merritt, and J. A. Dean, 6th Edition (1986),CBS Publishers & Distributors, Shahdara, Delhi.
7. Analytical Chemistry, R.A. Day and A.L. Underwood.

## BCH-605: Polymer Chemistry & Nanotechnology

**L-T-P: 2-1-0** **Credit: 3**

### Unit-1: Introduction

Classification of polymers, copolymers, inorganic polymers, tacticity of polymers, glass transition and melting temperature, degree of polymerization, number and weight average molecular weights, polydispersity index, determination of molecular weight by viscosity, colligative property measurement, light scattering, and end group analysis, mechanical properties of polymers.

### Unit-2: Different Polymerization techniques

Addition and condensation polymerization, kinetic and mechanistic study of cationic, anionic and free radical polymerization, controlled polymerization, metallocene polymerization, bulk, suspension & emulsion polymerization.

### Unit-3: Nanotechnology

Origin and importance of nanomaterials, properties and size effect of nanomaterials: optoelectronic, mechanical, magnetic, and catalytic properties, different synthetic methodology, characterization techniques and various applications of nanotechnology in industry.

### Recommended Books


1. Principle of Polymerization G. Odian, 3rd edition (1991) John Wiley, Singapore.
2. Textbook of Polymer Science, Billmayer, F. W. John Wiley & Sons, Inc.
3. Gowariker, V. R., Viswanathan, N. V. & Sreedhar, J. Polymer Science, New Age International (P) Ltd.
4. Polymer Chemistry, by Seymour R.B. and Carraher, Marcel Dekker (2000).
5. Introduction to Polymer Chemistry, C.E Carraher Jr. ,Taylor and Francis I$^{st}$ edition (2007), Boca Raton.
6. 1. G. Ozoin, Nanochemistry: A Chemical approach to nanomaterials, Springer-Verlag, 2005.
7. C. N. R Rao, A. Muller, A. K Cheetham, Nanomaterials Chemistry, Wiley-VCH, 2007.
8. C. N. R. Rao, A. Müller, A. K. Cheetham, The Chemistry of Nanomaterials: Synthesis, Properties and Applications, Vols 1 and 2, Wiley-VCH, Weinheim, 2004.

## BCH-606: Organic Spectroscopy

**L-T-P: 2-1-0** **Credit: 3**

### Unit-1: UV-Visible spectroscopy

Electronic transitions (σ-σ*, n-σ*, π-π*, n-π* transitions), absorption maximum and absorption intensity considering conjugative effect, steric effect, solvent effect, red shift (bathocromic shift), blue shift(hypsochromic shift), hyperchromic effect, hypochromic effect (typical examples), Woodward rule with reference to conjugated system like dienes, trienes and α,β-unsaturated carbonyls including cyclic systems.

### Unit-2: Infra Red spectroscopy

Hooke's law, stretching and bending vibrations, characteristic and diagnostic stretching frequencies, factors affecting stretching frequencies (H-bonding, mass effect, electronic factor, bond multiplicity, ring size), finger-print region, diagnostic bending frequencies for benzene and its *o*-, *m*- and *p*-isomers.

### Unit-3: $^{1}$H NMR spectroscopy

Principle, nuclear spin, NMR-active nuclei, chemically equivalent and nonequivalent protons; chemical shift, upfield and downfield shifts; shielding/deshielding of protons in systems involving C-C, C=O, C=C, benzene, cyclohexane; spin-spin splitting with reference to $CH_3CH_2Br$, $CH_3CH_2OH$, $Br_2CHCH_2Br$; characteristic $^{1}$H NMR signals of simple molecules.

***Application of the above spectroscopic methods in structure elucidation of simple organic molecules.***

### Recommended Books


1. W. Kemp, Organic Spectroscopy
2. R. M. Silverstein and F.X. Webster, Spectroscopic Identification of Organic Compounds, 6th Edition (2003) John Wiley, New York.
3. D. H. Williams and I.F. Fleming, Spectroscopic Methods in Organic Chemistry, 4th Edition (1988), Tata-McGraw Hill, New Delhi.
4. W. Kemp, NMR in Chemistry-A Multinuclear Approach.