# Kuvempu University
# Department of Chemistry
# M.Sc. Chemistry Syllabus – 2019-2020 (CBCS Scheme)
### M.Sc. Course Pattern and Scheme of Examination under CBCS approved by PG-BOS in Chemistry held on 25-01-2019

## Course Pattern:

| Semester | Theory code | Hrs/Week | Credits | Practicals code | Hrs/Week | Credits | Total Credits per Semester |
|---|---|---|---|---|---|---|---|
| | **Hard core** | | | | | | |
| | ChHC-1.1 | 4 | 4 | ChHCL-1.1 | 4 | 2 | |
| **I** | ChHC-1.2 | 4 | 4 | ChHCL-1.2 | 4 | 2 | |
| | ChHC-1.3 | 4 | 4 | ChHCL-1.3 | 4 | 2 | |
| | ChHC-1.4 | 4 | 4 | | | | **22** |
| | **Hard core** | | | | | | |
| | ChHC-2.1 | 4 | 4 | ChHCL-2.1 | 4 | 2 | |
| | ChHC-2.2 | 4 | 4 | ChHCL-2.2 | 4 | 2 | |
| **II** | ChHC-2.3 | 4 | 4 | ChHCL-2.3 | 4 | 2 | |
| | ChHC-2.4 | 4 | 4 | | | | |
| | **Elective** | | | | | | |
| | ChEL-2.1 | 2 | 2 | | | | **24** |
| | **Soft core** | | | | | | |
| | ChSC-3.1 | 4 | 4 | ChSCL-3.1 | 4 | 2 | |
| | ChSC-3.2 | 4 | 4 | ChSCL-3.2 | 4 | 2 | |
| **III** | ChSC-3.3 | 4 | 4 | ChSCL-3.3 | 4 | 2 | |
| | ChSC-3.4 | 4 | 4 | | | | |
| | **Elective** | | | | | | |
| | ChEL-3.1 | 2 | 2 | | | | **24** |
| | **Soft core** | | | | | | |
| | ChSC-4.1 | 4 | 4 | - | - | - | |
| | ChSC-4.2 | 4 | 4 | - | - | - | |
| | ChSC-4.3 | 4 | 4 | - | - | - | |
| **IV** | ChSC-4.4 | 4 | 4 | | | | |
| | **Project Work** ChPR-4.1 | 8 | 4 | | | | **20** |
| **Total Credits : I - IV SEMESTER (90) + Soft Skills (03) = 93** | | | | | | | |

## Theory and Practicals (M.Sc. in Chemistry - CBCS):

ChHC-1.1: Analytical Chemistry-I
ChHC-1.2: Inorganic Chemistry-I
ChHC-1.3: Organic Chemistry-I
ChHC-1.4: Physical Chemistry-I

ChHCL-1.1: Inorganic Chemistry Practicals-I
ChHCL-1.2: Organic Chemistry Practicals-I
ChHCL-1.3: Physical Chemistry Practicals-I

ChHC-2.1: Analytical Chemistry-II
ChHC-2.2: Inorganic Chemistry-II
ChHC-2.3: Organic Chemistry-II
ChHC-2.4: Physical Chemistry-II
ChEL-2.1: Chemistry Elective-I

ChHCL-2.1: Inorganic Chemistry Practicals-II
ChHCL-2.2: Organic Chemistry Practicals-II
ChHCL-2.3: Physical Chemistry Practicals-II

ChSC-3.1: Analytical Chemistry-III
ChSC-3.2: Inorganic Chemistry-III
ChSC-3.3: Organic Chemistry-III
ChSC-3.4: Physical Chemistry-III
ChEL-3.1: Chemistry Elective-II

ChSCL-3.1: Inorganic Chemistry Practicals-III
ChSCL-3.2: Organic Chemistry Practicals-III
ChSCL-3.3: Physical Chemistry Practicals-III

ChSC-4.1: Analytical Chemistry-IV
ChSC-4.2: Inorganic Chemistry-IV
ChSC-4.3: Organic Chemistry-IV
ChSC-4.4: Physical Chemistry-IV
ChPR-4.1: Project Work

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## Department of Chemistry
## M.Sc. Chemistry Syllabus – 2019-2020 (CBCS Scheme)
### M.Sc. Course Pattern and Scheme of Examination under CBCS approved by PG-BOS in Chemistry held on 25-01-2019.

## Examination Pattern:

| Theory | | | | | | Practical | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Semester** | **Paper** | **Duration (hrs)** | **Max. Marks** | **IA** | **Total** | **Paper** | **Duration (hrs)** | **Max. Marks** | **IA** | **Total** |
| **I** | ChHC-1.1 | 3 | 75 | 25 | 100 | ChHCL-1.1 | 4 | 50 | - | 50 |
| | ChHC-1.2 | 3 | 75 | 25 | 100 | ChHCL-1.2 | 4 | 50 | - | 50 |
| | ChHC-1.3 | 3 | 75 | 25 | 100 | ChHCL-1.3 | 4 | 50 | - | 50 |
| | ChHC-1.4 | 3 | 75 | 25 | 100 | | | | | |
| **Total** | | | | | **400** | | | | | **150** |
| **II** | ChHC-2.1 | 3 | 75 | 25 | 100 | ChHCL-2.1 | 4 | 50 | - | 50 |
| | ChHC-2.2 | 3 | 75 | 25 | 100 | ChHCL-2.2 | 4 | 50 | - | 50 |
| | ChHC-2.3 | 3 | 75 | 25 | 100 | ChHCL-2.3 | 4 | 50 | - | 50 |
| | ChHC-2.4 | 3 | 75 | 25 | 100 | | | | | |
| | ChEL-2.1 | 1.5 | 40 | 10 | 50 | | | | | |
| **Total** | | | | | **450** | | | | | **150** |
| **III** | ChSC-3.1 | 3 | 75 | 25 | 100 | ChSCL-3.1 | 4 | 50 | - | 50 |
| | ChSC-3.2 | 3 | 75 | 25 | 100 | ChSCL-3.2 | 4 | 50 | - | 50 |
| | ChSC-3.3 | 3 | 75 | 25 | 100 | ChSCL-3.3 | 4 | 50 | - | 50 |
| | ChSC-3.4 | 3 | 75 | 25 | 100 | | | | | |
| | ChEL-3.1 | 1.5 | 40 | 10 | 50 | | | | | |
| **Total** | | | | | **450** | | | | | **150** |
| **IV** | ChSC-4.1 | 3 | 75 | 25 | 100 | | | | | |
| | ChSC-4.2 | 3 | 75 | 25 | 100 | | | | | |
| | ChSC-4.3 | 3 | 75 | 25 | 100 | | | | | |
| | ChSC-4.4 | 3 | 75 | 25 | 100 | | | | | |
| | ChPR-4.1 | Project Report | 75 | - | 75 | | | | | |
| | | Project Viva | 25 | - | 25 | | | | | |
| **Total** | | | | | **500** | | | | | |
| **Theory + Project Marks: 1800** | | | **Practical Marks: 450** | | | **Total Marks: 2250** | | **Total credits 90** | | |

# Question Paper Pattern – 2019-2020
# M.Sc. Examination
# (CBCS Scheme)
# CHEMISTRY

Paper Title and Code:

Time: 3hrs] [Max. Marks: 75

Note: 1) Answer Part-A and any FIVE questions from Part-B.
2) Figures to the right indicate marks.

**PART - A**

1. Answer the following:

a), b), c), d), e), f), g), h), i) and j) 10 x 2 = 20

**PART – B**

(Answer any FIVE questions) 5 x 11 = 55

| | | | |
|---|---|---|---|
| 2. | a) | 5 Marks | a) 4 Marks |
| | b) | 6 Marks | b) 7 Marks |
| 3. | a) | 5 Marks | a) 4 Marks |
| | b) | 6 Marks | b) 7 Marks |
| 4. | a) | 5 Marks | a) 4 Marks |
| | b) | 6 Marks | b) 7 Marks |
| 5. | a) | 5 Marks | a) 4 Marks |
| | b) | 6 Marks | b) 7 Marks |
| 6. | a) | 5 Marks | a) 4 Marks |
| | b) | 6 Marks | b) 7 Marks |
| 7. | a) | 5 Marks | a) 4 Marks |
| | b) | 6 Marks | b) 7 Marks |
| 8. | a) | 5 Marks | a) 4 Marks |
| | b) | 6 Marks | b) 7 Marks |
| 9. | a) | 5 Marks | a) 4 Marks |
| | b) | 6 Marks | b) 7 Marks |

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# Question Paper Pattern - 2019-2020
# M.Sc. Examination
# (CBCS Scheme)
# CHEMISTRY (Elective Paper)

Paper Title and Code:

Time: 1 ½ hrs] [Max. Marks: 40

Note: 1) Answer Part-A and any THREE questions from Part - B
2) Figures to the right indicate marks.

**PART - A**

1. Answer the following: (At least 03 Questions should be selected from each Unit)
a), b), c), d), e) 5 x 2 = 10

**PART – B**

(Answer any THREE questions) 3 x 10 = 30

| | | | |
|---|---|---|---|
| 2. | a) | 5 Marks | a) 4 Marks |
| | b) | 5 Marks | b) 6 Marks |
| 3. | a) | 5 Marks | a) 4 Marks |
| | b) | 5 Marks | b) 6 Marks |
| 4. | a) | 5 Marks | a) 4 Marks |
| | b) | 5 Marks | b) 6 Marks |
| 5. | a) | 5 Marks | a) 4 Marks |
| | b) | 5 Marks | b) 6 Marks |
| 6. | a) | 5 Marks | a) 4 Marks |
| | b) | 5 Marks | b) 6 Marks |

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## M.Sc. Chemistry Syllabus - 2019-2020 (CBCS Scheme)
## Revised Regulations -2010
# I - SEMESTER
# ChHC-1.1: ANALYTICAL CHEMISTRY - I

**Total: 64 hrs**

**UNIT-I: EVALUTION OF ANALITYCAL DATA 16 hrs**

Relevance of analytical chemistry, classification of analytical methods – qualitative, quantitative, instrumental, non-instrumental methods. Limitations of analytical methods, classification of errors (to be discussed in brief), normal error curve and its significance. Accuracy, precision, average deviation, standard deviation, coefficient of variance, reliability of results, confidential interval, comparison of results (student's t-test, F-test), comparing the mean of two samples, paired t-test, number of replicable determinations, correlations and regression, linear regression, errors in the slope and intercept, error in the estimation of concentration, standard additions, non-linear regression, comparison of more than two means, experimental design, two-way analysis of variance, chemometrics and experimental design, factorial design, Yates' method, interaction effect – alternative calculation, factorial design – critical appraisal, optimization methods, sequential simplex optimization, critical appraisal, treatment of multivariate data, factor analysis, quick statistics.

**Sampling:** Sampling techniques, sampling statistics, variability in the sample, sample stability, regulation and legislation, terminology of sampling, methods of sampling for gases (vapours), liquids and solids, effects of sampling uncertainties, sampling hazardous. Need for quality assurance; ISO 9000 series of quality system. Significance and importance of six sigma concepts in maintaining the quality.

**UNIT-II: TITRIMETRIC AND GRAVIMETRIC METHOD OF ANALYSIS 16 hrs**

**Titrimetry:** Theoretical considerations, titrimetry, theory of indicators, indicator action, preparation of indicator solutions, metal ion indicators, mixed indicators, primary and secondary standard solutions and their preparations. Classification of reactions in titrimetric analysis, neutralization titrations (strong acid-strong base, weak acid-strong base, weak base-strong acid, weak acid-weak base, polyprotic acid-strong base), choice of indicators in neutralization reactions, titrations in non-aqueous solvents, indicators for non-aqueous titrations, complexation titrations – EDTA titrations (direct and back titrations, titration of mixture of ions), precipitation titrations, detection of end point in precipitation titrations, oxidation-reduction titrations, detection of end point in redox titrations.

**Gravimetry:** General principles, requirement for quantitative separations, the process of precipitation, saturated and supersaturated solutions, nucleation, crystal growth, conditions of precipitation, completeness of precipitation, factors influencing solubility of precipitate, purity of precipitate, effect of digestion, adsorption of ions on precipitates, co-precipitation, occlusion and post-precipitation, Gravimetric estimations of – chloride as silver chloride, calcium as calcium oxalate, iron as ferric oxide, nickel as nickel-DMG.

**UNIT-III: ELECTROANALYTICAL TECHNIQUES** **16 hrs**

Introduction, electrochemical cells, electrical double layer, faradic and non-faradic current, mass transfer in cells, schematic representation of cells, galvanic and electrolytic cells, anodes and cathodes, potentials in electroanalytical cells, thermodynamics of cell potentials, liquid junction potential, electrode potentials, nature of electrode potentials, standard electrode potentials, standard hydrogen electrode (SHE), standard calomel electrode (SCE). Classification of electroanalytical techniques.

Polarography: Theory, principle and applications classical polarography, dropping mercury electrode, polarogram, polarographic measurements, polarographic current, Ilkovic equation, current and concentration relationship, half wave potential, oxygen interference- advantages and limitations. Qualitative and quantitative analysis. Derivative polarography.

Amperometry, amperomtric titrations, Coulometry at controlled potential and at constant current.

Cyclic voltammetry-basic principles, cyclic voltammogram of $K_4[Fe(CN)_6]$ system , irreversible and quasi-reversible curves, instrumentation and applications.

Electrogravimetry: Theory, electrode reactions, over-voltage, characteristics of a good deposit, completeness of deposition, separation of metals at controlled cathode potential. Estimation of copper and nickel in Cu-Ni alloy.

**UNIT-IV: CHROMATOGRAPHIC TECHNIQUES - I** **16 hrs**

General description of chromatography- classification, chromatograms, retention time, relation retention factor, capacity factor, selectivity factor, band broadening and column efficiency, methods for describing column efficiency - plate theory. Theory of band broadening, van Deemter equation, column resolution, variables affecting column resolution.

**Paper Chromatography (PC):** Principle, $R_f$, $R_x$ and $R_G$ values, techniques of paper chromatography, two-dimensional paper chromatography, visualization and evaluation of chromatograms, quantitative estimations, sources of errors, precautions, applications, experimental paper chromatography.

**Thin-layer Chromatography (TLC):** Superiority of TLC, theory of TLC, techniques of TLC, applications.

**Gas Chromatography:** Introduction, an overview of GSC and GLC, instrumentation, hyphenated techniques in Gas chromatography (GC-MS), derivative gas chromatography, pyrolysis gas chromatography – advantages and applications. **HPLC:** Introduction, superiority of HPLC, instrumentation, applications.

**Super critical fluid chromatography (SFC):** Instrumentation of SFC, comparison of SFC with HPLC and GLC.

**Ion-Exchange chromatography (IEC):** Ion-exchangers, cation-exchange resins, anion-exchange resins, ion-exchange mechanism, factors affecting ion-exchange equilibrium, ion-exchange capacity, affinity scale, instrumentation, techniques for ion-exchange, liquid ion-exchanger, applications of IEC, experimental IEC.

**REFERENCES:**


1. **Vogel's Textbook of Quantitative Chemical Analysis**, J. Mendham, R.C. Denney, J.D. Barnes, M. Thomas, B. Sivasankar, 6th Edition, Pearson Education, New Delhi, India, 2012.
2. **Instrumental methods of Chemical Analysis (covering UGC Syllabus),** H. Kaur, Pragathi Prakashan, New Delhi, India
4. **Quantitative Chemical Analysis,** Daniel C. Harris, 6th Edition, W.H. Freeman and Company, New York, USA, 2003.
5. **Fundamentals of Analytical Chemistry**, D.A. Skoog, D.M. West, E.J. Holler, S.R. Crouch, 8th Edition, Thomson Aisa Pvt. Ltd., Singapore, 2004.
6. **Instrumental Analysis**, D.A. Skoog, E.J. Holler, S.R. Crouch, 11th Indian Reprint, Cengage Learning India Pvt. Ltd., New Delhi, 2012.
7. **Analytical Chemistry – Theory and Practice,**, R.M. Verma, 3rd Edition, CBS Publishers and Distributors, New Delhi, India, 2007.
8. **Quantitative Analysis,** Day and Underwood, Prentice/Hall Pvt. Ltd. 6th Edition (1993).
9. **Vogel's text Book of Quantitative Chemical Analysis,** Revised by G.H. Jaffery, J. Bassett, J. Mendhrn and R.C. Denny, ELBS 5th Edition (1998).
10. **Analytical Chemistry,** Gray D. Christian, 5th Edition, John Wiley and Sons, Inc
11. **Introduction to Chromatography- Theory and Practice,** V.K. Srivatsan and K.K. Srivatsan, S. Chand Company Ltd. 4th Edition (1991).


# ChHC-1.2: INORGANIC CHEMISTRY - I

**Total: 64 hrs**

**UNIT-I: PERIODIC PROPERTIES OF ELEMENTS** **16 hrs**

A brief review of – division of elements into *s, p, d* and *f*- blocks. Atomic properties, covalent radius, periodic trends in covalent radii, Van der Waals radius, ionic radius, periodic properties.

**Chemistry of transition metals:** d-Block elements, electronic configuration, general characteristics and correlation with electronic configuration, comparative study of 3d, 4d and 5d elements by taking titanium sub-group as example.

**Chemistry of inner-transition metals:** Lanthanides series **- g**eneral characteristics of lanthanides. Extraction of a mixture of lanthanides from monazite sand, separation of lanthanides by – fractional crystallization and precipitation, solvent extraction, change of oxidation states, ion exchange chromatography and complex formation methods. Uses of lanthanides. Lanthanum compounds – lanthanum oxide, halids, chloride, bromide, iodide, sulphate, nitrate and carbonate.

Actinide series – Introduction, electronic configuration, sources of actinides, properties of actinides – oxidation states, ionic radii, colour, formation of actinides compounds. Comparison of actinides with lanthanides. Magnetic properties of lanthanides and actinides. Absorption spectra of lanthanides and actinides.

Trans-uranium elements, further extension of periodic table, super heavy elements (SHE).

**UNIT-II: CHEMICAL BONDING** **16 hrs**

Introduction, brief review of – octet rule, ionic bond, electrovalence, inert pair effect, covalent bond, maximum covalency rule and its applications, failure of octet rule. Valence bond theory, Heitler – London theory, Pauling – Slater's theory, orbital overlap theory, sigma and pi-bonds,

non-polar and polar covalent bonds. Coordinate bond, concept of resonance, polarization of ions, Fajan's rules, variation of acidic, amphoteric and basic character of the oxides and hydroxides of elements of group IIIA, bond length, bond energy, Pauling's formula, odd-electron bonds, odd-electron molecules and ions.

**Molecular orbital theory (MOT)**: Salient features of MOT, variation of electron-charge density with inter-nuclear distance in $H_2$ molecule, characteristics of bonding and anti-bonding molecular orbitals, comparison between - i) bonding and anti-bonding molecular orbitals, ii) sigma and pi molecular orbitals, iii) atomic and molecular orbitals, bond order, molecular orbital configuration of $H_2$, $H_2^+$, $H_2^-$, $He_2$, determination of molecular orbital configuration of $A_2$ type species ($Li_2$, $Be_2$, $B_2$, $C_2$, $N_2$, $N_2^+$, $O_2$, $O_2^+$, $O_2^-$, $O_2^{2-}$, $F_2$, $Ne_2$), molecular orbital configuration of CO, CN, $CN^-$, NO, $NO^+$, $NO^{2+}$, $NO^-$, HF species, Coulson molecular orbital configuration of CO and $NO^+$, comparison between VBT and MOT.

**UNIT-III: VALENCE-SHELL ELECTRON-PAIR REPULSION THEORY 16 hrs**

Postulate of VSEPR theory, hybridization, structure and geometry of – $AB_2$ type species ($BeCl_2$, $CO_2$), $AB_3$ type species ($BCl_3$, $SO_3$), $AB_4$ type species ($CH_4$, $NH_4^+$, $SO_4^{2-}$), $AB_5$ type species ($PF_5$), $AB_2(lp)$ type species ($SnCl_2$, $PbCl_2$, $SO_2$), $AB_3(lp)$ type species ($NH_3$, $PH_3$, $PCl_3$, $ClO_3^-$,), $AB_2(lp)_2$ type species ($H_2O$, $SCl_2$, $SeCl_2$, $NH_2^-$, $ICl_2^+$), $AB_4(lp)$ type species ($SF_4$, $TeCl_4$, $SeCl_4$), $AB_3(lp)_2$ type species ($ClF_3$, $BrF_3$, $ICl_3$, $IF_3$), $AB_2(lp)_3$ type species ($XeF_2$, $ICl_2^-$), $AB_5(lp)$ type species ($IF_5$, $BrF_5$, $ClF_5$, $[SbF_4]^{2-}$), $AB_4(lp)_2$ type species ($XeF_4$, $ICl_4^-$).

Formation of adducts ($H_3N\rightarrow BF_3$, $H_2S\rightarrow BF_3$), hybridization, structure and geometry of inter-halogen compounds (ICl, $ClF_3$, $(ICl_3)_2$, $IF_5$, $IF_7$), structure and geometry of xenon compounds ($XeF_2$, $XeF_4$, $XeF_6$, $XeO_3$, $XeO_4$, $XeOF_4$, $XeO_2F_2$, $XeO_3F_2$, $XeO_3F_4$). Structure and geometry of –, $PCl_6^-$, $P_2O_5$, $P_2O_{10}$, SOCl, $SO_2Cl$, $SnCl42^-SnF_6^{2-}$, $AlF_6^-$, $SbF_5^{2-}$, $SbF_6^{3-}$, $SeO_2$, $SeO_3$, $TeO_2$, $TeO_3$, $PoO_3$.

**UNIT-IV: STRUCTURE OF SOLIDS 16 hrs**

**Structure of solids:** Introduction, brief review of classification of solids (true, pseudo, crystalline, polycrystalline and amorphous solids). Properties of solids – conductors, insulators and semiconductors (*n*-type and *p*-type extrinsic semiconductors), superconductivity and super conducting materials, Magnetic properties – paramagnetic, diamagnetic, ferromagnetic, anti-ferromagnetic and ferromagnetic substances, dielectric properties, ionic crystals, metallic crystals, atomic and covalent crystals, molecular crystals. Isomorphism and Mitcherlich's law of isomorphism, allotropy, structure and type of ionic crystals – AB type (NaCl, ZnS, CsCl), $AB_2$ type ($CaF_2$, $TiO_2$, $CaC_2$, $FeS_2$), $A_2B$ type ($Na_2O$). Lattice energy, Born-Lande equation, salvation process and salvation energy, hydration process and hydration energy, hydration process and hydration energy, stoichiometric and non-stoichiometric crystals, defects in crystals, atomic and point defects, Schottky and Frenkel defects, non-stoichiometric defects, normal spinal structure, inverse spinel structure.

**REFERENCES:**


1. ***Inorganic Chemistry – Principles of Structure and Reactivity***, James E. Huheey, Ellen A. Keiter, Richard L. Keiter, Okhil K. Medhi, 4th Edition, Pearson Education, Indian Edition, New Delhi, India, 2013.
2. ***Inorganic Chemistry,*** Peter Atkins,Tina Overton, Jonathan Rourke, Mark Weller, Fraser Armstrong, 5th Edition, Oxford University Press, UK, 2013.

3. ***Inorganic Chemistry – Principles of Structure and Reactivity***, James E. Huheey, Ellen A. Keiter, Richard L. Keiter, 4th Edition, Pearson, Indian Edition, New Delhi, India, 2004.
4. ***Inorganic Chemistry,*** Gary L. Miessler, Donald A. Tarr, 3rd Edition, Pearson Education, New Delhi, India, 2004.
5. ***Inorganic Chemistry,*** Keith F. Purcell, John C. Kotz, First Indian Reprint, Cengage Learning India Pvt. Ltd., New Delhi, India 2010.
6. ***Concise Inorganic Chemistry,*** 5th Edition, J.D. Lee, Blackwell Science Ltd., London, 2003.
7. ***Advanced Inorganic Chemistry, Volume-I,*** Satya Prakash, G.D. Tuli, S,K, Basu, R.D. Madan, S. Chand and Company, New Delhi, India, 2008.
8. ***Principles of Inroganic Chemistry (UGC Syllabus)***, B.R. Puri, L.R. Sharma, K.C. Kalia, Milestone Publishers, New Delhi, India, 2008.
9. ***Inorganic Chemistry,*** James E. House, First Indian Reprint, Academic Press, USA, 2010.
10. ***Basic Concepts of Inorganic Chemistry,*** D.N. Singh, Pearson Education, New Delhi, 2010.
11. ***Advance Inorganic Chemistry,*** F. Albert Cotton, Geoffrey, Wilkinson, Carlos A. Murillo, Manfred Bochmann, 6th Edition, Wiley Student Edition, John Wiley and Sons, INC, New York, 2004.
14. ***Environmental Chemistry,*** A.K. De, 6th Edition, New Age International Publishers, New Delhi, India, 2008.
15. ***Environmental Pollution Analysis,*** S.M. Khopkar, Wiley International Publishers.

## ChHC-1.3: ORGANIC CHEMISTRY - I

**Total: 64 hrs**

### UNIT-I: BASIC ASPECTS OF ORGANIC STRUCTURES AND PROPERTIES

**16 hrs**

**Electron delocalization and Resonance:** Delocalized electron in conjugated systems, resonance hybrid, resonance energy, stability of allylic and benzylic cations and radicals, effect of delocalized electrons on $pK_a$.

**Aromaticity:** Concept of aromaticity, Huckel's rule, aromaticity of benzene, dienes, cyclopentadienyl anion, tropylium cation, cyclopropenyl cation, annulenes, azulene, heterocyclic compounds. Aromatic dications and dianions. Aromaticity due to polar structure. Concept of homoaromatic, nonaromatic and antiaromatic compounds.

**Aromatic Electrophilic Substitutions**: Arenium ion mechanism, Nitration, Sulphonation, Halogenation,Friedel-Crafts alkylation and acylation, Diazo-coupling, Vilsmeir Hack reaction, Gatterman Koch reaction, Von Richter rearrangement and their applications in organic synthesis.

Energy profile diagrams. Orientation and reactivity. Effect of substituent's on aromatic ring system.

**UNIT-II: REACTION INTERMEDIATES** **16 hrs**

**Reactive intermediates:** Formation, structure, stability and reactions of carbocations, carbanions, free radicals, carbenes, nitrenes, arynes, ylides (phosphorous and sulphur ylides) and enamines with representative examples.

**Methods of determining reaction mechanisms**: Kinetic method, identification of products, detection of intermediates, study of catalysts, isotopic labeling, cross-over experiments and stereochemical evidences with suitable examples.

**Aliphatic Nucleophilic Substitution**: The $SN^1$ $SN^2$ and SET mechanisms. The neighbouring group mechanism. Classical and nonclassical carbocations, phenonium ions, norbornyl system, common carbocation rearrangements. The $SN^i$ mechanism. Nucleophilic substitution at an allylic, aliphatic trigonal and a vinyl carbon. Reactivity effects of substrate structure, attaching nucleophile, leaving group and reaction medium. **Electrophilic Substitution**: E1, SE2 and SEi. The SE1mechanism, electrophilic substitution accompanied by double bond shifts. Effect of substrates, leaving group and the solvent polarity on the reactivity.

**UNIT-III: ADDITION AND ELIMINATION REACTIONS** **16 hrs**

**Addition Reactions:** Addition to carbon-carbon and carbon-hetero atom multiple bonds. Addition involving electrophiles, nucleophiles and free radicals, concerted addition. Mechanism, orientation and stereochemistry of addition reactions. Addition of hydrogen halides to alkenes. Addition of HCN, bisulphate, Grignard reagent, hydride, amino compounds, alcohols and thioalcohols to C=O. Acid catalyzed hydration and related addition reactions. Addition of halogens, sulphenylation and selenenylation. Addition reactions involving epoxides – epoxide from alkenes and peroxidic reagents, subsequent transformation of epoxides.

**Elimination Reactions:** $E_1$, $E_2$ and $E_{1CB}$ reactions, regioselectivity in β-elimination reactions (orientation of π-bonds), and stereochemistry requirement in β-elimination reactions. Saytzeff and Hoffmann rules, elimination vs substitution, $E_1$, $E_2$ and $E_{1CB}$ comparative study, 1,1-elimination (α-elimination) - dehalogenation of vicinal dihalides, elimination reactions without involving hydrogen like dehalogenations and related reactions, decarboxylative eliminations. Pyrolytic eliminations; Chugaev and Cope eliminations.

**UNIT-IV: STEREOCHEMISTRY** **16 hrs**

**Stereoisomerism:** Introduction, molecular structure – projection formulas (Fischer, Newmann, Sawhorse and Flying wedge), interconversion of projection formulas. Molecular symmetry and symmetry elements. Chirality and steroisomerism. Enatiomers, diastereomers, epimers, anomers (definition and examples). Racemic mixture, Racemisation involving - carbonanion, carbocation as intermediates, Walden inversion, rotation about carbon-carbon single bond. Resolution (racemic modification) – mechanical separation, preferential crystallization, biochemical,

chemical and chromatographic method. D,L-configuration threo, erythro – configuration. R,S-nomenclature for isomers with more than one chirality centre.

**Optical isomerism**: Conditions for optical isomerism: Elements of symmetry-plane of symmetry centre of symmetry, alternating axis of symmetry (rotation-reflection symmetry). **Optical isomerism due to molecular dissymmetry**: Eg. allenes, spiranes, biphenyls, alkylidine and cycloalkanes.

**Geometrical isomerism**: Due to C=C, C=N and N=N bonds, *E, Z* conventions, determination of configuration by physical and chemical methods. Geometrical isomerism in cyclic systems.

**Conformational analysis**: Elementary account of conformational equilibria of ethane, butane and cyclohexane. Conformation of cyclic compounds such as cyclopentane, cyclohexane, cyclohexanones and decalins. Conformational analysis of 1,2-, 1,3- and 1,4- disubstituted cyclohexane derivatives and their effect on the course and rate of reactions with examples.

Meaning and examples of stereospecific reactions, stereoselective reactions, diastereoselective reactions, regioselective reactions, and enantioselective reactions with examples.

**REFERENCES:**


1. ***Organic Chemistry***, J. Clayden, S. Warren, N. Greeves, P. Wothers, 1st Edition, Oxford University Press, UK, 2001.
2. ***Organic Chemistry – Solution Mannual***, S. Warren, Oxford University Press, UK, 2009.
3. ***Advanced Organic Chemistry, Part-A: Structure and Mechanisms,*** 5th Edition, Francis A. Carey, Richard J. Sundberg, Springer, New York, 2007.
4. ***Principles of Organic Synthesis***, R.O.C. Norman, J.M. Coxon, 3rd Edition (First Indian Reprint), Nelson Thrones, UK, 2003.
5. ***Advance Organic Chemistry – Reactions, mechanisms and structure***, Jerry March, 4th Edition, Wiley India Pvt. Ltd., New Delhi, 2008.
6. ***Organic Reaction Mechanisms,*** V.K. Ahluwalia, R.K. Parashar, 3rd Edition, Narosa Publishing House, New Delhi, 2009.
7. ***Pathway to Organic Chemistry – Structure and Mechanism***, P. Bhattacharjee, Arunabha Sen Books and Allied Pvt. Ltd., Kolkta, India, 2012.
8. ***Organic Chemistry,*** Paula Yurkanis Bruice, 3rd Edition, Pearson Education, Sai Printo Pack Pvt. Ltd., New Delhi, India, 2007.
9. ***Organic Chemistry (As per UGC Syllabus),*** S.M. Mukherji, S.P Singh, R.P. Kapoor, R. Dass, Vol. I, New Age International Pvt. Ltd., New Delhi, 2010.
10. **Stereochemistry of Organic Compounds – Principles and applications**, D. Nasipuri, Revised 2nd Edition, New Age International Pvt. Ltd., New Delhi, 2009.
11. ***Organic Reactions and their Mechanisms,*** P.S. Kalsi, 2nd Edition, New Age International Pvt. Ltd., New Delhi, 2007.
12. ***Organic Chemistry,*** Solomons, Fryhle, 8th Edition (Wiley Student Edition), Brijbasi Art Press Ltd., Noida, India 2004.
13. ***Organic Chemistry***, G. Marc Loudon, 4th Edition, Oxford University Press, UK, 2000.
14. ***Organic Chemistry,*** R.T. Morrison, R.N. Boyd, 6th Edition, Pearson Education (Singapore Pvt. Ltd.), Delhi, Indian, 2005.
15. ***Organic Chemistry***, L.G. Wade, JR., 5th Edition, Pearson Education (Singapore Pvt. Ltd.), Delhi, Indian, 2004.
16. ***Organic Chemistry***, M.A. Fox, J.K. Whitesell, 2nd Edition, Jones and Bartlett Publishers, Sudbury, Massachusetts, London, 1997.

17. ***Organic Chemistry***, M. Jones, Jr., 2nd Edition, W.W. Norton and Company, New York, 2000.
18. ***Organic Chemistry,*** Francis A. Carey, 5th Edition, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2004.
19. ***Modern Methods of Organic Synthesis,*** W. Carruthers, 3rd Edition, Cambridge University Press, UK, 2004.

# ChHC-1.4: PHYSICAL CHEMISTRY - I

**Total: 64 hrs**

**UNIT-1: THERMODYNAMICS** **16 hrs**

The laws of thermodynamics (Statements and significances), concepts of free energy, enthalpy and entropy, thermodynamic criteria for equilibrium and spontaneity, variation of free energy with temperature and pressure. Maxwell's relations (Derivations), thermodynamic equations of state (Derivations), principle of equipartition energy. Entropy of vapourisation and Trauton's rule, limitations of Van't Hoff's equation, Nernst heat theorem, determination of free energy change. Third law of thermodynamics, determination of third law entropies, concepts of residual entropy.

Thermodynamics of systems of variable compositions, partial molar properties, partial molar volume and its determination (Intercept method), partial molar free energy – chemical potential and its significance, Gibbs-Duhem equation, thermodynamics of ideal and real gases and gas mixtures. Fugacity - its variation and determination, activity and activity coefficient. Gibbs-Duhem-Margules equation and its application. Thermodynamics of ideal and non-ideal dilute solutions.

**UNIT-I: STATISTICAL THERMODYNAMICS** **16 hrs**

Maxwell-boltzmann distribution law (sterling's approximations), Types of statistics - Maxwell-Boltzmann, Bose-Einstein, Fermi-Dirac statistics. Evaluation of Lagrange's undetermined multipliers, Molecular partition function for an ideal gas, evolution of translational, rotational, vibration, electronic and nuclear partition functions. Thermodynamic properties in terms of the partition function. Thermodynamic properties of an ideal monoatomic gas and diatomic gas. Molar partition function of a system. Partition function of a real gas. Calculation of thermodynamic functions and equilibrium constant in terms of partition functions. Entropy of mono atomic gas, Sackur-Tetrode equation. Comparison of third law and statistical entropies.

Statistical thermodynamic properties of solids, thermal characteristics of crystalline solid, heat capacities of monoatomic crystals, Einstein theory of heat capacity, Debye theory of heat capacity, Debye-$T^3$ law.

**UNIT-III: CHEMICAL DYNAMICS** **16 hrs**

The rate of reactions, the rate law and the rate constant, order of a reaction, integration of rate expressions [first, second, third and zero order reactions], half-life of a reaction, methods of determining order of a reaction [differential, integral, half-life and isolation methods], order and molecularity of a reaction, mechanism of complex reactions, collisions and encounters, effect of temperature and catalyst on reaction rates, the Arrhenius equation. Theories of reaction rates [collision theory and activated complex theory of bimolecular gaseous reactions], the Erying

equation, the Lindemann theory of unimolecular gaseous reactions. Kinetics of complex reactions [reversible, consecutive, and chain reactions].
Kinetics of reactions in solution [diffusion controlled reactions-the Debye-Smoluchowski equation]. Influence of ionic strength and solvent on reaction rates. Kinetic isotopic effects. Kinetics of fast reactions: flow methods, pulse method, flash photolysis method, pulse radiolysis method, relaxation method (Temperature-Jump Method), Femtochemistry.

**UNIT-IV: ELECTROCHEMISTRY** **16 hrs**

Electrolytic solutions, . Activity and activity coefficients, mean ionic activity coefficient, dependence of activity coefficients on ionic strength (Debye - Huckel limiting law), Debye - Huckel equation for appreciable concentration [Debye - Huckel - Bronsted equation].
Thermodynamics of electrolytic cells, polarization and over voltage, decomposition potential. Half cell reactions, reversible electrodes, single electrode potential, standard electrode potentials, electrochemical series, Nernst equation. Electrochemical energy systems - introduction, fundamentals of batteries, dry cell, alkaline $MnO_2$ batteries and other secondary batteries, Lead acid and alkaline storage batteries. Battery charging-theory and practice. Energy economics, Fuel cells – types, electrochemistry of fuel cells.

## REFERENCES:


1. ***Quantum Chemistry***, R.K. Prasad, 4th Edition, New Age International Publishers, New Delhi, 2010.
2. ***Quantum Mechanics for Chemists***, David O. Hayward, The Royal Society of Chemistry, UK, 2002.
3. ***Principles of Physical Chemistry (Comprehensive UGC Syllabus)***, B.R. Puri, L.R. Sharma, M.S. Pathania, 46th Edition, Vishal Publishing House, Jalandhar, India, 2012.
4. ***Physical Chemistry – A Molecular Approach***, Donald A. McQuarrie, John D. Simon, 3rd Edition (Viva Student Edition), Viva Books Pvt. Ltd., New Delhi, 2011.
5. ***Elements of Physical Chemistry***, B.R. Puri, L.R. Sharma, M.S. Pathania, 1st Edition, Vishal Publishing House, Jalandhar, India, 2013.
6. ***Quantum Chemistry***, John P. Lowe, Kirk A. Peterson, 3rd Edition, Academic Press, London, UK, 2009.
7. ***Quantum Chemistry***, Donald A. McQuarrie, 1st Indian Edition, Viva Books Pvt. Ltd., New Delhi, 2003.
8. ***Physical Chemistry***, N.B. Singh, S.S. Das, R.J. Singh, 2nd Edition, New Age International Publishers, New Delhi, 2007.
9. ***Atkins' Physical Chemistry***, Peter Atkins, 8th Edition, Jolio De Paula, International Student Edition, Osford University Press, New York, 2010.
10. ***Physical Chemistry***, Ira N Levine, 5th Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2007.
11. ***Physical Chemistry,*** R. Stephen Berry, Stuart A. Rice, John Ross, 2nd Edition, Oxford University Press, New York, 2007.
12. ***Quantum Chemistry***, Ira N. Levine, 5th Edition, Pearson Education Pvt. Ltd., New Delhi, 2004.
13. ***Chemical Kinetics***, K.J. Laidler, 3rd Edition, Pearson Education Pvt. Ltd., New Delhi, 2004.
14. ***Electrochemistry – Principles and Applications,*** Porter
15. ***Electrochemistry,*** B.K. Sharma , Krishna Prakashan Media (p) Ltd, 1998.

16. ***Fundamentals of Molecular Spectroscopy***, Colin N. Banwell, Elaine M. McCash, 4th Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2008.
17. ***Thermodynamics, Kinetic Theory, and Statistical Thermodynamics***, Francis W. Sears Gerhard L. Salinger, 3rd Edition, Narosa Publishing House, New Delhi, 1998.
18. ***An Introduction to Electrochemistry***, Samuel Glasstone, Litton Educational Publishing, Inc., New York, 2008.
19. ***Industrial Electrochemistry***, D. Pletcher and F.C. Walsh, Chapman and Hall, 2nd Edition, 1984.
20. ***Industrial Electrochemistry***, F. C. Walsh D. Pletcher, Kluwer Academic Pub, 2nd Edition, 1990.

# M.Sc. Chemistry Practicals
## I – SEMESTER
## ChHCL-1.1: Inorganic Chemistry Practicals – I

**64 hrs.**

### COMPLEXOMETRIC TITRATIONS

1. Estimation of the amount of Calcium and Magnesium ions present in the given solution complexometrically by using EDTA solution.
2. Estimation of copper ions complexometrically using EDTA solution.
3. Estimation of Lead ions complexometrically using EDTA solution.
4. Estimation of Nickel ions complexometrically using EDTA solution.

### REDOX TITRATIONS

5. Estimation of the amount of Fe (II) and Fe (III) present in the given solution using $K_2Cr_2O_7$.
6. Estimation of the amount of Fe (II) and Fe (III) present in the given solution by using ceric ammonium sulphate solution.
7. Estimation of the amount of Fe (II) and Fe (III) present in the given solution by using Vanadium solution.
8. Estimation of Chromium and manganese in a sample.

### GRAVIMETRIC ESTIMATIONS

9. Estimation of copper as copper thiocyanate gravimetrically.
10. Estimation of Sulphate as Barium sulphate gravimetrically.
11. Estimation of Nickel as Nickel Dimethyl glyoximate gravimetrically.
12. Estimation of lead as leadchromate gravimetrically

**REFERENCES:**

1. Vogel's Textbook of Quantitative analysis, - J Mendham, R.C. Denney, J.D. Barnes M.J.K. Thomas, 3rd, 4th , 5th and 6th edition.
2. College practical Chemistry, - V K Ahulwalia
3. Analytical Chemistry, - G.D. Christian.
4. Practical Inorganic Chemistry, - K. Somashekara Rao.
5. Principles of Inorganic Chemistry,- Puri, Sharma, Khalia.

# ChHCL-1.2: Organic Chemistry Practicals – I

**64 hrs.**

**I. QUALITATIVE ANALYSIS**

Systematic separation of organic binary mixtures of solid type using chemical and physical methods. At least six experiments from the following combinations,

Acid + Phenol  Phenol + Base  Base + Neutral
Acid + Base  Phenol + Neutral
Acid + neutral

**References**


1. Advanced Practical Organic Chemistry
   N K Vishnoi , Second edition, Vikas Publishing House Pvt. Ltd, 1996
2. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis
   Renu Aggarwal, V. K. Ahluwalia, Universities press (India), 2001
3. Systematic Laboratory Experiments in Organic Chemistry
   Arun Sethi, New Age International, 2003.
4. Comprehensive Practical Organic Chemistry: Qualitative Analysis
   Ahluwalia V.K. Sunitha Dhingra, First edition, Orient Longman, 2004
5. Practical Organic Chemistry: Qualitative Analysis
   Bhutani S.P. Chhikara A, First edition, ANE books-new Delhi, 2009
6. Vogel's Textbook of Practical Organic Chemistry
   Brian S. Furniss, 5th Edition, Pearson India, 2005.
7. Laboratory techniques in Organic chemistry
   V.K. Ahluwalia , Pooja Bhagat & Renu Aggarwal, I.K. International Publishing House Pvt.Ltd.
8. Laboratory Manual of Organic Chemistry
   Raj K. Bansal. 5th edition, New Age international, 2008
9. Practical Organic Chemistry
   F.G. Mann, B.C Saunders, Fourth edition, Pearson India,2009.


# ChHCL-1.3: Physical Chemistry Practicals – I

**64 hrs.**

1. Study on the effect of catalyst on the rate of reaction of acid catalyzed hydrolysis of an ester.
2. Reaction kinetics (i) To study the effect of ionic concentration on the rate constant of the reaction.
3. Reaction kinetics (ii) To study the effect of ionic concentration on the rate constant of the reaction.
4. Conductometric titration of a strong acid v/s strong base.
5. Conductometric titration of a weak acid v/s strong base.
6. Conductometric titration of mixture of a strong acid + weak acid and strong base.
7. Potentiometric redox titration ($K_2Cr_2O_7$ v/s FAS).
8. Potentiometric redox titration ($KMnO_4$ v/s FAS).

9. Potentiometric titration (CAS v/s FAS).
10. Determination of $pK_a$ value of weak electrolyte (acetic acid) by conductometric titration.
11. Determination of $pK_a$ value of weak electrolyte (formic acid) by conductometric titration.
12. Determination of pKa value of weak electrolyte (acetic acid) by potentiometric titration.
13. Determination of pKa value of weak electrolyte (formic acid) by potentiometric titration.
14. Isoelectric point of glycine.
15. Polymer viscosity.

**References:**


1. Advanced Practical Physical Chemistry, J.B.Yadav.
2. College Practical Chemistry, V.K. Ahulwalia, Sunitha Dhigra Adarsh Gulati.
3. Experimental Physical Chemistry, V.D.Athawale, Parul Mathur.
4. Practical Physical Chemistry, B. Vishwanathan, P.S.Raghavan
5. Experimental Physical Chemistry: Laboratary Text, Arthur Halpern, Geoge McBane, 3rd Edition.
6. Physical Chemistry Practical, Saroj Kumar Maity, Naba Kumar Ghosh.
7. Vogel's Quantitative Chemical Analysis, J Mendham.
8. Practical Physical chemistry, Findlay Alexander, 17th Edition.
9. A Text book of Practical Physical Chemistry, K Fajan, J Wust.
10. Experiments in Physical Chemistry, Carl Garland Joseph Nibler, David Shoemaker, 8th Edition.
11. Practical Physical chemistry, James Brierley firth.
12. Findlay's Practical Physical chemistry, B.P. Levitt, 9th Edition.
13. Experiments in Physical Chemistry, J. M. Wilson, R. J. Newcombe, A. R. Denaro, 2nd Edition.
14. A Manual of Practical Physical Chemistry (Classic Reprint), Francis William Gray.


## M.Sc. Chemistry Syllabus - 2019-2020 (CBCS Scheme)
## Revised Regulations -2010
# II - SEMESTER
# ChHC-2.1: ANALYTICAL CHEMISTRY - II

**Total: 64 hrs**

**UNIT-I: ELECTRONIC SPECTROSCOPY** **16 hrs**

**Introduction:** Nature and interaction of electromagnetic radiation with matter, types of molecular spectra, selection rules, characteristic features for absorption or emission of electromagnetic radiation, band width, factors contributing to the band width, Doppler broadening, intensity of spectral lines and transition probability, factors influencing positions and intensity of spectral lines, energy dissipation from excited states.

**Electronic Spectroscopy:** Energy levels, molecular orbitals, theory of electronic spectroscopy, Frank-Condon principle, transition probability, types of transitions, types of absorption bands, solvent effect on electronic transitions, electronic spectra of polyatomic molecules, chromophore and auxochrome, Woodward-Fischer rules for calculating absorption maximum, calculation of absorption maximum in conjugated dienes, trienes, polyenes, poly-ynes, eneynes, α,β-unsaturated carbonyl compounds, benzene and substituted benzenes, other aromatic hydrocarbons, heterocyclic systems. Stereochemical factors in electronic spectroscopy – biphenyls and binaphthyls, *cis*- and *trans*-isomers. Angular distortion and cross-conjugation,

steric inhibition of resonance. Instrumentation for electronic spectroscopy.

**UNIT-II: INFRARED SPECTROSCOPY AND RAMAN SPECTROSCOPY 16 hrs**

Vibrational motion of a diatomic molecule, force constant and bond strengths, vibration-rotation spectroscopy, characteristic features.

**Infrared (IR) spectroscopy:** Origin of IR spectrum, IR regions (finger print and group frequency regions), normal modes of molecular vibrations, factors influencing vibrational frequencies (physical states of the sample, vibrational coupling, electrical effect, inductive effects, hydrogen bonding and ring structure), metal-ligand vibrations, instrumentation – FTIR, sampling handling techniques, interpretation and examination of IR spectrum, group frequencies of - alkanes, alkenes, alkynes, aromatic hydrocarbons, alcohols, phenols, aldehydes, ketones, carboxylic acids, acid halides, acid anhydrides, acid amides, amino acids, amines, isocyanates, thiocyanites, esters, lactones, ethers, epoxides, peroxides, nitro and nitroso groups, heteroarmatic compounds, sulphur and silicone compounds, applications of IR spectroscopy. Applications of IR to inorganic complexes – amino, sulphato, thiocyanato and thiourea complexes.

**Raman spectroscopy:** Introduction, quantum mechanical theory of Raman effect (Rayleigh scattering, Raman scattering - Stokes and Anti-Stokes lines), classical theory of Raman effect, rotational and vibrational Raman spectra, rule of mutual exclusion, instrumentation, Raman effect in solids, liquids and gases, applications of Raman spectroscopy (Inorganic, Organic, Physical and Polymer chemistry), Resonance Raman Spectroscopy (RRS) and its applications, Resonance Raman Effect (RRE), non-linear Raman effects, Coherent Anti-Stokes Raman Scattering (CARS) and its applications. Comparison between IR and Raman spectroscopy.

**UNIT-III: FES, AAS, AES, MOLECULAR LUMINESCENCE SPECTROSCOPY 16 hrs**

**Flame emission spectroscopy (FES):** Basic principles, flames and flame temperatures, excitation profiles and chemical reactions in flame, spectra of metals in flame, instrumentation (single beam and double beam), evaluation methods in flame photometry, factors affecting intensity of emitted radiation, interferences, background correction methods, applications, flame emission experiments, limitations of FES.

**Atomic absorption spectroscopy (AAS):** Basic principles, absorption of radiation energy by atoms, instrumentation (single beam and double beam), detection limits, interferences, advantages of AAS over FES, some typical AAS determinations.

**Atomic emission spectroscopy (AES):** Basic principles, advantages and disadvantages of AES, origin of spectra, instrumentation, measurement of light intensity, applications.

**Molecular luminescence spectroscopy:** Basic principles of fluorescence and phosphorescence, excitation and deactivation processes (energy level diagram), factors affecting fluorescence and phosphorescence, quenching of fluorescence, fluorescence (or phosphorescence) intensity, fluorescence and chemical structure, instrumentation for fluorimetry and phosphorimetry, application of fluorimetry and phosphorimetry, fluorescent indicators, comparison between fluorimetry and phosphorimetry, chemiluminescence.

**UNIT-IV: SEPARATION TECHNIQUES 16 hrs**

**Size exclusion (Gel) chromatography:** Introduction, theory and principles of size exclusion process, materials for size exclusion process, application in polymer chemistry (weight average and number average concept).

**Affinity chromatography:** Introduction, classification, Selection of matrix, role of spacers, affinity ligands, applications of affinity chromatography in the separation of biomolecules.

**Solvent extraction:** Theory of extraction, mechanism of solvent extraction, aqueous phase, organic phase, factors favouring solvent extraction of inorganic species, extraction involving ion association complexes, synergic extraction, solvent extraction by crown ethers, cryptands, calixarenes, applications of solvent extraction (determination of copper as diethyldithiocarbamate complex, determination of iron as 8-hydroxyquinolate).

**Solid-phase extraction:** solid-phase micro extraction (SPME), advantages of SPME.

**Electrophoresis:** Free solution, paper and capillary electrophoresis, theory, instrumentation for capillary electrophoresis, separation of amino acids by capillary zone electrophoresis, applications of capillary electrophoresis, experimental paper electrophoresis.

**REFERENCES:**


1. ***Vogel's Textbook of Quantitative Chemical Analysis***, J. Mendham, R.C. Denney, J.D. Barnes, M. Thomas, B. Sivasankar, 6th Edition, Pearson Education, New Delhi, India, 2012.
2. ***Principles of Instrumental Analysis***, D.A. Skoog, E.J. Holler, T.A. Nieman, 5th Edition, Thomson Aisa Pvt. Ltd., Singapore, 2004.
3. ***Instrumental methods of Chemical Analysis (covering UGC Syllabus),*** H. Kaur, Pragathi Prakashan, New Delhi, India
4. ***Quantitative Chemical Analysis,*** Daniel C. Harris, 6th Edition, W.H. Freeman and Company, New York, USA, 2003.
5. ***Fundamentals of Analytical Chemistry***, D.A. Skoog, D.M. West, E.J. Holler, S.R. Crouch, 8th Edition, Thomson Aisa Pvt. Ltd., Singapore, 2004.
6. ***Introduction to Spectroscopy,*** D.L. Pavia, G.M. Lampman, G.S. Kriz, 3rd Edition, Cengage Learning India Pvt. Ltd., New Delhi, 2008.
7. ***Spectrometric Identification of Organic Compounds,*** R.M. Silverstein, F.X. Webster, 6th Edition, Wiley Student Edition, New Delhi, India, 2007.
8. ***Applications of Absorption Spectroscopy of Organic Compounds***, John R. Dyer, Prentice-Hall of India Pvt. Ltd., New Delhi, India, 2007.
9. ***Instrumental Analysis***, D.A. Skoog, E.J. Holler, S.R. Crouch, 11th Indian Reprint, Cengage Learning India Pvt. Ltd., New Delhi, 2012.
10. ***Molecular Structure and Spectroscopy***, G. Aruldhas, 2nd Edition, Prentice-Hall of India Pvt. Ltd., New Delhi, India, 2007.
11. ***Symmetry and Spectroscopy of Molecules,*** K. Veera Reddy, New Age International Pvt. Ltd., New Delhi, India, 1998.
12. ***Analytical Chemistry – Theory and Practice,***, R.M. Verma, 3rd Edition, CBS Publishers and Distributors, New Delhi, India, 2007.
13. ***Vibrational Spectroscopy – Theory and Applications***, D.N. Sathyanarayana, New Age International Publishers, New Delhi, India, 2004.
14. ***Organic Spectroscopy***, William Kemp, 3rd Edition, Palgrave, New York, USA, 2004.
15. ***Basic Atomic and Molecular Spectroscopy***, J. Michael Hollas, Royal Society of Chemistry, Cambridge, UK, 2002.
16. ***Quantitative Analysis,*** Day and Underwood, Prentice/Hall Pvt. Ltd. 6th Edition (1993).
17. ***Vogel's text Book of Quantitative Chemical Analysis,*** Revised by G.H. Jaffery, J. Bassett, J. Mendhrn and R.C. Denny, ELBS 5th Edition (1998).
18. ***Analytical Chemistry,*** Gray D. Christian, 5th Edition, John Wiley and Sons, Inc
19. ***Introduction to Chromatography- Theory and Practice,*** V.K. Srivatsan and K.K. Srivatsan, S. Chand Company Ltd. 4th Edition (1991).

20. ***Instrumental Methods of Analysis***-Willard, Merrit and Dean, 7th Edition, (1998).
21. Instrumental Methods of Chemical Analysis-B.K. Sharma, Goel Publishing House. Meerut, (2000).

# ChHC-2.2: INORGANIC CHEMISTRY - II

**Total: 64 hrs**

## UNIT-I: CONCEPTS OF ACIDS AND BASES 16 hrs

Arrhenius concept, Bronsted-Lowry concept, conjugate acid-base pairs, amphiprotonic substances, leveling and differentiating solvents, Bronsted base, variation of basicity of the anions ($CH_3^-$, $NH_2^-$, $OH^-$, $F^-$), variation of acidity ($H_2O$, $H_2S$, $H_2Se$, $H_2Te$), order of acidity of HX molecules in aqueous solution, stability and acidity of the oxyanions ($ClO^-$,$ClO_2^-$, $ClO_3^-$, $ClO_4^-$, $BrO^-$, $BrO_3^-$, $IO^-$, $IO_3^-$, $IO_4^-$, $NO_2^-$, $NO_3^-$, $SO_4^{2-}$, $SO_3^{2-}$), Relative strength of oxy acids ($HClO$, $HClO_2$, $HClO_3$, $HClO_4$), relative acids strength of oxy acids of the elements of the same group ($HClO_3$, $HBrO_3$, $HIO_3$), acidic strength of $H_3PO_2$, $H_3PO_3$ and $H_3PO_4$, solvent system (auto-ionization) concept, examples of ammono acids, ammono bases, Lewis concept – electron pair acceptor-donor concept, Lewis acids and bases, relative order of Lewis acidic strengths ($BF_3$, $BCl_3$, $BBr_3$ and $BI_3$), relative order of Lewis basic strengths ($NH_3$, $H_2O$, HF and Ne), relative order of Lewis basic strengths of $NH_3$, $PH_3AsH_3$, $SbH_3$ and $BiH_3$, Pearson's classification of Lewis acids and bases into hard and soft acids and bases, HSAB principle, Usanovich concept.

## UNIT-II: INORGANIC POLYMERS AND CAGES 16 hrs

**Inorganic Polymers:** Preparation, structure and reactivity of borazine, substituted borazines (B-trimethyl borazine, boroxine, N-trimethyl borazine), boron nitride. Polymers containing phosphorous – chain polymers and network polymers, preparation and properties of polyphosphonitrilic chlorides, structure of $(NPCl_2)_3$, $(NPCl_2)_4$, vitreous polyphosphates – phosphate glasses, crystalline polymetaphosphates, structure of $HPO_3$, $(HPO_3)_2$, $(HPO_3)_4$, polyorthophosphoric acids. Borophosphate glasses.

Polymeric compounds of sulphur: nitrides of sulphur, preparation, structure and properties of $(SN)_4$, preparation of $S_2N_2$, $S_5N_2$. Thiazyl halides – trithiaziyl trifluoride $(NSF)_3$, tetrathiazyl tetrafluoride $(NSF)_4$, trithiazyl trichloride $(NSCl)_3$. Imides of sulphur – preparation, structure and properties.

**Cages:** Structure and properties of $P_4O_6$, $P_4O_7$, $P_4O_8$, $P_4S_3$, $P_4S_4$, $P_4S_5$, $P_4S_6$, $P_4S_7$ and $P_4S_8$.

## UNIT-III: BORON HYDRIDES AND METAL CLUSTERS 16 hrs

Boron hydrides, neutral boron hydrides, $(BH)_pH_q$ – structure and bonding, topological approach to boron hydride structure (styx numbers), preparation, structure and properties of $B_4H_{10}$, $[B_8H_8]^{2-}$, $[B_{12}H_{12}]^{2-}$. Structural relationship of closo, nido, arachno, hypo, conjucto boranes. Carboranes - preparation, structure and properties of $[C_2B_9H_{11}]^{2-}$. Structure and bonding of metalloboranes and metallacarboranes, isolobal fragments, Zintl ions, carbide clusters.

Metal clusters: Dinuclear clusters, structure, synthesis and properties of dinuclear compounds - $[Re_2Cl_8]^{2-}$, $[Re_2Cl_4(PMe_2Ph_4)]^+$, $[Mo_2(SO_4)_4]^{3-}$, $[Fe_2(CO)_9]$, $[M_2(OR)_6]$ – structure and preparation of $[Mo_2(OR)_6]$, $[W_2(OR)_6]$. Trinuclear clusters – structure, preparation and properties of $[(ReCl_3)_3]$, $[(Fe_3(CO)_{12}]$, $[(Ru_3(CO)_{12}]$. Tetranuclear clusters – structures of $[W_4(OR)_{12}]$, $[Co_4(CO)_{12}]$, $[Ir_4(CO)_{12}]$.

**UNIT-IV: COORDINATION CHEMISTRY -I** **16 hrs**

Effective atomic number, stability of complex ions, stability constants, factors affecting the stability of complexes (nature of metal ion, ligand, chelate effect), step-wise stability ($K_n$) and Overall stability constant ($\beta_n$), relation between $K_n$ and ($\beta_n$), determination of stability constants from - thermodynamic, spectrophotometric, pH, polarographic, ion-exchange and solubility methods, determination of composition of complexes – Jobs, mole ratio and slope ratio methods, Irving William series. Stereochemistry of coordination compounds with different coordination numbers, isomerism in coordination compounds – structural (hydrate, coordination, linkage, position isomerism), stereo isomerism (geometrical and optical isomerism).

**REFERENCES:**


1. ***Inorganic Chemistry – Principles of Structure and Reactivity***, James E. Huheey, Ellen A. Keiter, Richard L. Keiter, Okhil K. Medhi, 4th Edition, Pearson Education, Indian Edition, New Delhi, India, 2013.
2. ***Inorganic Chemistry,*** Peter Atkins,Tina Overton, Jonathan Rourke, Mark Weller, Fraser Armstrong, 5th Edition, Oxford University Press, UK, 2013.
3. ***Inorganic Chemistry – Principles of Structure and Reactivity***, James E. Huheey, Ellen A. Keiter, Richard L. Keiter, 4th Edition, Pearson, Indian Edition, New Delhi, India, 2004.
4. ***Inorganic Chemistry,*** Gary L. Miessler, Donald A. Tarr, 3rd Edition, Pearson Education, New Delhi, India, 2004.
5. ***Inorganic Chemistry,*** Keith F. Purcell, John C. Kotz, First Indian Reprint, Cengage Learning India Pvt. Ltd., New Delhi, India 2010.
6. ***Concise Inorganic Chemistry,*** 5th Edition, J.D. Lee, Blackwell Science Ltd., London, 2003.
7. ***Advanced Inorganic Chemistry, Volume-I,*** Satya Prakash, G.D. Tuli, S,K, Basu, R.D. Madan, S. Chand and Company, New Delhi, India, 2008.
8. ***Principles of Inroganic Chemistry (UGC Syllabus)***, B.R. Puri, L.R. Sharma, K.C. Kalia, Milestone Publishers, New Delhi, India, 2008.
9. ***Inorganic Chemistry,*** James E. House, First Indian Reprint, Academic Press, USA, 2010.
10. ***Basic Concepts of Inorganic Chemistry,*** D.N. Singh, Pearson Education, New Delhi, 2010.
11. ***Advance Inorganic Chemistry,*** F. Albert Cotton, Geoffrey, Wilkinson, Carlos A. Murillo, Manfred Bochmann, 6th Edition, Wiley Student Edition, John Wiley and Sons, INC, New York, 2004.
12. ***Vogel's Qualitative Inorganic Analysis,*** 7th Edition, G. Svehla, Pearson Education, New Delhi, 1996.


## ChHC-2.3: ORGANIC CHEMISTRY - II

**Total: 64 hrs**

**UNIT-I: MOLECULAR REARRANGEMENTS** **16 hrs**

**General mechanistic treatment of nucleophilic, electrophilic and free-radical rearrangements**.

**Rearrangements reactions involving migration to electron deficient Carbon:** Wagner-Meerwein rearrangement, pinacol-pinacolone rearrangement, dienone-phenol rearrangement,

acid catalyzed isomerization of aromatic hydrocarbons; benzil-benzilic rearrangement, rearrangements involving diazomethane and alkanes, Wolf rearrangement, migration of hetero atom; rearrangement of aryl hydroxylamines (Bamberger rearrangement).

**Rearrangements reactions involving migration to electron deficient Nitrogen:** Hoffmann, Curtius, Schmidt, Lossen and Beckmann rearrangement.

**Rearrangements reactions involving migration to electron deficient Oxygen:** Baeyer-Villiger oxidation and Dakin rearrangement.

**Rearrangements reactions involving migration to electron rich Carbon:** Favorskii, Sommlet-Hauser, Neber, Stevens and Wittig rearrangements.

**UNIT-II: OXIDATION** **16 hrs**

Introduction, oxidation by potassium permanganate - alcohols, alkenes, alkynes, aldehydes, and ketones. Oxidation by manganese dioxide: allylic and benzylic alcohols. Oxidation of alcohols and phenols by chromic acid and potassium dichromate, Jones reagent, chromium trioxide-pyridine complex, pyridinium chlorochromate (PCC), pyridinium dichromate (PDC), oxidation of alkanes, alkenes, aromatic side chains and aromatic rings. **Oxidation with per acids** – oxidation of alkenes, ketones. **Oxidation with miscellaneous oxidants**: Ozones, t-Butyl hydroperoxide, aluminium tri-isopropaxide, aluminium tri-t-butoxide, lead tetra-acetate, selenium dioxide, osmium tetroxide, periodic acid, dimethyl sulphoxide, N-Bromosuccinimide.

**UNIT-III: REDUCTION** **16 hrs**

**Reduction:** Catalytic hydrogenation; Classifications, reactions and their applications, Homogeneous and Heterogeneous hydrogenation, Hydrogenolysis and their applications – **Introduction** to Pt, Pd, Ni, catalysts, reduction of alkenes, alkynes and Nitro compounds. **Reduction with metal hydrides** ($LiAlH_4$, $NaBH_4$, $NaBH_3CN$, $B_2H_6$), reduction by dissolving metals (Na-alcohol, Na-liq.ammonia, Mg-Hg, Zn-HCl), reduction by miscellaneous reducing agents (di-imide, hydrazine, silanes, $SnCl_2$, tin-hydrochloric acid, Zn-acetic acid, Zn-NaOH, sodium metabisulphite, sodium dithionite, Mg-alcohol, sodium hydrogen sulphide, formic acid).

**UNIT-IV: REAGENTS IN ORGANIC SYNTHESIS** **16 hrs**

**Reagents and reactions in organic synthesis:** Use of following reagents in organic synthesis and functional group transformations: Lithium diisopropylamide (LDA), Gilmann reagent, dicyclohexyl carbodimide (DCC), dichlorodicyanoquinone (DDQ), Silane reagentstrialkylsilyl halides, trimethylsilyl cyanide, trimethyl silane, phase transfer catalyst, crown ethers, cyclodextrins, Ziegler-Natta catalyst, diazomethane, Woodward and Prevost hydroxylation, Stark enamine reaction, phosphorous ylides - Wittig and related reactions, sulphur ylides – reactions with aldehydes and ketones, 1,3-dithiane anions – Umpolung reaction, Peterson reaction.

**REFERENCES:**


1. ***Organic Chemistry***, J. Clayden, S. Warren, N. Greeves, P. Wothers, 1st Edition, Oxford University Press, UK, 2001.
2. ***Organic Chemistry – Solution Mannual***, S. Warren, Oxford University Press, UK, 2009.
3. ***Advanced Organic Chemistry, Part-A:Structure and Mechanisms,*** 5th Edition, Francis A. Carey, Richard J. Sundberg, Springer, New York, 2007.
4. ***Principles of Organic Synthesis***, R.O.C. Norman, J.M. Coxon, 3rd Edition (First Indian Reprint), Nelson Thrones, UK, 2003.
5. ***Advance Organic Chemistry – Reactions, mechanisms and structure***, Jerry March, 4th Edition, Wiley India Pvt. Ltd., New Delhi, 2008.
6. ***Organic Reaction Mechanisms,*** V.K. Ahluwalia, R.K. Parashar, 3rd Edition, Narosa Publishing House, New Delhi, 2009.
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9. ***Organic Chemistry,*** R.T. Morrison, R.N. Boyd, 6th Edition, Pearson Education (Singapore Pvt. Ltd.), Delhi, Indian, 2005.
10. ***Organic Chemistry***, L.G. Wade, JR., 5th Edition, Pearson Education (Singapore Pvt. Ltd.), Delhi, Indian, 2004.
11. ***Organic Chemistry***, M.A. Fox, J.K. Whitesell, 2nd Edition, Jones and Bartlett Publishers, Sudbury, Massachusetts, London, 1997.
12. ***Organic Chemistry,*** Francis A. Carey, 5th Edition, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2004.
13. ***Stereochemistry – Conformation and Mechanism,*** P.S. Kalsi, 7th Edition, New Age International Publishers, New Delhi, India, 2008.
14. ***Heterocyclic Chemistry,*** Thomas L. Gilchrist, 3rd Edition, Pearson Education, New Delhi, India, 2007.
15. ***Heterocyclic Chemistry,*** Raj K, Bansal, 4th Edition, New Age International Publishers, New Delhi, India, 2009.
16. ***Organic Chemistry,*** I.L. Finar, 5th Edition (Volume-2), Pearson Education, New Delhi, India, 2009.
17. ***Organic Chemistry,*** I.L. Finar, 6th Edition (Volume-1), Pearson Education, New Delhi, India, 2007.


# ChHC-2.4: PHYSICAL CHEMISTRY - II

**Total: 64 hrs**

**UNIT-I: QUANTUM MECHANICS - I** **16 hrs**

Particle wave – the Schrödinger equation (one-dimensional time-dependant), the wave function and its physical meaning, condition for acceptable wave function, conditions of normalization and orthogonality.

Operators - Algebraba of operators, commumutative property, linear operator, commutative operator. Eigen values and Eigen functions - Hamiltonian property of operators, Postulates of quantum mechanics, some typical theorems relating to basic postulates. Free particle system –

position, momentum and uncertainty relations, energy of the particle, motion in three dimensions, formulation of Schrödinger's equation (application to particle in one- and three-dimensional boxes). Particle in a box – infinite potential barriers, one dimensional box, three dimensional box, particle with finite potential barrier of definite thickness, the quantum mechanical tunneling.

**UNIT-II: MOLECULAR SPECTROSCOPY** **16 hrs**

The theoretical treatment of rotation, (rigid and non-rigid rotator models), linear poly-atomic molecules. Determination of bond lengths. Isotopic effect on rotation spectra. Vibrational spectra of diatomic molecules, linear harmonic oscillator model. The anharmonic vibrations, Morse potential and potential energy surfaces, fundamental vibration-frequencies, overtones and hot bands, degree of freedom of polyatomic molecules. Vibration-rotation spectra of diatomic and linear polyatomic molecules, PQR branches.

**UNIT-III: RADIATION AND PHOTOCHEMISTRY** **16 hrs**

**Photochemistry:** Photophysical processes, A review of laws of photochemistry (Beer-Lambert law, Grotthus-Draper law, Bunsen and Roscoe law, Stark-Einstein law and Platnikow law). Quantum yield and its determination. Actinometers (Bunsen and Roscoe's actinometer, Eder's actinometer, Uranyl Oxalate actinometer, Malachite Green Leucocyanide actinometer, Ferrioxalate actinometer and Reinecke's salt actinometer), Stem-Volmer equation, Lasers in photochemical studies, photo-electrochemistry, solar energy conversion and storage.

**Radiation chemistry:** Interaction of radiation with matter, method of losing energy and common units, dosimetry (terms and units, chemical dosimeters - Fricke and Ceric sulphate dosimeters). Radiation chemistry of gases, water, aqueous solution and solids. Biological effects of radiation. Safety measures against radiation hazards.

**UNIT-IV: POLYMER CHEMISTRY** **16 hrs**

Types of polymer (linear, branched, cross linked and copolymer with example - a qualitative account). Molecular weight distributions: number average and weight-average molecular weight. Thermoplastics and thermosets, fibers and plastics (only qualitative account). Determination of average molecular weight – end group analysis, viscosity method, ultra-centrifugation method, osmotic pressure method [derivation of equations not necessary], sedimentation velocity method, turbidity method and light scattering method [Zimm plot]. Kinetics of polymerization-condensation and step-growth polymerization, kinetics of free radical polymerization, chain transfer reactions, anionic polymerization, co-polymerization. Polydispersivity.

Analysis and testing of polymers, chemical analysis of polymers, spectroscopy method, X-ray diffraction study, microscopy and thermal analysis. Physical testing: tensile strength, fatigue, impact tear resistance hardness and abrasion resistance. Properties of commercial polymers-fire retarding polymers-electrically conducting polymers, biomedical polymers, polymer blends, alloys and composites. Polymer additives (Fillers, Plasticizers, Antioxidants, Colorants, Flame Retardants, Stabilizers) and compounding.

## REFERENCES:

1. ***Quantum Chemistry***, R.K. Prasad, 4th Edition, New Age International Publishers, New Delhi, 2010.

2. ***Polymer Chemistry,*** Malcolm P. Stevans, First Indian Edition, Oxford University Press, New York, 2008.
3. ***Quantum Mechanics for Chemists***, David O. Hayward, The Royal Society of Chemistry, UK, 2002.
4. ***Principles of Physical Chemistry***, B.R. Puri, L.R. Sharma, M.S. Pathania, 45th Edition, Vishal Publishing House, Jalandhar, India, 2012.
5. ***Physical Chemistry – A Molecular Approach***, Donald A. McQuarrie, John D. Simon, 3rd Edition (Viva Student Edition), Viva Books Pvt. Ltd., New Delhi, 2011.
6. ***Elements of Physical Chemistry***, B.R. Puri, L.R. Sharma, M.S. Pathania, 1st Edition, Vishal Publishing House, Jalandhar, India, 2013.
7. ***Quantum Chemistry***, John P. Lowe, Kirk A. Peterson, 3rd Edition, Academic Press, London, UK, 2009.
8. ***Quantum Chemistry***, Donald A. McQuarrie, 1st Indian Edition, Viva Books Pvt. Ltd., New Delhi, 2003.
9. ***Physical Chemistry***, N.B. Singh, S.S. Das, R.J. Singh, 2nd Edition, New Age International Publishers, New Delhi, 2007.
10. ***Atkins' Physical Chemistry***, Peter Atkins, 8th Edition, Jolio De Paula, International Student Edition, Osford University Press, New York, 2010.
11. ***Physical Chemistry***, Ira N Levine, 5th Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2007.
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13. ***Quantum Chemistry***, Ira N. Levine, 5th Edition, Pearson Education Pvt. Ltd., New Delhi, 2004.
14. ***Chemical Kinetics***, K.J. Laidler, 3rd Edition, Pearson Education Pvt. Ltd., New Delhi, 2004.
15. ***Textbook of Polymer Science***, Fred W. Billmayer, 3rd Edition, John Wiley & Sons Pvt. Ltd., Singapore, Indian Edition, 2007.
16. ***Fundamentals of Molecular Spectroscopy***, Colin N. Banwell, Elaine M. McCash, 4th Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2008.
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18. ***Thermodynamics, Kinetic Theory, and Statistical Thermodynamics***, Francis W. Sears Gerhard L. Salinger, 3rd Edition, Narosa Publishing House, New Delhi, 1998.
19. ***Polymer Science***, V.R. Gowariker, N.V. Viswanathan, Jayadev Sreedhar, 5th Edition, New Age International Publishers, New Delhi, 2005.
20. ***An Introduction to Electrochemistry***, Samuel Glasstone, Litton Educational Publishing, Inc., New York, 2008.
21. ***Industrial Electrochemistry***, D. Pletcher and F.C. Walsh, Chapman and Hall, 2nd Edition, 1984.

# M.Sc. Chemistry Practicals
## II – SEMESTER
## ChHCL-2.1: Inorganic Chemistry Practicals – II

**64 hrs.**

**ORE ANALYSIS**

1. Estimation of calcium carbonate in limestone by oxalate method.
2. Estimation of amount of iron present in hematite ore.
3. Estimation of $MnO_2$ present in the given pyrolusite ore.
4. Estimation of amount of nitrite present in sodium nitrite ore solution.

**ESTMATIONS**

5. Estimation of amount of available chlorine in bleaching powder.
6. Estimation of available $O_2$ in Hydrogen peroxide.
7. Estimation of Chromium and manganese in steel sample
8. Estimation of amount of copper present in $CuSO_4$ solution.
9. Separation and estimation of Copper and Iron in a solution mixture.
10. Separation and estimation of Nickel and Iron in a solution mixture.
11. Estimation of Ascorbic acid.
12. Estimation of Chlorate in potassium chlorate solution.

**REFERENCES:**


1. Vogel's Textbook of Quantitative analysis, - J Mendham, R.C. Denney, J.D. Barnes M.J.K. Thomas, 3rd, 4th , 5th and 6th edition.
2. College practical Chemistry, - V K Ahulwalia
3. Analytical Chemistry, - G.D. Christian.
4. Practical Inorganic Chemistry, - K. Somashekara Rao.
5. Principles of Inorganic Chemistry,- Puri, Sharma, Khalia.


## ChHCL-2.2: Organic Chemistry Practicals – II

**64 hrs.**

**I. PREPARATIONS:**

At least six preparations have to be carried out involving following types of reactions.

1. Preparation of acetanilide from acetophenone
2. Preparation of para nitroaniline from acetanilide.
3. Preparation of para bromoaniline from acetanilide.
4. Preparation of azlactone from hippuric acid

5. Preparation of benzilic acid from benzil
6. Preparation of anthranilic acid from phthalimide
7. Preparation of 2-Phenyl indole from Phenyl hydrazine and acetophenone
8. Preparation of 2,5 Dihydroxy acetophenone from Hydroquinone.
9. Preparation of Acridone from 2- Chloro benzoic acid.
10. Preparation of benzoic acid ( Cannizarro reaction)
11. Preparation of Chalcone

**II. QUANTITATIVE ANALYSIS**

1. Estimation of glucose by Bertrands method
2. Estimation of ascorbic acid.
3. Estimation of hydroxyl group.
4. Estimation of amino group.
5. Determination of Saponification value of oils and fats.
6. Estimation of ester group.
7. Determination of Iodine value of fat and oils.
8. Estimation of Nitro group.

**References**


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   N K Vishnoi , Second edition, Vikas Publishing House Pvt. Ltd, 1996
2. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis
   Renu Aggarwal, V. K. Ahluwalia, Universities press (India), 2001
3. Systematic Laboratory Experiments in Organic Chemistry
   Arun Sethi, New Age International, 2003.
4. Comprehensive Practical Organic Chemistry: Qualitative Analysis
   Ahluwalia V.K. Sunitha Dhingra, First edition, Orient Longman, 2004
5. Practical Organic Chemistry: Qualitative Analysis
   Bhutani S.P. Chhikara A, First edition, ANE books-new Delhi, 2009
6. Vogel's Textbook of Practical Organic Chemistry (Vol.I,II and III)
   Brian S. Furniss, 5th Edition, Pearson India, 2005.
7. Laboratory techniques in Organic chemistry
   V.K. Ahluwalia , Pooja Bhagat & Renu Aggarwal, I.K. International Publishing House Pvt.Ltd.
8. Laboratory Manual of Organic Chemistry
   Raj K. Bansal. 5th edition, New Age international, 2008
9. Practical Organic Chemistry, F.G. Mann, B.C Saunders, Fourth edition, Pearson India,2009.


## ChHCL-2.3: Physical Chemistry Practicals – II

**64 hrs.**

1. Determination of mean ionic activity co-efficient of weak acid (formic acid).
2. Determination of mean ionic activity co-efficient of weak acid (acetic acid).
3. Determination of $pK_a$ value of polybasic acid by Potentiometric titration.
4. pH titration of HCl v/s NaOH.
5. pH titration of $CH_3COOH$ v/s NaOH.
6. pH titration $CuSO_4$ v/s NaOH.

7. Determination of equivalent conductance at infinite dilution for strong electrolyte (KCl).
8. Determination of equivalent conductance at infinite dilution for strong electrolyte (NaCl).
9. Determination of strength of $ZnSO_4$ solution using $BaCl_2$ solution conductometrically.
10. Determination of strength of $NiSO_4$ solution using $BaCl_2$ solution conductometrically.
11. Partial molar volume of ethanol-water system.
12. Spectrophotometric/Colorimetric determination of Chromium.
13. Spectrophotometric/Colorimetric determination of Manganese.
14. Spectrophotometric/Colorimetric determination of Copper.
15. Heat of solution of benzoic acid.
16. Heat of solution of salicylic acid.

**References:**


1. Advanced Practical Physical Chemistry, J.B.Yadav.
2. College Practical Chemistry, V.K. Ahulwalia, Sunitha Dhigra Adarsh Gulati.
3. Experimental Physical Chemistry, V.D.Athawale, Parul Mathur.
4. Practical Physical Chemistry, B. Vishwanathan, P.S.Raghavan
5. Experimental Physical Chemistry: Laboratary Text, Arthur Halpern, Geoge McBane, 3rd Edition.
6. Physical Chemistry Practical, Saroj Kumar Maity, Naba Kumar Ghosh.
7. Vogel's Quantitative Chemical Analysis, J Mendham.
8. Practical Physical chemistry, Findlay Alexander, 17th Edition.
9. A Text book of Practical Physical Chemistry, K Fajan, J Wust.
10. Experiments in Physical Chemistry, Carl Garland Joseph Nibler, David Shoemaker, 8th Edition.
11. Practical Physical chemistry, James Brierley firth.
12. Findlay's Practical Physical chemistry, B.P. Levitt, 9th Edition.
13. Experiments in Physical Chemistry, J. M. Wilson, R. J. Newcombe, A. R. Denaro, 2nd Edition.
14. A Manual of Practical Physical Chemistry (Classic Reprint), Francis William Gray.


## M.Sc. Chemistry Syllabus - 2019-2020 (CBCS Scheme)
## Revised Regulations -2010
# III - SEMESTER
# ChSC-3.1: ANALYTICAL CHEMISTRY – III

**Total: 64 hrs**

**UNIT-I: MOLECULAR SYMMETRY AND GROUP THEORY** **16 hrs**

**Introduction to symmetry**: symmetry operations, symmetry elements – rotational axis of symmetry, plane of symmetry, rotation-reflection axis (improper rotational axis), center of symmetry (inversion centre), identity element, Cartesian coordinate system and symmetry elements, mathematical requirement for a point group.

**Group theory:** Concept of group, properties of group, Abelian and non-Abelian groups, definition of point groups, procedure for classification of molecules in to point groups, group multiplication tables ($C_{2V}$ and $C_{3V}$ point groups).

**Matrix methods in symmetry:** Definition and types of matrices, block-factorization of matrix, matrix representation of symmetry elements, matrix mathematics (addition, subtraction,

multiplication, determinants, inverse and diagonalization of matrices), representation of symmetry operations as matrices, product of symmetry operations (in terms matrices), matrix representation of point groups ($C_{2V}$ and $C_{3V}$ point groups),

**Character Tables:** Reducible and irreducible representations, character of a representation, properties of irreducible representations, structure of character tables, construction of character tables ($C_{2V}$, $C_{3V}$ and $C_{4V}$ point groups), Mulliken symbols for irreducible representations, determination of symmetry species for translations and rotations ($C_{2V}$ and $C_{2h}$), the standard reduction formula ($C_{2V}$ and $C_{3V}$).

**Symmetry of normal modes of molecules:** Cartesian coordinate method and internal coordinate method (molecules belong to $C_{2V}$ and $C_{3V}$ point groups), Infrared and Raman activity of molecules belong to $C_{2V}$ ($H_2O$, $ClF_3$, *cis*-$N_2F_2$) and $C_{3V}$ ($NH_3$) point groups.

**UNIT-II: NMR SPECTROSCOPY 16 hrs**

**$^1$H NMR spectroscopy:** Introduction, nuclear spin states, nuclear magnetic moments, absorption of energy, mechanism of absorption, population densities of nuclear spin states, the chemical shift and shielding. Chemical equivalence, integrals and integration, chemical environment and chemical shift, local diamagnetic shielding (effects of electronegativity, hybridization, acidic and exchangeable protons, hydrogen bonding), magnetic anisotropy, spin-spin splitting, (n+1) rule, Pascal's triangle, the coupling constant, mechanism of coupling (one-bond, two-bond, three-bond and log-range coupling), comparison of NMR spectra at low and high field strengths, Instrumentation for NMR Spectroscopy. Typical $^1$H NMR absorption of - alkanes, alkenes, alkynes, aromatic compounds, alcohols, ethers, amines, nitriles, aldehydes, ketones, esters, carboxylic acid and amide compounds.

Exchange in $H_2O$ and $D_2O$ (acid/water and alcohol/water mixtures, deuterium exchange, peak broadening due to exchange), tautomerism, protons on nitrogen – quadrupole broadening and decoupling, effect of solvent on chemical shift, chemical shift reagents (High-field spectra), chiral resolving agents, spin decoupling methods (double resonance), NOE difference spectra.

**UNIT-III: ADVANCED NMR SPECTROSCOPY AND MASS SPECTROMETRY 16 hrs**

**Advanced NMR spectroscopy:** Pulse sequences, pulse widths, spins, magnetization vectors, DEPT experiment, determining number of attached hydrogens (methine, methylene, methyl, quaternary carbons), introduction to 2D-NMR, an overview of the COSY technique and how to read COSY spectra, an overview of the HETCOR technique and how to read HETCOR spectra, an overview of Magnetic Resonance Imaging (MRI), some sample $^1$H NMR spectra.

**Carbon-13 NMR**:

The Caron-13 nucleus, $^{13}$C chemical shifts – correlation charts, calculation of chemical shifts, proton-coupled $^{13}$C spectra, spin-spin splitting of Carbon-13 signals, proton-decoupled $^{13}$C spectra, Nuclear Overhauser Enhancement (NOE), cross polarization – origin of Nuclear Overhauser effect, problems with integration in $^{13}$C spectra, molecular relaxation processes, off-resonance decoupling, Carbon-13 NMR solvents, heteronuclear coupling of carbon to Deuterium, $^{19}$F and $^{31}$P, some sample Carbon-13 NMR spectra.

**Mass spectrometry:** Basic theory, instrumentation, molecular ion peak, base peak, meta-stable peak, modes of fragmentations, McLafferty rearrangement, Retro Diels-Alder reaction, ortho effect, determination of molecular formulas (precise-mass determination, isotope ratio data), nitrogen rule, some fragmentation patterns of – alkanes, cycloalkanes, alkenes, alkynes, aromatic hydrocarbons, alcohols, phenols, ethers, aldehydes, ketones, esters, carboxylic acids, amines, nitrogen and sulphur compounds and alkyl halides, some sample mass spectra. An overview of MALDI technique.

**UNIT-IV: ESR, MOSSBAUER and NQR SPECTROSCOPY** **16 hrs**

Electron spin resonance (ESR) spectroscopy: Basic principles, instrumentation, experimental technique, FTESRS, double resonance spectrometers, ENDOR and ELDOR, interpretation of derivative curve in an ESR spectrum, ESR spectra of DPPH, intensity of ESR lines, g-value, factors affecting ESR lines, hyperfine interaction, Fermi (or contact or isotopic) hyperfine interaction, hyperfine splitting constant, anisotropic hyperfine interaction, Zero-field splitting and Kramer's degeneracy, Spin-Hamiltonian, spin densities and McConnell relationship, applications of ESR, ESR spectra of free-radical containing a single set of equivalent protons (methyl, p-benzoquine anion, cyclopentadienyl, benzene, cycloheptatrienyl anions), study of transition metal complexes, biological applications of ESR, spin labeling ESR spectroscopy.

**Mossbauer spectroscopy:** Basic principles, Mossbauer nuclides, spectral parameters required for evaluating Mossbauer spectra, isomer shift, quadrupole interactions, magnetic interactions (time and temperature dependent effect), instrumentation, Lamb Mossbauer factor, application – bonding in Fe-complexes, study of Sn compounds, structure determination, biological applications.

**Nuclear quadrupole resonance (NQR) spectroscopy:** Quadrupole nuclei, quadrupole moment, electric field gradient and coupling constant, theory of NQR, splitting in NQR spectra, Zeeman effect, instrumentation, applications, interpretation of eQq data, effect of crystal lattice on the magnitude of eQq, structural information from NQR spectra.

**REFERENCES:**


1. ***Vogel's Textbook of Quantitative Chemical Analysis***, J. Mendham, R.C. Denney, J.D. Barnes, M. Thomas, B. Sivasankar, 6th Edition, Pearson Education, New Delhi, India, 2012.
2. ***Principles of Instrumental Analysis***, D.A. Skoog, E.J. Holler, T.A. Nieman, 5th Edition, Thomson Aisa Pvt. Ltd., Singapore, 2004.
3. ***Instrumental methods of Chemical Analysis (covering UGC Syllabus),*** H. Kaur, Pragathi Prakashan, New Delhi, India
4. ***Quantitative Chemical Analysis,*** Daniel C. Harris, 6th Edition, W.H. Freeman and Company, New York, USA, 2003.
5. ***Fundamentals of Analytical Chemistry***, D.A. Skoog, D.M. West, E.J. Holler, S.R. Crouch, 8th Edition, Thomson Aisa Pvt. Ltd., Singapore, 2004.
6. ***Introduction to Spectroscopy,*** D.L. Pavia, G.M. Lampman, G.S. Kriz, 3rd Edition, Cengage Learning India Pvt. Ltd., New Delhi, 2008.
7. ***Spectrometric Identification of Organic Compounds,*** R.M. Silverstein, F.X. Webster, 6th Edition, Wiley Student Edition, New Delhi, India, 2007.
8. ***Applications of Absorption Spectroscopy of Organic Compounds***, John R. Dyer, Prentice-Hall of India Pvt. Ltd., New Delhi, India, 2007.
9. ***Instrumental Analysis***, D.A. Skoog, E.J. Holler, S.R. Crouch, 11th Indian Reprint, Cengage Learning India Pvt. Ltd., New Delhi, 2012.
10. ***Molecular Structure and Spectroscopy***, G. Aruldhas, 2nd Edition, Prentice-Hall of India Pvt. Ltd., New Delhi, India, 2007.
11. ***Symmetry and Spectroscopy of Molecules,*** K. Veera Reddy, New Age International Pvt. Ltd., New Delhi, India, 1998.

12. ***Analytical Chemistry – Theory and Practice,***, R.M. Verma, 3rd Edition, CBS Publishers and Distributors, New Delhi, India, 2007.
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14. ***Organic Spectroscopy***, William Kemp, 3rd Edition, Palgrave, New York, USA, 2004.
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17. ***Vogel's text Book of Quantitative Chemical Analysis,*** Revised by G.H. Jaffery, J. Bassett, J. Mendhrn and R.C. Denny, ELBS 5th Edition (1998).
18. ***Analytical Chemistry,*** Gray D. Christian, 5th Edition, John Wiley and Sons, Inc
19. ***Introduction to Chromatography- Theory and Practice,*** V.K. Srivatsan and K.K. Srivatsan, S. Chand Company Ltd. 4th Edition (1991).
20. ***Instrumental Methods of Analysis***-Willard, Merrit and Dean, 7th Edition, (1998).
21. ***Instrumental Methods of Chemical Analysis***-B.K. Sharma, Goel Publishing House. Meerut, (2000).
22. ***Group theory and its applications to Chemistry*** – K.V. Raman, Tata McGraw Hill 1997.
23. ***Fundamentals of Molecular Spectroscopy***, 3rd edition – C.N. Banwall, McGraw Hill, Book co, (UK) Ltd 1983.

# ChSC-3.2: INORGANIC CHEMISTRY - III

**Total: 64 hrs**

**UNIT-I: COORDINATION CHEMISTRY -II** **16 hrs**

Valence bond theory (VBT), crystal field theory (CFT), spectrochemical series, orientation of d-orbitals and crystal field splitting of energy levels in tetrahedral and octahedral complexes, CFSE, factors influencing the magnitude of crystal field splitting – nature of ligands, oxidation state of metal ions, size of d-orbitals, geometry of complexes. Colour of transition metal complexes, modified crystal field theory (ligand field theory), evidence of covalent bonding in metal ligand bonding – Lande's splitting factor, ESR spectra, NMR spectra, NQR spectra and inter-electronic repulsion.

Molecular orbital theory of coordination complexes - Sigma and pi bonding in octahedral, tetrahedral and square planar complexes.

**UNIT-II: COORDINATION CHEMISTRY -III** **16 hrs**

Crystal field effects on – ionic radii, lattice energy, heats of ligation, heats of hydration, heats of ligation of other ligands, geometry of complexes, spinel and inverse spinel. John-Teller distortion in octahedral complexes.

Electronic spectra of atoms – spectroscopic terms, classification of microstates, coupling of single electron angular momenta (spin-spin, orbital-orbital and spin-orbital coupling), Russel-Saunders and j-j coupling, energies of terms (Hund's rule), Racah parameters, Electronic spectra of complexes – ligand filed transition, spectroscopic terms, correlating terms, energies of weak

and strong field limits, Tanabe-Sugano diagrams, Orgel diagrams and ground term symbols ($d^1$ to $d^{10}$ systems), calculation $D_q$, B and β, nephelauxetic series, charge-transfer bands (LMCT and MLCT transitions), selection rules and intensities (spin and Laporte selection rules), tetragonal distortion from octahedral symmetry. Magnetic properties of complexes by Gouy balance method.

**UNIT-III: REACTION MECHANISM IN COORDINATION COMPOUNDS 16 hrs**

Reactions, kinetics and mechanism - substitution reaction in octahedral complexes (associative and dissociative mechanism), types of intermediates formed in associative and dissociative reactions, lability and inertness of octahedral complexes, interpretation of lability and inertness of transition metal complexes – valence bond theory, crystal field theory, crystal field activation energy, factors affecting lability of non-transition metal complexes (charge, size of the central metal atom, charge/ionic size ration, geometry of the complex), acid and base hydrolysis of octahedral complexes, direct and indirect evidences of conjugate mechanism, anation reactions, isomerisation and recimisation of trischelate complexes, substitution reaction in square planar complexes, trans effect, thermodynamic and kinetic stability, theories of trans effect (polarization and pi-bonding theory).

**Oxidation – Reduction reactions:** Classification of redox reactions, inner-sphere and outer-sphere mechanisms, excited state outer-sphere electron transfer reaction, mixed valency complexes, two-electron transfer reactions (complementary and non-complementary reactions). Photochemical reactions: Prompt and delayed reactions, d-d and charge-transfer reactions, transition in metal-metal bonded systems.

**UNIT-IV: ORGANOMETALLIC CHEMISTRY 16 hrs**

Introduction, organic ligands, nomenclature, 18-electron rule, electron counting in complexes, metal carbonyl complexes, preparation and properties of carbonyl complexes, polynuclear carbonyl complexes, carbonylate ions, bridging modes of CO, carbonyl hydride, binary carbonyl complexes, isolobal fragments, nitrosyl complexes, dinitrogen complexes, metal alkyls, carbenes (Fischer and Schrock types), carbynes and carbides complexes, non-aromatic alkene and alkyne complexes, synthesis and structure of complexes with metals (alkene, alkyl, butadiene, cyclobutadiene, cyclooctatetraene, allyl, cyclopentadiene, and arene complexes), substitution reactions in carbonyl complexes, oxidative addition and reductive elimination, insertion and elimination, nucleophilic and electrophilic attack of coordinated ligands, carbonylate anions as nucleophiles, Olefin (sigma-bond) metathesis.

**Catalysis by organometallic compounds:** Importance and mechanism of - Alkene hydrogenation (Wilkinson's catalysis), hydroformylation (Oxo-process), Monsanto acetic acid process, Wacker process (Smidt process), synthetic gasoline, synthesis of $H_2$ gas, Ziegler-Natta polymerization, Fisher-Tropsch reaction. Fluxional behavior in organometallic compounds.

**REFERENCES:**


1. ***Advanced Inorganic Chemistry***, 5th edition, F.A. Cotton and G. Wilkinson, John-Willey and sons 1988.
2. ***Inorganic Chemistry, principles of structure and reactivity***, 3rd ed. James E. Huheey, Ellen E Keithr and Richard L Keither, Harper Collins college pub, 1993.3
3. ***Inorganic Chemistry***, 3rd ed. D.P.Shriver and P.W.Atkins, Oxford University press, 1999

4. ***Comprehensive coordination Chemistry*.** Eds: G.Wilkinson, R.D.Gillers and J.A.McCleurry, Pergomon Press
5. ***Synthesis and Characterization of Inorganic Compounds***, W. L. Jolly, Prentice Hall
6. Concise Coordination Chemistry, R.Gopalan and V.Ramalingam.
7. ***Inorganic Photochemistry: Introduction to Photochemical and Photophysical Aspects of Metal Complexes,*** Kala Publications, Thiruchirapally, India, 2002.
8. ***A.W. Adamson and P.D. Fleischauer,*** Concepts of Inorganic Photochemistry, Johan Wiley, 1975.

## ChSC-3.3: ORGANIC CHEMISTRY - III

**Total: 64 hrs**

### UNIT-I: NAMED REACTIONS 16 hrs

**C–C Bond forming reactions:** Aldol condensation, Claisen condensation, Dieckmann condensation, Knoevenagel condensation, Mannich reaction, Michael reaction, Robinson annulations, Stobbe condensation, Wittig reaction, Acylion synthesis. Alder – Ene reaction, Bischler – Napieralski reaction.
**Coupling reactions:** Hiyama cross-coupling reaction, Kumada cross-coupling reaction, McMurry coupling reaction, Negishi cross-coupling reaction, Stille coupling, Suzuki – Miyaura coupling,
**C–N Bond forming reactions:** Buchirer reaction, Buchwald – Hartwig amination, Stork enamine reaction, Doebner – von Miller reaction, Hofmann – Loffler – Freytag reaction, Barton reaction.
**C–O Bond forming reactions:** Dakin reaction, Mislow – Evans rearrangement, Mukaiyama reagent, Bayer – Villager reaction.
**C–X Bond forming reactions:** Chan – Lam coupling reaction, Hell – Volhard – Zelinsky reaction, Hunsidiecker – Borodin reaction.

### UNIT-II: HETEROCYCLIC COMPOUNDS 16 hrs

Nomenclature of heterocyclic compounds. Synthesis (Each two methods) and reactivity (towards electrophilic and nucleophilic reactions) – Pyrroles, Furans, Thiophenes, Pyridines, Azepines, Oxepins, Thiepins.
**Fused heterocycles: S**ynthesis (Each two methods) and chemical properties towards electrophilic and nucleophilic reactions of benzopyrroles, benzofurans, benzothiophenes, quinolines and isoquinolines.
**Mesoinonic compounds:** Nomenclature, synthesis, reactions and applications of Sydnones, Oxadiazolium and Thiadiazolium compounds.

### UNIT-III-PHOTOCHEMISTRY AND PERICYCLIC RTEACTIONS 16 hrs

**Photochemistry:** Bonding and antibonding orbitals, singlet and triple states, modes of energy transfers from the excited states- Jablonski diagram. Photoaddition: alkenes to carbonyl compounds (Paterno-Buchi reaction), alkenes and alkynes to aromatic compounds, photochemical reactions: photoreduction, photooxidation, photodimerization, photochemical substitution, photoisomerization. Photochemical fragmentation: Photolysis of carbonyl

compounds (Norrish type-I and Norrish type-II reactions), photolysis of diazoalkanes and alkyl azides, di-pi-methane rearrangement, photochemistry of arenes.

**Pericyclic reactions:** Introduction, Classification: Electrocyclic, cycloaddition, sigmatropic, chelotropic and ene reaction. Definition of various terms: Con-rotatory, disrotatory, suprafacial, antarafacial, HOMO, LUMO, etc. Frontier molecular orbitals, formation and properties of molecular orbitals of ethene, 1,3-butadiene, 1,3,5-hexatriene, allyl and pentadienyl system.

Electrocyclic reactions – FMO approach for electrocyclic reactions, electrocyclic reactions of butadine-cyclobutene and hexatriene-cyclohexadiene interconversions.

Cycloaddition reactions: [4+2] cycloaddition reaction (Diels-Alder reaction), FMO approach for [4 + 2] cycloaddition reaction, intramolecular Diels-Alder reaction.

[2 + 2] cycloadditions – thermal and photochemical cycloadditions.

Sigmatropic rearrangements: Nomenclature, suprafacial and anatrafacial processes,[1,3], [1,5], and [3,3] sigmatropic rearrangement, Cope and Claisen rearrangement. FMO approach for sigmatropic shift of hydrogen and carbon (suitable examples are to be taken for each class of transformation). Woodward-Hofmann rules.

**UNIT-IV: RETRO SYNTHESIS VIA DISCONNECTION APPROACH 16 hrs**

## Organic Synthesis

Introduction to synthons, synthetic equivalents, functional group interconversions,

**Protection and de-protection in organic synthesis –** Protection of hydroxyl, carboxyl, carbonyl, amino, thiol groups and their de-protection. Illustration of protection and deprotection in organic synthesis with examples.

**Disconnection approach:** One group C-X disconnection- Carbonyl compounds, ethers and sulphides (Benzyl benzoate, propanil, p-methyanisole, isopentyl benzyl ether, chlorobenside).

**Two group disconnection**- 1, 1- difunctionalized compounds (Acetals, cyanohydrins, amino acids etc.) , 1,2-difunctionalized compounds (1,2-dicarbonyl compounds, α-hydroxyl carbonyl compounds).

**Retrosynthesis:**

Retrosynthesis of benzocaine, 4-methoxy acetophenone, saccharin, bisvoline, canthredine, lycorane and multstrin.

**REFERENCES:**


1. Modern Synthetic Reactions, H.O. House, W.A Benjamin
2. Some Modern Methods of Organic Synthesis, W Carruthers, Cambridge Univ. Press
3. Principles of Organic Synthesis, R.O.C Norman and J.M. Coxon, Blackie Academic & Professional
4. Advanced organic chemistry.F.A.carey and R.J.sunderberg
5. Rood's Chemistry of Carbon Compounds, S. Coffey.
6. Organic Synthesis-Concept, Methods and Starting Materials, J. Fuhmop and G. Penzillin.
7. Guide Book to Organic Synthesis, R.K. Mackie & D.M. Smith, ELBS.

8. Organic Synthesis, V.K. Ahuwalia and Renu Agarwal, Narosa
9. Synthesis, Approaches in Organic Chemistry, R.K. Bansal, Narosa
10. Advanced Organic Chemistry -Reactions, Mecha- nism and Structure, Jerry March, John Wiley.
11. Designing Organic Synthesis, S.Warren, Wiley.
12. Organic Synthesis , Stuart warren, 2012 John Wieley and sons camebridge University.

# ChSC-3.4: PHYSICAL CHEMISTRY- III

**Total: 64 hrs**

**UNIT-I: QUANTUM MECHANICS-II** **16 hrs**

Application of Schrödinger's wave-equation to harmonic oscillator, rigid-rotor and H-atom (separation of r, $\theta$, $\phi$ equation and their solutions). Approximate methods – Necessity of approximate methods, perturbation method, the theory of perturbation method – first and second order correction, application to He-atom (first order correction only) – calculation of first ionization potential and binding energy. Variation theorem – statement and proof. Application of variation theorem to a particle in one dimensional box, linear oscillator, H and He-atoms.

**UNIT-II QUANTUM MECHANICS-III** **16 hrs**

SCF method for many electron systems. Slater orbitals – Effective Nuclear Charge (ENC), expressions for Slater's orbitals for 1s, 2s, 3s, 2p and 3d electrons (no derivation), Slater's rules for calculation of ENC – Slater's orbitals for helium, carbon and nitrogen atoms. Chemical bonding in diatomics, elementary concept of MO and VB theories; Huckel molecular orbital (HMO) theory for conjugated $\pi$-electron systems and its applications to 1,3-butadiene and benzene.

**UNIT-III: SURFACE CHEMISTRY AND CATALYSIS** **16 hrs**

**Surface Chemistry:** Adsorption by solids, types of adsorption isotherms, chemisorption, adsorption of gasses by solids, factors influencing adsorption, Freundlich and Langmuir adsorption theories, BET theory of multilayer adsorption (Derivation of BET equation), surface area measurement, types of adsorption isotherms, adsorption from solution, Gibbs adsorption isotherm, insoluble surface films on liquids, modern techniques for investigating surfaces: LEED, PES, STM, EXAFS and SEXAFS techniques.

**Catalysis:** Introduction, characteristics of catalytic reactions, acid-base catalysis, Michaelis-Menten equation, effect of temperature, pH and concentration on enzyme catalysis. Heterogeneous catalysis: surface reactions, kinetics of surface reactions, unimolecular and bimolecular surface reactions, pH-dependence of rate constants of catalyzed reactions, oscillatory reactions and their applications.

**UNIT-IV: COLLOIDS** **16 hrs**

**Colloids:** Colloidal systems, classification of colloids, lyophobic and lyophilic sols, preparation of lyophobic colloidal solutions (dispersion and condensation methods), purification of colloidal solutions, Properties of colloidal systems: Electrical properties – charge on colloidal particles, electrical double layer, zeta potential, DLVO theory of the stability of lyophobic colloids,

flocculation values, coagulation of colloidal solutions. Electrokinetic properties – electrophoresis and electro-osmosis streaming and sedimentation potential. Determination of size of colloidal particles, surfactants, hydrophile-lypophile balance (HLB). Emulsions, gels, elastic and non-elastic gels. Micelle formation – mass action model and phase separation model, shape and structure of micelles, micellar aggregation numbers, critical micelle concentration (CMC), factors affecting CMC in aqueous media, thermodynamic approach to CMC, thermodynamics of micellization, micelle temperature range (MTR) or Krafft point. Solubilization – location of solubilizates in micelles, the phase rule of solubilization. Micellar catalysis, importance and applications of colloids.

## REFERENCES:


1. ***Quantum Chemistry***, R.K. Prasad, 4th Edition, New Age International Publishers, New Delhi, 2010.
2. ***Polymer Chemistry,*** Malcolm P. Stevans, First Indian Edition, Oxford University Press, New York, 2008.
3. ***Quantum Mechanics for Chemists***, David O. Hayward, The Royal Society of Chemistry, UK, 2002.
4. ***Principles of Physical Chemistry***, B.R. Puri, L.R. Sharma, M.S. Pathania, 45th Edition, Vishal Publishing House, Jalandhar, India, 2012.
5. ***Physical Chemistry – A Molecular Approach***, Donald A. McQuarrie, John D. Simon, 3rd Edition (Viva Student Edition), Viva Books Pvt. Ltd., New Delhi, 2011.
6. ***Elements of Physical Chemistry***, B.R. Puri, L.R. Sharma, M.S. Pathania, 1st Edition, Vishal Publishing House, Jalandhar, India, 2013.
7. ***Quantum Chemistry***, John P. Lowe, Kirk A. Peterson, 3rd Edition, Academic Press, London, UK, 2009.
8. ***Quantum Chemistry***, Donald A. McQuarrie, 1st Indian Edition, Viva Books Pvt. Ltd., New Delhi, 2003.
9. ***Physical Chemistry***, N.B. Singh, S.S. Das, R.J. Singh, 2nd Edition, New Age International Publishers, New Delhi, 2007.
10. ***Atkins' Physical Chemistry***, Peter Atkins, 8th Edition, Jolio De Paula, International Student Edition, Osford University Press, New York, 2010.
11. ***Physical Chemistry***, Ira N Levine, 5th Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2007.
12. ***Physical Chemistry,*** R. Stephen Berry, Stuart A. Rice, John Ross, 2nd Edition, Oxford University Press, New York, 2007.
13. ***Quantum Chemistry***, Ira N. Levine, 5th Edition, Pearson Education Pvt. Ltd., New Delhi, 2004.
14. ***Chemical Kinetics***, K.J. Laidler, 3rd Edition, Pearson Education Pvt. Ltd., New Delhi, 2004.
15. ***Textbook of Polymer Science***, Fred W. Billmayer, 3rd Edition, John Wiley & Sons Pvt. Ltd., Singapore, Indian Edition, 2007.
16. ***Fundamentals of Molecular Spectroscopy***, Colin N. Banwell, Elaine M. McCash, 4th Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2008.
17. ***Polymer Science – A Textbook***, V.K. Ahluwalia, Anuradha Mishra, Ane Books India, Noida, 2008.
18. ***Thermodynamics, Kinetic Theory, and Statistical Thermodynamics***, Francis W. Sears Gerhard L. Salinger, 3rd Edition, Narosa Publishing House, New Delhi, 1998.

19. ***Polymer Science***, V.R. Gowariker, N.V. Viswanathan, Jayadev Sreedhar, 5th Edition, New Age International Publishers, New Delhi, 2005.
20. ***An Introduction to Electrochemistry***, Samuel Glasstone, Litton Educational Publishing, Inc., New York, 2008.
21. ***Industrial Electrochemistry***, D. Pletcher and F.C. Walsh, Chapman and Hall, 2nd Edition, 1984.

# M.Sc. Chemistry Practical
## III – SEMESTER
## ChHCL-3.1: Inorganic Chemistry Practical – III

**64 hrs.**

### COMPLEX PREPARATIONS

1. Preparation of Mercurytetrathiocyanatocobaltate(II)complex.
2. Preparation of Chloropentamminecobalt(III)chloride complex.
3. Preparation of Bisoxalatocuprate(II)di hydrate complex.
4. Preparation of Tris-oxalatoferrate(III) complex.
5. Preparation of Sulphatotristhioureazinc(II) complex.
6. Preparation of Tristhioureacopper(I)sulphate complex
7. Cis and trans Diaquadioxalatochromate(III)complex.

### COMPLEX ANALYSIS

1. Estimation of cobalt present in a given ChloropentammineCobalt(III)chloride complex.
2. Estimation of Copper and Oxalate present in a given Bisoxala to Cuprate(II)-di hydrate complex.
3. Estimation of Iron and Oxalate present in a given Trisoxalatoferrate(III) complex.
4. Colorimetric estimation of Fe(III) using thiocyanite as ligand.
5. Colorimetric estimation of metal ligand composition by jobs method of continuous variation.

**REFERENCES:**

1. Vogel's Textbook of Quantitative analysis, - J Mendham, R.C. Denney, J.D. Barnes M.J.K. Thomas, 3rd, 4th , 5th and 6th edition.
2. Concise coordination Chemistry , - R Gopalan , V Ramalingam
3. College Practical Chemistry, - V K Ahulwalia
4. Analytical Chemistry, - G.D. Christian.
5. Practical Inorganic Chemistry, - K. Somashekara Rao.
6. Principles of Inorganic Chemistry, - Puri, Sharma, Khalia.

# ChHCL-3.2: Organic Chemistry Practical – III

**64 hrs.**

**I. PREPARATION OF DYES AND DRUG**

1. Preparation of Methyl Orange
2. Preparation of Fluorescein
3. Synthesis of Crystal violet
4. Synthesis of Phenolphthalein
5. Preparation of paracetamol (acetaminophen)
6. Preparation of phenacetin
7. Synthesis of Sulfanilamide
8. Synthesis of Antipyrine
9. Synthesis of Aspirin

**II. ISOLATION AND SEPARATION OF NATURAL PRODUCTS (At least six)**

1. Piperine from pepper
2. Caffeine from tea leaves
3. Casein from milk
4. Nicotine from tobacco leaves
5. Hesperidin from peal of orange
6. Cineole from Eucalyptus leaves
7. Isolation of Cinnamaldehyde from Cinnamon
8. Isolation of Eugenol from Clove
9. Isolation of Lycopene from tomato
10. Isolation of Carotene from Carrots
11. Isolation of Cysteine from Hair.

**References**


1. Advanced Practical Organic Chemistry
   N K Vishnoi , Second edition, Vikas Publishing House Pvt. Ltd, 1996
2. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis
   Renu Aggarwal, V. K. Ahluwalia, Universities press (India), 2001
3. Systematic Laboratory Experiments in Organic Chemistry
   Arun Sethi, New Age International, 2003.
4. Comprehensive Practical Organic Chemistry: Qualitative Analysis
   Ahluwalia V.K. Sunitha Dhingra, First edition, Orient Longman, 2004
5. Practical Organic Chemistry: Qualitative Analysis
   Bhutani S.P. Chhikara A, First edition, ANE books-new Delhi, 2009
6. Vogel's Textbook of Practical Organic Chemistry
   Brian S. Furniss, 5th Edition, Pearson India, 2005.
7. Laboratory techniques in Organic chemistry, V.K. Ahluwalia , Pooja Bhagat & Renu Aggarwal,
   I.K. International Publishing House Pvt. Ltd.
8. Laboratory Manual of Organic Chemistry
   Raj K. Bansal. 5th edition, New Age international, 2008
9. Practical Organic Chemistry
   F.G. Mann, B.C Saunders, Fourth edition, Pearson India,2009.

## ChHCL-3.3: Physical Chemistry Practicals – III

**64 hrs.**

1. To investigate the reaction between potassium bisulphate and potassium iodide by colorimetric measurements.
2. Estimation of $Fe^{+2}$ ions by potentiometric titration
3. Determination of chemical oxygen demand.
4. Estimation of sulphate using EDTA solution.
5. To determine from solubility measurements the true thermodynamic solubility product of calcium sulphate at room temperature.
6. Phase diagram for three component system.
7. Kinetics of oxidation of alcohol by $K_2Cr_2O_7$ Solution.
8. Estimation of iodine in common salt.
9. Adsorption characteristics of acetic acid on charcoal.
10. Estimation of nitrite.
11. Electrogravimetry.
12. To determine the half wave potential of $Cd^{2+}$, $Cu^{2+}$ and $Zn^{2+}$ in 0.1M solution.
13. Corrosion rate measurement.
14. Determination unknown concentration of $ZnSO_4$ by polarography
15. Determination of unknown concentration of mixture by spectrophotometric method.
16. To determine the CMC of SLS from the measurement of conductivity at different concentration.

**References:**


1. Advanced Practical Physical Chemistry, J.B.Yadav.
2. College Practical Chemistry, V.K. Ahulwalia, Sunitha Dhigra Adarsh Gulati.
3. Experimental Physical Chemistry, V.D.Athawale, Parul Mathur.
4. Practical Physical Chemistry, B. Vishwanathan, P.S.Raghavan
5. Experimental Physical Chemistry: Laboratary Text, Arthur Halpern, Geoge McBane, 3rd Edition.
6. Physical Chemistry Practical, Saroj Kumar Maity, Naba Kumar Ghosh.
7. Vogel's Quantitative Chemical Analysis, J Mendham.
8. Practical Physical chemistry, Findlay Alexander, 17th Edition.
9. A Text book of Practical Physical Chemistry, K Fajan, J Wust.
10. Experiments in Physical Chemistry, Carl Garland Joseph Nibler, David Shoemaker, 8th Edition.
11. Practical Physical chemistry, James Brierley firth.
12. Findlay's Practical Physical chemistry, B.P. Levitt, 9th Edition.
13. Experiments in Physical Chemistry, J. M. Wilson, R. J. Newcombe, A. R. Denaro, 2nd Edition.
14. A Manual of Practical Physical Chemistry (Classic Reprint), Francis William Gray.

## M.Sc. Chemistry Syllabus – 2019-2020 (CBCS Scheme)
## Revised Regulations -2010
# IV - SEMESTER
# ChSC-4.1: ANALYTICAL CHEMISTRY – IV

**Total: 64 hrs**

**UNIT-I: STRUCTURAL ELUCIDATION OF ORGANIC COMPOUNDS 16 hrs**

Introduction, basic steps involved in the structure elucidation of organic compounds (molecular formula, molecular weight, elements present, H-index, DBE, presence of nitrogens, presence of chromophore and auxochrome, functional groups, chemical shift values, coupling constants, fragmentation patterns – base peak, molecular ion peak).

Structure elucidation of – hydrocarbons (normal, branched-chain and cyclo alkanes, alkenes, alkynes), aromatic hydrocarbons, polynuclear aromatic hydrocarbons, alcohols, phenols, esters, epoxides, peroxides, ketones, aldehydes, carboxylic acids, lactones, acid halides, acid anhydrides, amides, lactams, amines, nitriles, isonitriles, azo compounds, nitro compounds, sulphur compounds, halogen compounds, silicon compounds, phosphorous compounds, heteroaromatic compounds (at least one compound has to be studied under each category).

**UNIT-II: X-RAY, ELECTRON AND NEUTRON DIFFRACTION STUDIES 16 hrs**

**X-Ray diffraction studies:** Theory, Mosley's law, interaction of X-ray with matter, Auger and Coster Kronig processes, instrumentation, X-ray absorption and emission methods, X-ray diffraction, automated X-ray diffractometry, Miller indices, Bragg's condition for diffraction, X-ray detection and measurement, structural analysis of crystals, Laue method, Bragg's method, Rotating crystal method, Debye and Scherrer powder method, simple lattices and X-ray intensities, scattering factors, structure factor and its relation to electron density, identification of unit cells from systematic absences in diffraction patterns, predicting diffraction pattern of lattices, phase problem, procedure for X-ray structure analysis, Ramachandran diagram.

**Electron diffraction:** Basic principle, scattering intensity and scattering angle, Wierl equation, measurement technique, elucidation of structure of simple gas phase molecules, electron diffraction studies of some compounds, low-energy electron diffraction (LEED) and structure of surfaces.

**Neutron diffraction:** Introduction, theory, scattering of neutrons by solids and liquids, magnetic scattering, measurement technique, elucidation of structure of magnetically ordered unit cell, applications of neutron diffraction studies.

**UNIT-III: AUTOMATIC AND THERMAL METHODS OF ANALYSIS. 16 hrs**

**Automatic methods of analysis:** specifications and performance of automated methods, automation strategy, advantages and disadvantages of automated techniques, infrared process analyzers, selection of on-line analyzers, on-line potentiometric analyzers, chemical sensors (optodes and microsensors), automatic chemical analyzers, discrete analyzers, continuous analyzers (single channel and multi channel), continuous flow methods, flow-injection analysis, centrifugal analyzers, automatic elemental analyzers, laboratory robots.

**Thermal methods of analysis:** Introduction, thermogravimetric methods, thermogram, factors

affecting thermogram, thermogravimetric analysis (TGA) – instrumentation and applications (TGA analysis of polymers and inorganic compounds), static and dynamic thermogravimetry. Differential thermal analysis (DTA) – theory, instrumentation and applications (DTA analysis of polymers and inorganic compounds). Differential scanning calorimetry (DSC): theory, instrumentation and applications, factors affecting DTA and DSC.

**UNIT-IV: SURFACE CHARACTEIRIZATION TECHNIQUES 16 hrs**

**Surface characterization techniques:** Introduction, definition of solid surface, types of surface measurements, spectroscopic surface methods – general technique in surface spectroscopy. Electron spectroscopy: Basic principles, instrumentation and applications of X-ray photoelectron spectroscopy (XPS) and Auger electron spectroscopy (AES). Secondary-ion mass spectrometry, laser microprobe mass spectrometry, Electron microprobe spectrometry: Basic principles, instrumentation and applications of scanning electron microscopy (SEM), scanning probe microscopes, scanning tunneling microscope (STM) – principles, instrumentation and applications, atomic force microscope (AFM) - principles, instrumentation and applications.

**REFERENCES:**


1. **Vogel's Textbook of Quantitative Chemical Analysis**, J. Mendham, R.C. Denney, J.D. Barnes, M. Thomas, B. Sivasankar, 6th Edition, Pearson Education, New Delhi, India, 2012.
2. **Principles of Instrumental Analysis**, D.A. Skoog, E.J. Holler, T.A. Nieman, 5th Edition, Thomson Aisa Pvt. Ltd., Singapore, 2004.
3. **Instrumental methods of Chemical Analysis (covering UGC Syllabus),** H. Kaur, Pragathi Prakashan, New Delhi, India
4. **Quantitative Chemical Analysis,** Daniel C. Harris, 6th Edition, W.H. Freeman and Company, New York, USA, 2003.
5. **Fundamentals of Analytical Chemistry**, D.A. Skoog, D.M. West, E.J. Holler, S.R. Crouch, 8th Edition, Thomson Aisa Pvt. Ltd., Singapore, 2004.
6. **Introduction to Spectroscopy,** D.L. Pavia, G.M. Lampman, G.S. Kriz, 3rd Edition, Cengage Learning India Pvt. Ltd., New Delhi, 2008.
7. **Spectrometric Identification of Organic Compounds,** R.M. Silverstein, F.X. Webster, 6th Edition, Wiley Student Edition, New Delhi, India, 2007.
8. **Applications of Absorption Spectroscopy of Organic Compounds**, John R. Dyer, Prentice-Hall of India Pvt. Ltd., New Delhi, India, 2007.
9. **Instrumental Analysis**, D.A. Skoog, E.J. Holler, S.R. Crouch, 11th Indian Reprint, Cengage Learning India Pvt. Ltd., New Delhi, 2012.
10. **Molecular Structure and Spectroscopy**, G. Aruldhas, 2nd Edition, Prentice-Hall of India Pvt. Ltd., New Delhi, India, 2007.
11. **Symmetry and Spectroscopy of Molecules,** K. Veera Reddy, New Age International Pvt. Ltd., New Delhi, India, 1998.
12. **Analytical Chemistry – Theory and Practice,**, R.M. Verma, 3rd Edition, CBS Publishers and Distributors, New Delhi, India, 2007.
13. **Vibrational Spectroscopy – Theory and Applications**, D.N. Sathyanarayana, New Age International Publishers, New Delhi, India, 2004.
14. **Organic Spectroscopy**, William Kemp, 3rd Edition, Palgrave, New York, USA, 2004.

15. **Basic Atomic and Molecular Spectroscopy**, J. Michael Hollas, Royal Society of Chemistry, Cambridge, UK, 2002.
16. **Quantitative Analysis,** Day and Underwood, Prentice/Hall Pvt. Ltd. 6th Edition (1993).
17. **Vogel's text Book of Quantitative Chemical Analysis,** Revised by G.H. Jaffery, J. Bassett, J. Mendhrn and R.C. Denny, ELBS 5th Edition (1998).
18. **Analytical Chemistry,** Gray D. Christian, 5th Edition, John Wiley and Sons, Inc
19. **Introduction to Chromatography- Theory and Practice,** V.K. Srivatsan and K.K. Srivatsan, S. Chand Company Ltd. 4th Edition (1991).
20. **Instrumental Methods of Analysis**-Willard, Merrit and Dean, 7th Edition, (1998).
21. **Instrumental Methods of Chemical Analysis,** B.K. Sharma, Goel Publishing House. Meerut, (2000).
22. **Group theory and its applications to Chemistry,** K.V. Raman, Tata McGraw Hill 1997.
23. **Fundamentals of Molecular Spectroscopy**, 3rd edition – C.N. Banwall, McGraw Hill, Book co, (UK) Ltd 1983.

# ChSC-4.2: INORGANIC CHEMISTRY - IV

**Total: 64 hrs**

**UNIT I: BIOINORGANIC CHEMISTRY-I: 16 hrs**

Essential and trace metal ions in biological process, , bioligands- amino acids, proteins, nucleic acids, nucleotides and their potential metal binding sites; special ligands- porphyrins, chlorin and corrin. Metalloproteins- role of protein and metal ions in metalloproteins; metalloenzymes and metal activated enzymes.

**Ion transport across cell membrane:**

Structure and function of biological membranes, concentration of metal ions outside and inside cells, ion transport across cell membrane; crown ethers, ionophores-channel forming and carrier ionophores; active and passive transport; transport $Na^+$& K+ions: $Na^+/K^+$ pump- importance and mechanism of action; $Ca^{2+}$ storage and transport, $Ca^{2+}$ pump- importance and mechanism of action, role of $Ca^{2+}$ in muscle contraction and blood clotting.

Transport and storage of Fe: Structure and roles of ferritin, transferrin and siderophores; Transport of Cu: - Structure and role of ceruloplasmin.

**Biological oxygen carriers:** Heme proteins - $O_2$ uptake, transport and storage. Thermodynamic and kinetic aspects of dioxygen as oxidant, activation of $O_2$ through transition metal complexation; basic requirements for effective $O_2$ carriers, Structure and functioning of hemoglobin (Hb) and myoglobin(Mb) proteins, $O_2$ binding- cooperativity effect, Perutz trigger mechanism, Bohr effect, role of distal and proximal histidine; role of protein chains; CO and $CN^-$ poisoning and treatment. Model compounds for $O_2$ binding and synthetic $O_2$ carriers; non-porphyrin systems- hemerythrin and hemocyanin. Photosynthesis: Chlorophyll: structural features, role of $Mg^{2+}$; light and dark reactions, PS-I and PS-II, Z-scheme of photosynthesis, oxygen evolving complex(OEC).

**UNIT II: BIOINORGANIC CHEMISTRY-II 16 hrs**

Nitogen fixation - Chemical inertness of $N_2$- thermodynamic and kinetic aspects, activation of $N_2$ through metal interaction. Biological nitrogen fixation: Nitrogenase enzyme, structure, $N_2$ binding sites and mechanism of action.

**Electron transfer proteins:** organic cofactors-FAD, NAD, FMN, ubiquinone; Structure and functions of:- blue copper protein (plastocyanin); Fe-S protein- rubredoxin, ferridoxin and HIPIP; heme proteins: cytochromes- cytochrome c and cytochrome c-oxidase. Electron transport chain (ETC) in respiration.

**Metalloenzymes:** Zinc enzymes- nature's choice of Zn(II) for non-redox enzymes ; structure of active site and function of carboxypeptidase, carbonic anhydrase and alcohol dehydrogenase. Copper enzyme-super oxide dismutase. Molybdenum enzyme- xanthineoxidase. Iron enzyme-catalase, peroxidase and cytochrome p-450. Vitamin $B_{12}$ and coenzymes: structure of corrin ring, cobalamin unit, reduction of aquacobalamin $B_{12a}(Co^{III})$ to $B_{12r}(Co^{II})$ , $B_{12s}(Co^{I})$ and their importance; biomethylation and mutase activity of cobalamins.

Applied bioinorganic chemistry: Metal ion deficiency and treatment- Fe, Cu, Mn, Zn deficiency and treatment. Metal ion excess toxicity-Fe excess toxicity- African siderosis, hemosiderosis, hemochromatosis (bronze diabetes) and detoxification. Cu excess toxicity: Wilson's disease and treatment.

Heavy metal ion toxicity: Hg, Pb, Cd, As toxic effects – mechanism of toxic effects. Heavy metal toxicity treatment- chelation therapy: chelating agents for Hg, Pb, Cd, As toxicity. Metal complexes as drugs: cis-plain as anticancer agent: mechanism of action and side effects; gold complexes as antiarthritic drugs- chrysotherapy. Metal complexes in diagnosis - Gd complexes in magnetic resonance imaging (MRI).

**UNIT-III: ENVIRONMENTAL CHEMISTRY 16 hrs**

Concept and scope of environmental chemistry, environmental segments, natural cycles of the environment (hydrogen, carbon, oxygen, nitrogen, phosphorus and sulphur cycles), Atmosphere – composition of the atmosphere, Earth's radiation balance, particles, ions and radicals in the atmosphere, chemical and photochemical reactions in atmosphere – oxygen and ozone chemistry, $SO_2$, $NO_x$, organic compounds, Greenhouse effect (Global warming), ozone depletion (making a hole in the sky), Hydrosphere – the hydrologic cycle, physical chemistry of sea water, aquatic biochemical processes. Chemical toxicology – toxic chemicals in the environment, impact of toxic chemicals on enzymes, biochemical effects of – As, Cd, Pb, Hg, CO, $NO_x$, $SO_2$, Ozone, PAN, cyanide, pesticides, carcinogens), Bio-Warfare agents, environment and public health. Air pollution – air pollutants (CO, $NO_x$, hydrocarbons and photochemical smog, CFCs, $SO_2$, acid rain, particulates, radioactive substances, tropospheric chemistry), Air quality standards – sampling, monitoring, some air pollutant accidents (TCDD Accident at Seveso, Italy – July 1976, The Bhopal Disaster – December 3, 1984, Chernobyl Disaster – April 28, 1986).

Water pollution – Aquatic environment, water pollutants, eutrophication, water quality parameters and standards, trace elements in water, monitoring techniques and methodology – (pH, specific conductance, DO, $NH_3$, nitrate and nitrites, chloride, fluoride, cyanide, sulphide, sulphate, phosphate, total hardness, phenols, oil spills, pesticides, surfactants, microorganisms, COD, BOD). Determination of DO, COD and BOD. Treatment of water pollutants – primary, secondary and tertiary processes.

**UNIT-IV: CHEMISTRY OF NEW MATERIALS 16 hrs**

Chemistry of new materials: Conducting polymers: Polyaniline (PAN), poly p-phenylene (PPP),), poly-pyrrole (PPP) , poly-phenylacetelene (PPA) - mechanism of conduction, doping, properties, engineering and biological applications.

Super conductors- introduction, type I and type II super conductors, preparation of high Tc super conductor-$Y_1Ba_2Cu_3O_8$, BCS theory, Meisner effect, magnetic levitation, applications of high Tc super conductors.

Supra molecular chemistry: Definition, nature of supra molecular interactions; supra molecular host-guest compounds, common host molecules- crown ethers, porphyrins, zeolites, pillarenes, clixarenes, Molecular recognition and molecular receptors; Supra molecular catalysis, molecular switches, molecular wires.

**REFERENCES:**


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2. **Inorganic Chemistry**, 3rd ed. D.P.Shriver and P.W.Atkins, Oxford University press, 1999.
3. **Principles of Inorganic Chemistry** - B.R.Puri, L.R.Sharma and K.C.Kalia , Mile Stone Publishers, Delhi, 2010.
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6. **Bioinorganic Chemistry**-Asim K. Das, 2010 Reprint, Books and Allied(P) Ltd, Kolkota.
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9. **Nanotechnology: Importance and applications,** M.H. Fulekar, IK Internation al, 2010.
10. **Supramolecular chemistry- Concepts and Perspectives**, J.M. Lehn, Wiley-VCH, 1995.
11. **Supramolecular Chemistr'.** P. D. Beer, P. A. Gale, D. K. Smith, Oxford University Press, 1999.
12. **Supramolecular Chemistry,** J.W.Steed, J.L. Atwood, Wiley, 2000.


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## ChSC-4.3: ORGANIC CHEMISTRY - IV

### CHEMISTRY OF NATURAL PRODUCTS-I

**Total: 64 hrs**
**16hrs**

**UNIT-I: Carbohydrates:** Classification of carbohydrates, D,L-notations, configuration and conformations of carbohydrates. redox reactions of monosaccharides, osazone formation, chain elongation (Kiliani-Fischer synthesis), chain shortening (Ruff degradation), cyclic structure of monosaccharides (hemiacetal formartion), stability of glucose, acylation and alkylation of monosaccharides, formation of glycosides, anomeric effect, reducing and non-reducing sugars. Disaccharides- structural elucidation of sucrose, cellobiose, maltose and lactose, Polysaccharides- structural elucidation of cellulose, starch (amylose and amylopectin) and glycogen.

**UNIT-II: Amino acids and Proteins: Amino acids:** Classification and nomenclature of amino acids, general properties and reactions of amino acids, configuration of amino acids, General methods of synthesis of amino acids – Amination of α-haloacids, Gabriel's phthalimide synthesis, Strecker synthesis, Malonic ester synthesis, Darapsky synthesis, Azlactone synthesis.

**Proteins:** Structure and nomenclature of peptides and proteins, automated solid phase peptide synthesis (Bruce-Merrifield synthesis), cleavage of disulphide linkages, determination of amino acid composition, sequencing the peptide from N-terminus (Edman degradation) and C-terminus, determination of structure of proteins (primary, secondary and tertiary structures).
**Nucleic acids:** Classification of nucleic acids, structure of nucleosides and nucleosides containing pyrimidine and purine bases, sequence of nucleic acids, Crick-Watson model of DNA, structure of RNA (m-RNA, t-RNA and r-RNA), genetic code – salient features.

## CHEMISTRY OF NATURAL PRODUCTS- II

**16hrs**

**UNIT-III: Terpenoids** - Classification, nomenclature, occurrence, general methods of structure determination, and each one method of synthesis of - Citral, α-Terpineol, Menthol, Zingiberene, Santonin.

**Flavonoids** - Occurrence, nomenclature and general methods of structure determination and each one method of synthesis of Apigenin, Luteolin, Quercetin, and Myrcetin.
**Vitamins:** Classification, nomenclature, biological importance, structure, and each one method of synthesis of Vitamin-$B_1$, $B_2$, $B_3$, $B_6$, $B_{12}$, Folic acid (Folate), Vitamin-A., $A_1$, $A_2$, Vitamin-E, Vitamin-C.

**16hrs**

**UNIT-IV: Alkaloids** - Definition, nomenclature, occurrence and classification based on nitrogen heterocyclic ring and general methods of structure elucidation, Stereochemistry and each one method of synthesis of Papaverine, Reserpine, Ephedrine, Nicotine, Atropine, Quinine and Morphine.
**Steroids** - Occurrence, nomenclature, basic skeleton. Diel's hydrocarbon. Stereochemistry and structural elucidation of Cholesterol, Lanosterol, Ergosterol, Stigmasterol, Androsterone, Testosterone, Estrone, Progestrone, Aldosterone.

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7. **Organic Chemistry,** Francis A. Carey, 5th Edition, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2004.
8. **Organic Chemistry,** I.L. Finar, 5th Edition (Volume-2), Pearson Education, New Delhi, India, 2009.
9. O**rganic Chemistry of Natural products**, Gurudeep R. Chatwal, (Edited by M. Arora), Vol. 2, Himalaya Publishing House, Mumbai, India, 2008.
10. **Organic Chemistry – Natural Products**, O.P. Agarwal, Vol. I, GOEL Publishing House, Meerut, India, 2003.
11. **Organic Chemistry – Natural Products**, O.P. Agarwal, Vol. II, GOEL Publishing House, Meerut, India, 2004.
12. Introduction to Alkaloids – G.A. Swan
13. The Alkaloids - K.W. Bently
14. Steroids – L. Fiescher and M. Fischer
15. Steroids – Shoppe
16. Chemistry Of Natural Products by Sujata V. Bhat, Bhimsen A. Nagasampagi, Meenakshi Sivakumar
17. Organic Chemistry 2nd Edition, Nick Greeves ), Stuart Warren , Jonathan Clayden

# ChSC-4.4: PHYSICAL CHEMISTRY - IV

**Total: 64 hrs**

## UNIT- I: CHEMISTRY OF NANOMATERIALS 16 hrs

**Introduction:** Fundamentals and importance, Metal nanoclusters, magic numbers, theoretical modeling of nano particles, Geometric structure, electronic structure, reactivity, fluctuations, magnetic clusters, Bulk to nano transitions. Semi conducting nanoparticles- optical properties, photofragmentation, coulombic explosion.

**Carbon nano particles:** Introduction, Carbon molecules, Nature of the carbon bond, New carbon structures. Carbon clusters: small carbon clusters, $C_{60}$; Discovery, structure, crystal, alkali doping, super conductivity, Fullerens, other Bulkyballs. Carbon nano-tubes: Fabrication, structure, electrical properties, vibrational properties, mechanical properties, application of nano materials.

**Methods of preparation:** Plasma arcing, chemical vapour deposition, sol-gel, silica-gel, hydrolysis, Condensation and polymerization of monomers to form particles, Electrodeposition, ball milling, Chemical methods, Thermolysis, Pulsed laser methods.

## UNIT – II: METAL FINISHING 16 hrs

**Metal finishing:** Electrode potential-standard potential, EMF series and its applications, Deposition potential-deposition from simple salt solution and solution mixtures, polarization and over voltage, effect of polarization on electrodeposition, limiting current density, hydrogen over voltage. Principles of electroplating. Role of anodes in electroplating. Pre-plating process and surface preparation. Hull cell experiment, covering power and throwing power. Electroplating practice for metals and alloys (Cu, Ni, Zn, brass, bronze).

Specifications and testing of electroplates - Introduction, thickness-destructive and non destructive testing methods, Adhesion-bend test, burnishing test, file test, grinding test, heat test, peel test, corrosion resistance-salt spray test, acetic acid salt spray test, copper accelerated acetic

acid salt spray test, corrodekote test, Sulphur dioxide test, porosity-Ferroxyl test, electrographic test, hot water test, hardness test. Immersion (Galvanic) plating, electroless plating.

**UNIT-III: CORROSION AND PHASEEQUILIBRIA** **16 hrs**

**Corrosion and its control:** Types of corrosion (atmospheric, environmental and microbial). Galvanic series – merits and demerits, thermodynamics and kinetics of corrosion, corrosion rate measurement, corrosion failure and passivity. Methods of prevention of corrosion, corrosion problems in practice.

**Phase equilibria:** Introduction, derivation of phase rule, applications of phase rule to one-component systems (water and sulphur systems). Two-component systems (potassium iodide-water system and ferric chloride-water system), three-component systems (two solids + one liquid system, and three liquid systems).

**UNIT-IV: ELECTROSYNTHESIS** **16 hrs**

Fundamentals, generalized electrochemical reaction, reaction variables in electro synthesis, setting up the electrolysis cell – Basic laboratory apparatus, two-electrode cells, three-electrode cells. Electrode material, cell geometry. Selection of electrode potential, divided and undivided cells, preparation of solution for electrolysis – solvent and supporting electrolyte, temperature effects.

**Electro-organic reactions:** Electrooxidation and reductions of hydrocarbons, nitro compounds, sulphur compounds, nitrogen heterocyclic compounds, halogen compounds and carboxylic acids (Kolbe's synthesis). Some preparative examples - Reductive intermolecular Carbon-Nitrogen bond formation, Carboxylic acids from primary alcohols, cyanation of N,N-Propylpyrrolidine, preparation of 3,6-Dichloropicolinic acid from 3,4,5,6-Tetrachloropicolinic acid.

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1. **Introduction to Nanotechnology,** Charles P. Poole, Jr., and Frank J. Owens, Wiley -Interscience, A. John Wiley and Sons, Inc., 2006.
2. **Nanotechnology (Basic Science and Emerging Technologies)**, Mick Wilson, Kamali Kannangara Geoff Smith, Michelle Simmons, and Burkhard Raguse, First Indian Edition, Overseas Press India Private Limited, 2005.
3. **Chemical and Electrochemical Energy Systems,** R. Narayan and B. Vishwanathan (University Press).
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