**Department of Chemistry**
**Sidho-Kanho-Birsha University**

**Chemistry Post-graduate course structure (Semester wise)**
**[Passed at BOS meeting held on 14.09.2016]**

| Semester | Course code | Course title | Credit | Marks | Number of class hour/week |
|---|---|---|---|---|---|
| Semester I | MCHECCT101 | General Chemistry Theory | 4 | 40+10 | 4 |
| | MCHECCT102 | Inorganic Chemistry Theory | 4 | 40+10 | 4 |
| | MCHECCT103 | Organic Chemistry Theory | 4 | 40+10 | 4 |
| | MCHECCT104 | Physical Chemistry Theory | 4 | 40+10 | 4 |
| | MCHECCS105 | Inorganic Chemistry Practical | 4 | 50 | 8 |
| | MCHECCS106 | Organic Chemistry Practical | 4 | 50 | 8 |

| Semester | Course code | Course title | Credit | Marks | Number of class hour/week |
|---|---|---|---|---|---|
| Semester II | MCHECCT201 | Analytical Chemistry Theory | 4 | 40+10 | 4 |
| | MCHECCT202 | Inorganic Chemistry Theory | 4 | 40+10 | 4 |
| | MCHECCT203 | Organic Chemistry Theory | 4 | 40+10 | 4 |
| | MCHECCT204 | Physical Chemistry Theory | 4 | 40+10 | 4 |
| | MCHECCS205 | Physical Chemistry Practical | 4 | 50 | 8 |
| | MCHECCS206 | Analytical Chemistry Practical & Data Processing | 4 | 50 | 8 |

| Semester | Course code | Course title | Credit | Marks | Number of class hour/week |
|---|---|---|---|---|---|
| Semester III | MCHECCT301 | Advanced General Chemistry-I Theory | 4 | 40+10 | 4 |
| | MCHECCT302 | Advanced General Chemistry-II Theory | 4 | 40+10 | 4 |
| | MCHEMET303 | Special Theory | 4 | 40+10 | 4 |
| | MCHEMES304 | Special Practical | 4 | 50 | 8 |
| | MCHEOET305 | Open elective - Essence of Chemistry (For students from other Departments) | 4 | 50 | 4 |
| | MCHEOPP306 | Social outreach programm | 4 | 50 | 8 |

Special (Papers: MCHEMET303 & MCHEMES304)
One to be chosen from below
I – Inorganic Chemistry
O – Organic Chemistry
P – Physical Chemistry

| Semester | Course code | Course title | Credit | Marks | Number of class hour/week |
|---|---|---|---|---|---|
| Semester IV | MCHEMET401 | Special Theory | 4 | 40+10 | 4 |
| | MCHEMET402 | Special Theory | 4 | 40+10 | 4 |
| | MCHEMET403 | Special Theory | 4 | 40+10 | 4 |
| | MCHEMES404 | Special Practical | 4 | 50 | 8 |
| | MCHEMEP405 | Special Project work | 4 | 50 | 8 |
| | MCHEACT406 | Add-on course | 4 | 50 | 4 |

Special (Papers: MCHEMET401, MCHEMET402, MCHEMET403, MCHEMES404, MCHEMEP405)
One to be chosen from below
I – Inorganic Chemistry
O – Organic Chemistry
P – Physical Chemistry

**Department of Chemistry**
**Sidho-Kanho-Birsha University**

**Chemistry Post-graduate course**
**Detailed Syllabus (Semester wise)**

## SEMESTER I

### MCHECCT101
### General Chemistry

Group A

1. Nuclear properties and structure: (20 lectures)

Introduction to nuclear stability, formulation of semi-empirical binding energy equation, mass parabola and application of binding energy equation; nuclear reactions, Q value and cross section of nuclear reaction, compound nucleus theory (qualitative approach), calculation of fission probability using binding energy equation, shell model, nuclear magic number and its derivation from nuclear potential well, calculation of nuclear spin, nuclear isomerism and non-optical transitions; Synthetic elements; theoretical background, production of super heavy elements.

2. Radioactive equilibrium: (10 lectures)

Successive disintegration, Bateman equation, secular and transient equilibrium, no equilibrium; analysis of special types of successive disintegration, formation of radioelement in a nuclear reaction.

Group B

3. Environmental chemistry: (17 lectures)

Characteristics of atmosphere, radiation balance; Greenhouse effect monitoring, mechanistic pathways of smog formation and ozone hole, acid rain; major, minor and trace constituents of the atmosphere; water quality parameters, biochemical effects of As, Pb, Cd, Hg, organic toxicants, pesticides and their chemical speciation; eutrophication, waste water treatment—primary, secondary and tertiary treatment, nuclear waste; nuclear accidents, control of air pollution: different methods — gravitational setting chamber, cyclone separators, electrostatic precipitation; role of plants, various sources of soil pollution; noise pollution: classification, hazards.

4. Application of Statistics to Data Treatment and Evaluation: (13 lectures)

Significance Test – Paired, one tailed and two tailed t-test, F-test, Q-test for outliers, Estimation of detection limits, Least square method for calibration plots, Quality assurance and controlled charts, Regression and correlation analysis.

### MCHECCT102
### Inorganic Chemistry

Group A

1. Valency theories: quantum chemical approach: (15 lectures)

Variation method, LCAO and Huckel approximation applied to H2+ and H2 type systems, sigma and pi MO's (ethylene, allyl systems, butadiene, benzene etc.); comparative study of the application of VB and MO methods to diatomic species; MO of polyatomic molecules; Walsh diagram, configuration interaction, orbital construction for Hn type systems.

2. Coordination chemistry: bonding, stereochemistry and structure: (15 lectures)

Spectroscopic ground states; Orgel energy level and Tanabe-Sugano diagrams for transition metal complexes; ligand symmetry orbital, molecular orbital, spectral properties, Nephelauxetic effect,

Racah parameter, vibronic coupling, band broadening, spin-orbit coupling, spin-forbidden transition, intensity stealing, magnetic properties, anomalous and subnormal magnetic moments, lowering of symmetry, electronic, steric, Jahn-Teller and Renner-Teller effects on energy levels, conformation of chelator/congregator, structural equilibrium and implication, Labile and inert complexes

Group B

3. Cluster compounds: (15 lectures)

Introduction, clusters in elemental states, cluster classification, skeletal electron (Elm) counting, higher boron hydrides structures and reactions, equation of balance,Lipscomb topological diagrams, polyhedral skeletal electron pair theory (PSEPT),carboranes,metalloboranes and heteroboranes, metallocarboranes, zintl ions, chevrel compounds, infinite metal chains, multidecker molecules, cluster-surface analogy.

4. Bioinorganic chemistry: (15 lectures)

Metal ions in biology, myoglobin, heamoglobin, heamocyanin, hemerythrin, chemistry of respiration; cytochromes, rubredoxin, feredoxins; biological fixation of nitrogen, chlorophyll and photosynthesis; PS-I, PSII, study of metalloprotein and metalloenzyme catalase, peroxidase, ceruloplasmin, cytochrome oxidase, carbonic anhydrase, carboxy peptidase, metallothionine, xanthine oxidase, sulphite oxidase, nitrate reductase, superoxide dismutase, vitamin B12 and B12-enzyme; toxicity and detoxification of metal ions; chelation therapy.

## MCHECCT103
## Organic Chemistry

Group A

1. Stereochemistry: (16 lectures)

Chirality and symmetry, stereogenicity and stereoisomerism, stereochemical descriptors (R,S system, D,L system, E,Z system, Erythro, Threo system), Topicity relationship (homotopic,diastereotopic and enantiotopic), Topicity descriptor (Pro-R/Pro-S, Re/Si), determination of relative configuration: Prelog's rule, Cram's rule (Felkin modification),conformation and reactivity of monocyclic systems (3 to 8 membered rings), fused (5/5, 6/6 and 6/5), spiro and bridged bicycle systems, allylic strain, reactions of 5/6-membered ring containing one or more trigonal carbon(s)

2. Reactive intermediates with allied reaction mechanisms: (10 lectures)

Classical and non classical carbocations and carbanions, radicals, radical cations and anions, carbenes, arynes and nitrenes.

3. Structure-reactivity relationship: (04 lectures)

The Hammett equation and linear free energy relationship, equilibria and rates in organic reactions, substituent and reaction constants, Taft equation.

Group B

4. Application of spectroscopy in structure elucidation: (20 lectures)

Ultraviolet Spectroscopy: Theory and classification of electronic transitions, vacuum ultraviolet, Beer-Lambert law,effect of solvent on electronic transitions, ultraviolet bands for carbonyl compounds, unsaturated carbonyl compounds, dienes, conjugated polyenes, Fieser-Woodward rules (for conjugated dienes,carbonyl compounds), UV spectra of aromatic and heterocyclic compounds, charge transfer band.

Infrared Spectroscopy: Introduction and experimental methods, units, notation and regions; Dispersive and FT-IR,sampling techniques, fundamental vibrations, overtones, group frequencies, factors affecting group frequencies, conjugation, inductive, resonance, steric effects, application of IR in the study of hydrogen bonding, stereoisomerism, tautomerism, identification of functional groups.

NMR spectroscopy: Introduction, Magnetic properties of nuclei, Resonance condition, Field Frequency diagram,Precession of nuclei, relaxation, CW and PFT methods, sample handling, Chemical shift, Mechanism of shielding and deshielding, chemical shifts of different types of organic compounds, spin-spin coupling, germinal and vicinal coupling, Relative intensities, Chemical and magnetic equivalence of protons, protons attached to elements other than carbon, chemical exchange phenomena, temperature effects.

Mass Spectrometry and Composite Problems: Instrumentation, methods of ionization: EI, CI, Electron impact mass spectroscopy, low and high resolution, exact masses of nucleides, molecular ions, isotope ions, mass marking techniques,fragment ions of odd and even electron types, rearrangement of ions, base peak, nitrogen rule,metastable peaks, isotope peaks, isotope effects in chloro and bromo compounds, calculation of molecular formula, factors effecting cleavage patterns.Composite problems representing application of spectroscopy (IR, UV-vis, $^{1}$H NMR) in structure elucidation.

5. Organic transformations: (10 lectures)
Multi-component reactions-early examples, Ugi reaction, Passerini reactions, Biginelli condensation; Baylis-Hillman reaction, Olefin metathesis, Remote functionalisation,

## MCHECCT104
## Physical Chemstry

Group A
1. Symmetry and group theory I: (12 lectures)
Point symmetry operations, groups and group multiplication tables, similarity transformation and conjugate classes, identification of point groups and stereographic projection, representation of symmetry operators and groups; characters of symmetry operators in a representation, invariance of character under similarity transformation, symmetry elements and symmetry operations of the Platonic solids, symmetry of the fullerene [60] structure.

2. Quantum mechanics I: (10 lectures)
Some important experiments - black-body radiation, photoelectric effect, Davison and Germer experiment, Franck-Hertz experiment, identification of classical and quantum systems, de Broglie wavelength, Bohr's correspondence principle with examples; postulates of quantum mechanics, properties of wave functions, operators and related theorems.

3. Atomic spectra: (08 lectures)
Quantum numbers, orbital and spin angular momenta of electrons, Stern-Gerlach experiment, vector atom model, term symbols (one and two optical electron systems), normal and anomalous Zeeman effect, Paschen back effect.

Group B
4. Thermodynamics and statistical mechanics: (12 lectures)
Legendre transformation with applications; Maxwell-Boltzmann distribution with degeneracy (for both distinguishable and indistinguishable particles), partition function and its properties, interpretation of thermodynamic laws, thermodynamic function in terms of partition functions, molecular partition functions (translational, rotational, vibrational and electronic) for ideal gas, calculation of thermodynamic functions for monoatomic and diatomic gases, equipartition principle, equilibrium constant in terms of partition function.

5. Principles of molecular spectroscopy: (18 lectures)
Electromagnetic spectrum and molecular processes associated with the regions; rotational spectra: classification of molecules into spherical, symmetric and asymmetric tops; diatomic molecules as rigid rotors energy levels, selection rules and spectral features, isotope effect, intensity distribution, effect of nonrigidity on spectral features; vibrational spectra of diatomics: potential energy of an oscillator, Harmonic Oscillator approximation, energy levels and selection rules, anharmonicity and its effect on

energy levels and spectral features: overtones and hot bands, vibration-rotation spectra of diatomics: origin; selection rules; P, Q and R branches; Raman spectra: origin, selection rules, rotational and vibrational Raman spectra of diatomics; NMR spectra: theory, relaxation process, instrumentation, chemical shift and shielding, factors contributing to magnitude of shielding, spin interactions↓ its origin, equivalent protons, qualitative idea of energy levels of AX and A2 systems, a few representative examples.

## MCHECCS105
## Inorganic Chemistry Practical

1. Inorganic qualitative analysis: (6 radicals including rare elements): Systematic analysis of unknown inorganic samples containing acid and basic radicals with composition.

## MCHECCS106
## Organic Chemistry Practical

1. Detection of functional groups of the supplied samples (Solid, liquid, hydrocarbon) containing nitrogeneous [nitro, amide, anilide, amine, non-nitrogeneous (carboxylic acid, ester, aldehyde, ketone, phenolic –OH, alcoholic – OH, determination of mp/bp of the supplied sample and derivative.

2. Synthesis of organic compounds involving nitration, diazotisation, photochemical reaction,Sandmayer reaction, pinacol-pinacolone rearrangement, claisen rearrangement etc.

Recommended Books/Journals

H. J. Arnikar, Essentials of Nuclear Chemistry, 4th Edn Reprint, New Age International (P) Ltd Publications,New Delhi, 2001.
R. D. Evans, The Atomic Nucleus, McGraw-Hill, New York, 1979.
B. Harvey, Introduction to Nuclear Physics and Chemistry, Prentice Hall, 1965.
S. Glasstone, Source Book of Atomic Energy, East-West Press Pvt. Ltd, New Delhi, 1967.
G. R. Choppin and J. Rydberg, Nuclear Chemistry: Theory and Applications, Pergamon Press.
G. Friedlander, J. W. Kennedy, E. S. Macias and J. M. Miller, Nuclear and Radiochemistry, 3rd Ed., Jhon Wiley & Sons Inc., New York, 1981.
V. I. Goldanskii and R. H. Herber, Chemical Applications of Mossbauer Spectroscopoy, Academic Press.
N. Greenwood and T. C. Gibb, Mossbauer Spectroscopy, Chapman and Hall, London, 1971.
C. N. Banwell and E. M. McCash, Fundamentals of Molecular Spectroscopy, Tata McGraw-Hill Publishing Company Ltd, New Delhi, 1994.
J. M. Hollas, Modern Spectroscopy, Wiley, New York, 1996.
R. S. Drago, Physical Methods for Chemists, Saunders, Philadelphia, 1992.
J. M. Hollas, Modern Spectroscopy, Wiley, New York, 1996.
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I.L. Finar, Organic Chemistry, Vol I, 6th Edn., Addison Wesley Longmann, London, 1998.
I.L. Finar, Organic Chemistry, Vol II, 5th Edn., ELBS, London, 1995.
J. March, Advanced Organic Chemistry: Reactions, Mechanisms and Structure, 5th Edn., John Wiley.
S. P. McManus, Organic Reactive Intermediates, Academic Press, New York, 1973.
F.A. Carey and R.J. Sundberg, Advanced Organic Chemistry Part A and Part B, 4th Edn., Plenum Press.
T. L. Gilchrist and C. W. Rees, Carbenes, Nitrenes and Arynes, Nelson, New York, 1973.
T. H. Lowry and K.C. Richardson, Mechanism and Theory in Organic Chemistry, 3rd Edn., Harper and Row, New York, 1998.
W. J. I. Noble, Highlights of Organic Chemistry, Mercel Dekker, 1974.

E.L. Eliel, S.H. Wilen and L.N. Mander, Stereochemistry of Organic Compounds, John Wiley & Sons.
D. Nasipuri, Stereochemistry of Organic Compounds, 2nd Edn., Wiley Eastern, New Delhi, 1993.
W. Kemp, Organic Spectroscopy, 3rd Edn., McMillan, Hong Kong, 1991.
D. H. Williams and I. Fleming, Spectroscopic Methods in Organic Chemistry, 5th Edn., Tata McGraw-Hill, New Delhi,2005.
J. R. Dyer, Applications of Absorption Spectroscopy of Organic compounds, 2nd print Prentice_Hall.
R. M. Silverstein and F. Webster, Spectrometric Identification of Organic Compounds, 6th Edn.,John Wiley, New York, 1998.
K. Biemann, Mass Spectrometry – Application to Organic Chemistry, McGraw-Hill, New York,1962.
H. Budzikiewicz, C. Djerassi and D.H. Williams, Mass Spectrometry of Organic Compounds, Holden-Day, 1967.
R.C. Banks, E.R. Matjeka and G. Mercer, Introductory Problems in Spectroscopy, Benjamin/Cumings Publishing Co., 1980.
R.T. Morison, and R. N. Boyd, Organic Chemistry, 6th Edn., Prentice-Hall India Private Ltd..
J. Barker, Mass Spectrometry, 2nd Edn., John Wiley, New York, 2000.
K. Downard, Mass Spectrometry: A Foundation Course, Royal Society of Chemistry, UK, 2004.
G. Siurdek, The Expanding Role of Mass Spectrometry in Biotechnology, MCC Press, San diego,2004
C. Dass, An Introduction to Biological Mass Spectrometry, Wiley, USA, 2002.
C. N. Banwell and E. M. McCash, Fundamentals of Molecular Spectroscopy (4th edition), Tata McGraw-Hill Publishing Company Ltd., New Delhi, 1994.
R. M. Silverstein, G. C. Bassler and T. C. Morril, Spectroscopic Identification of Organic Compounds, John Wiley, 1991.
W. Kemp, Organic Spectroscopy (2nd edition), ELBS-Macmillan, 1987
R.M. Silverstein, G.C. Bassler, C. Morril, Spectrometric Identification of Organic Compounds (5th edition), John Wiley & Sons, 1991.
J. R. Lakowicz, Principles of Fluorescence Spectroscopy (3rd edition), 2006.
M. Rose, and R.A.W. Johnston, Mass Spectrometry for Chemists and Biochemists (2nd edition), Cambridge University Press, 1996.
D.L. Pavia, G.M. Lampman, G.S. Kriz, Introduction to Spectroscopy (3rd edition), Thomson Brooks/Cole.
Fritz Helmet, Mössbauer Spectroscopy
J.A. Weil, and J.R. Bolton, Electron Paramagnetic Resonance: Elementary Theory and Practical Applications.
G. W. Castellan, Physical Chemistry, 3rd Edn, Narosa Publishing House, 1995.
I. N. Levine, Physical Chemistry, Tata McGraw-Hill, 1978.
G. K. Vemulapalli, Physical Chemistry, Prentice-Hall, India, 1997.
R. S. Berry, S. A. Rice and J. Ross, Physical Chemistry, Oxford University Press, Oxford, 2000.
P. W. Atkins, Physical Chemistry, Oxford University Press, Oxford, 1998.
F. A. Cotton, Chemical Applications of Group Theory, 3rd Edn Reprint, John Wiley and Sons.
A. Vincent, Molecular Symmetry and Group Theory, John Wiley and Sons, New York, 1998.
H. Eyring, J. Walter and G. F. Kimball, Quantum Chemistry, Wiley, New York, 1944.
A. K. Chandra, Introductory Quantum Chemistry, Tata McGraw-Hill Publishing Co, New Delhi.
F. L. Pilar, Elementary Quantum Chemistry, Tata McGraw-Hill, 1990.
P. W. Atkins, Molecular Quantum Mechanics, Clarendon Press, Oxford, 1980.
E. Merzbacher, Quantum Mechanics, John Wiley and Sons, 1970.
L. I. Schiff, Quantum Mechanics, McGraw-Hill, 1985.
L. Pauling and E. B. Wilson, Introduction to Quantum Mechanics, McGraw-Hill, 1939.
C. N.Banwell and E. M. McCash, Fundamentals of Molecular Spectroscopy, 4th Edn, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 1994.
G. M. Barrow, Introduction to Molecular Spectroscopy, McGraw-Hill.
H. E. White, Introduction to Atomic Spectra, McGraw-Hill Kogakusha Ltd., Tokyo, 1934.
K. Denbigh, Principles of Chemical Equilibrium, Cambridge University Press,Cambridge, 1981.
N. A. Gokcen and R. G. Reddy, Thermodynamics, Plenum Press, New York, 1996.
I. M. Klotz and R. M. Rosenberg, Chemical Thermodynamics, John Wiley, New York, 1994.
F. Reif, Fundamentals of Statistical and Thermal Physics, McGraw-Hill, 1965.

SEMESTER II

MCHECCT201
Analytical Chemistry

Group A
1. Separation techniques: (18 lectures)
Solvent extraction: principle, distribution ratio and partition coefficient, successive extraction and separation; different methods of extraction systems.
Chromatography: general principle; classification, mathematical relations of capacity, selectivity factor, distribution constant and retention time; chromatogram, elution in column chromatography: band broadening and column efficiency; van Deemter equation; column resolution,numerical problems, gas chromatography, thin-layer chromatography, size-exclusion chromatography.

2. Radiochemical methods of Analysis: (12 lectures)
Radio-analytical chemistry, Radiation chemistry; Radiation dosimetry- Physical dosimetry, Chemical dosimetry ( Ferrous sulphate and Ceric sulphate dosimetry), Glass dosimetry. Neutron activation analysis, radioactive reagents in the analysis of trace element, isotopic dilution techniques, radiometric titration.

Group B
3. Thermal methods: (14 lectures)
Different methods of analysis: TGA, DTA, DSC; thermogram, thermal stability of covalent and non-covalent bonds, thermal degradation, single crystal phase transformation, thermochemiluminescence, thermometric titration, solid state reaction kinetics

4. Electroanalytical methods I: (16 lectures)
Electrochemical cell, electrodes: reference and indicator electrodes, membrane electrodes, electrode-solution interface layer, gas-sensing probe, electrolytic process, three electrode system; supporting electrolyte, DME; Cottrell equation, Ilkovic equation, Ilkovic-Heyrolsky equation, test of reversibility, current-voltage diagram, DC and AC polarography, stripping voltammetry, amperometric titration, Cyclic voltametry.

MCHECCT202
Inorganic Chemistry

Group A
1. Chemistry of f-block elements: (15 lectures)
Terresterial abundance and distribution of lanthanides and actinides, relativistic effect,electronic configuration and oxidation states; aqueous, redox and complex chemistry in different oxidation states as applicable; electronic spectra and magnetic properties- comparison with d-block elements, Lanthanide and actinide contractions and consequences, Separation of lanthanides and actinides, Lanthanide shift reagents and uses of lanthanide compounds.

2. Inorganic Spectroscopy (15 Lectures)
Fluxionality, distortion and dynamic equilibria; EPR: anisotropy, intensity, hyperfine splitting, photoelectron spectroscopy, XPS, UPS, AUGER, XRF.

Group B
3. Organometallic chemistry I: (15 lectures)
Historical development, classification, nomenclature, valence electron count, oxidation number and formal ligand charge; structure and bonding of carbonyls, nitrosyls and related piacids, alkyl, alkene, alkyne, π-allyl, polyene and cyclopolyene compounds; metal carbenes and carbynes, isolobal analogy, Dewar-Chatt model, oxophilicity, Agostic interaction. Metal-carbon bonded compounds (σ-bonded), synthesis, reactivity, oxidative addition and reductive elimination reaction, insertion reactions.

4. Defects in ionic solids: (15 lectures)
Crystal defects and non-stoichiometry: perfect and imperfect crystals, intrinsic and extrinsic defects; point, line, and plane defects. Determination of equilibrium concentrations Schottky and Frankel defects formation, Non schiometric defects, color centres in ionic crystals, Stoichiometric imbalance in crystals.

## MCHECCT203
## Organic Chemistry

Group A
1. Heterocyclic chemistry: (13 Lectures)
Synthesis, reactivity and uses of the following compounds and their derivatives: imidazole, pyrazole, oxazole, isooxazole, thiazole, iso-thiazole.

2. Reactions with cyclic transition states or cyclic transition intermediates: (04 Lectures)
Tethering – silicon and sulphur as tethers, Robinson annulations, iodolactonization, synthesis of transfused ring.

3. Reagents and reactions in organic synthesis: (13 lectures)
Hydride transfer reagents: Boron based ($NaBH_4$, $Na(CN)BH_3$, super hydride, alpine borane, selectrides etc), Aluminium based ($LiAlH_4$ and substituted $LiAlH_4$, Red-Al, DIBAL-H), trialkyl tin hydride, silane, diimide, enzymatic reduction (Baker's yeast), PCC, PDC, Mn(IV)oxide, $RuO_4$(TPAP), $OsO_4$, 1,3-Dithiane, Wilkinson catalyst, trimethyl silyl iodide (TMSI).
Woodward and Prevost hydroxylation, Sharpless epoxidation, Moffat oxidation, Swern oxidation, Dess-Martin Periodinane, Peterson reaction.

Group B
4. Photochemistry: (18 lectures)
Basic principles, Jablonski diagram, photosensitization and quenching, photochemistry of olefinic compounds, cis-trans isomerisation, Peterno-Buchi reaction, Norrish Type – I and II reactions,photoreduction of ketones, di-π methane rearrangement, photo-induced reactions in organic compounds.

5. Biomacromolecules: (12 Lectures)
Structure of proteins: Primary, secondary, tertiary and quaternary structures; chemical and enzymatic hydrolysis of proteins, denaturation of protein.
Enzymes as biological catalysts, nomenclature, classification, extraction and purification (basic concept only), Fischer's lock and key concept, Koshland's induced fit hypothesis, Enzyme kinetics, Michaelis-Menten and Line weaver-Burk plots, reversible and irreversible inhibitions of enzymes.

## MCHECCT204
## Physical Chemistry

Group A
1. Group theory II: (10 lectures)
The Great Orthogonality Theorem: statement and interpretation, proof of important corollaries; construction of character tables: construction of their character tables for abelian and cyclic groups. Direct product groups and construction of their character tables, direct product representations, reduction formula, vanishing of integrals and its applications, invariance of the Hamiltonian operator and eigenfunctions of H as bases of irreducible representations.

2. Quantum mechanics II: (12 lectures)
Schrödinger equation, energy-eigenvalue equation, expectation value, eigenvalue and spread of observation, definition of uncertainty; equation of motion, constants of motion; detailed treatment of the particle in a box, including degeneracy; step potential and tunneling.

3. Crystal structure: (8 lectures)
Crystal symmetry: translation, glide plane and screw axis; diffraction of X-rays by crystals: Laue and Bragg conditions; concept of reciprocal lattice, crystal structure factor, systematic absence; B-zones and Fermi level in lattice, concept of particle-hole in conduction process, Band theory, theory of conductors, semiconductors and insulators

Group B
4. Electrochemistry I: (12 lectures)
Introduction, ion-solvent interaction: Born model and Born equation, enthalpy of ion solvent interaction and its calculation, Eley-Evan model, solvation number and methods for determination of solvation number, ion association: Bjerrum equation, fraction of ions associated, ion association constant; electrode kinetics: relation between current and rate of electrode reaction, current-overpotential relationship, Tafel equation and its importance

5. Chemical kinetics I: (18 lectures)
Theories of reaction rates: applications to uni-, bi- and ter-molecular reactions, thermodynamic formulation of reaction rate, reactions in solution: cage effect, diffusion and activation controlled reactions (elementary idea), dielectric effect on ion-ion reaction; electrostriction; volume of activation; effect of pressure on reaction rate. Curtin-Hammett principle, linear free energy relationship, Hammett and Taft equation.

## MCHECCS205
## Physical Chemistry Practical

1. Conductivity: a) Determination of strength of CH3COOH and hence verification of Ostwald dilution law. b) Saponification of ester, c) Determination of CMC of micelles.
2. Potentiometry: a) Determination of $E^0$ of quinhydrone electrode, b) Fe2+/Fe3+ system.
3. Kinetics: a) Determination of order of reaction of $I^-$ & $BrO_3^-$, b) Iodination of acetone.
4. Equilibrium: a) Determination of CST, b) Determination of coordination number, c) Solubility product
5. Colorimetry: a) Jobś method, b) Iodination of acetone
6. Polarimetry: Study of kinetics of acid catalysed reaction of sugar.

## MCHECCS 206
## Analytical Chemistry Practical & Data Processing

1. Separation techniques involving ion exchange and solvent extraction
2. Titrimetric estimation of different organic compounds
3. Data processing and elementary numerical techniques
4. Computer application in chemistry-Exposure to available standard application
packages like: chemdraw,generation of graphs,data sheet creation,tables using excel programme,etc.

Recommended Books/Journals:
J. A. Joule and K. Mills, Heterocyclic Chemistry, 4th Edition, Blackwell publishing.
R. Kartritzky, Handbook of Heterocyclic Chemistry, Pergamon Press, London, 1986.
J. March, Advanced Organic Chemistry: Reactions, Mechanisms and Structure, 5th Edn., John Wiley. F.A. Carey and R.J. Sundberg, Advanced Organic Chemistry Part A and Part B, 4th Edn.,
Plenum Press, New York, 2001.
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R.S. Ward, Selectivity in Organic Synthesis, John Wiley & Sons, 1999, New York.
J. Clayden, N. Greeves, S. Warren and P. Wothers, Organic Chemistry, Oxford University Press.
J.H. Fuhrhop and G. Li, Organic Synthesis, Concepts and Methods, Wiley VCH, New York, 2003.
R. Bruckner, Advanced Organic Chemistry, Reaction mechanism, Academic Press.

Michael B. Smith, Organic synthesis, McGraw-Hill International Editions.
W. Carruthers, I. Coldham, Modern Methods of Organic synthesis, 4th Edn. Cambridge.
R. Norman, J. M. Coxon, Principles of Organic Synthesis, Blackie Academic and Professional.
K. K. Rohtagi-Mukherjee, Fundamental of Photochemistry, Wiley-Eastern.
A. Cox, T. Camp, Introductuctory Photochemistry, McGraw-Hill.
R. P. Kundall, A. Gilbert, Photochemistry, Thomson Nelson.
J. Coxon, B. Halton, Organic Photochemistry, Cambridge University Press.
D. L. Nelson and M.M. Cox, Lehninger: Principles of Biochemistry, W.H. Freeman Co, London,2005.
H. Neurath, The Proteins: Composition, Structure and Function, Vols. 1-5, Academic Press.
J. P. Greenstein and M. Winitz, Chemistry of the Amino Acids (3 Vols.), Wiley, New York, 1961.
H. Dugas, Bioorganic Chemistry, A Chemical approach to Enzyme Chemistry, 3rd Edn. Springer.
W. J. I. Noble, Highlights of Organic Chemistry, Mercel Dekker, 1974.
S.W. Fox and J.F. Foster, Introduction to Protein Chemistry, John Wiley, New York, 1957.
G. W. Castellan, Physical Chemistry, 3rd Edn, Narosa Publishing House, New Delhi, 1995.
R. A. Alberty and R. J. Silbey, Physical Chemistry, 1st Edn, John Wiley & Sons, Inc., 1995.
R. S. Berry, S. A. Rice and J. Ross, Physical Chemistry, Oxford University Press, Oxford, 2000.
F. A. Cotton, Chemical Applications of Group Theory, 3rd Edn Reprint, John Wiley and Sons.
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S. C. Rakshit, Molecular Symmetry Group and Chemistry, The New Book Stall, Kolkata, 1988.
Volker Heine, Group Theory in Quantum Mechanics: An Introduction to Its Present Usage, Dover Publication, New York, 1991.
H. Eyring, J. Walter and G. F. Kimball, Quantum Chemistry, Wiley, New York, 1944.
A. K. Chandra, Introductory Quantum Chemistry, Tata McGraw-Hill Publishing Co, New Delhi.
S.N.Ghosal, Quantum Chemistry
F. L. Pilar, Elementary Quantum Chemistry, Tata McGraw-Hill, 1990.
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L. I. Schiff, Quantum Mechanics, McGraw-Hill, 1985.
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P. C. W. Davies, Quantum Mechanics, ELBS, 1985.
J. L. Powell and B. Crasemann, Quantum Mechanics, Addison-Wesley, London, 1961.
D. Bohm, Quantum Theory, Asia Pub. House, Bombay, 1960.
S. Glasstone, An Introduction to Electrochemistry, D. Van Nostrand Company, 1962.
J. O'M. Bockris and A. K. N. Reddy, Modern Electrochemistry, Vol. I, Plenum Press.
K. J. Laidler, Reaction Kkinetics, Vols. I & II, Pergamon Press, London, 1970.
K. J. Laidler, Chemical Kinetics, Tata McGraw-Hill Publishing Co. Ltd, New Delhi, 1988.
L. P. Hammett, Physical Organic Chemistry, McGraw-Hill Book Company, New Delhi, 1970.
M. R. Wright, Fundamental Chemical Kinetics, Horwood Publishing, 1999.
J. Albery, Electrode Kinetics, Oxford Chemistry Series, Clarendron Press, Oxford, 1975.
G. D. Mahan, Many Particle Physics, Kluer Academy, Plenum Publisher, 2000.
C. Kittel, Introduction to Solid State Physics, John Wiley & Sons, 4th Ed.
M. F. C. Ladd and R. A. Palmer, Structure Determination by X-ray Crystallography, Plenum Press.
P. A. Cox, The Electronic Structure & Chemistry of Solids, Oxford University Press, 1987.
X. Clegg, Crystal Structure Determination, Oxford University Press, 2005.

SEMESTER III

MCHECCT301
Advanced General Chemistry-I

Group A
1. Group theory III: (10 Lectures)
Projection operators (without derivation), application of group theoretical methods for (i) construction of SALC's and their use in calculation of π MO's under the Huckel approximations, (ii) calculation of MO's of ABn type molecules, (iii) study of hybridization, selection rules, allowedness/forbiddenness of n-π* and π-π* transitions, (iv) symmetry aspects of molecular vibrations: infrared and Raman activity.

2. Surface chemistry: (8 Lectures)
Introduction, adsorption isotherms, surface excess; BET isotherm, LB film, membrane equilibrium, micellisation.

3. Quantum mechanics III: (12 Lectures)
Exactly solvable problems: Solutions for the stationary states of harmonic oscillator (wave function and operator methods), rigid rotator and the H-atom (with complex and real solutions).

Group B
4. Macromolecules: (10 Lectures)
Introduction; Carother's equation, osmotic pressure, viscosity, sedimentation and light scattering experiments for determination of molecular weight; kinetics of addition and condensation polymerization, stereochemistry, flexibility of polymer chain, statistics of polymer dimensions and configurations, effect of solvent on the average dimensions; theories of polymer solutions: excluded volume and Flory-Huggins theory.

5. Materials chemistry: (20 Lectures)
Preparation of nano particles: top down and bottom up approach, electrochemical, chemical, photochemical and biochemical synthesis of nano particles. Properties of nano particles, variation of properties with size. Applications of nano particles. Synthesis and properties of carbon nanotubes. Organic conductors, liquid crystals.

MCHECCT 302
Advanced General Chemistry-II

Group A
1. Metal ion promoted reactions: (9 lectures)
Fundamentals, simple cycle, catalytic cycle, pliancy of substrates, oxidative addition, reductive elimination, insertion; Tolman catalytic loop, homogeneous/heterogeneous catalysis: Wacker-Smidt synthesis, hydroformylation reactions, Monsanto acetic acid process, hydrogenation by Wilkinson's catalyst, water gas shift reaction (WGSR), Fischer- Tropsch synthesis, alkene polymerization, hydrosilation, hydrophosphilynation, hydroamination, hydrocyanation and hydroboration reactions, Heck reaction .

2. Molecular magnetism I: (9 lectures)
Different magnetic materials, use of Pascal's constants in structure determination, van Vleck equation and its applications, Curie and Curie-Weiss laws, Lande interval rule, microstates, multiplet, multiplet width, hole formalism, zero-field splitting, spin-orbit coupling, quenching of orbital contribution, crsytal field diagram, high spin/low spin equilibrium.

3. Structure and properties of solids: (12 lectures)
Band theory of metals, Band gap, Band structure of non-transition metals, Band structure of transition metals, Bonding theory in metallic crystals: Free electron theory of metallic bonding: Drude-Lorentz classical free electron theory, Sommerfield's quantum mechanical free electron theory, Electrical conductivity and Hall effect, Thermal conductivity, p-n junction, Semiconductors (intrinsic and extrinsic), insulators, rectifiers and transistors, superconductors.

Group B
4. Organic Spectroscopy (7 Lectures)
Detailed study of $^{1}$HNMR and $^{13}$CNMR spectroscopy including $^{19}$F, $^{11}$B, $^{13}$P

5. Pericyclic reaction (15 Lectures):
Definition, classification, cyclo-additions and cyclo-reversion reactions, [2+2], [2+4], [4+6] reactions, catalysis; electrocyclic reaction and the electroreversion reactions; sigmatropic reactions of [i,j] and [j,j] types, regioselectivity in cycloadditions; generalised rules of pericyclic reactions

6. Inorganic reaction mechanism I: (8 lectures)
Fundamentals, Mechanism of substitution reactions, water exchange, aquation, anation, acid catalysed aquation, Rate laws, Four broad classes of mechanism of substitution-Associative, Dissociative, Interchange Ia and Id; Linear free energy relationship.

## MCHEMET303
## Inorganic Chemistry Special

Group A
1. Nano Science: (15 lectures)
Scanning Probe Microscopy (SPM) Introduction: Basic principles of SPM Techniques. The details of STM, Summary of STM. General concept and Defining Characteristics of AFM. Electron Microscopy Introduction: Resolution vs Magnification. Scanning Electron Microscope, SEM Techniques. Electron Gun, Specimen interactions. Energy Dispersive X-ray analysis, Environmental SEM. Transmission Electron Microscope. Bright field image mode, Dark field image mode, High Resolution TEM

2. Inorganic reaction mechanism II: (15 lectures)
Substitution reactions in square planar, tetrahedral and octahedral geometries with special reference to dn ion complexes, Experimental tests of mechanism, Base hydrolysis, Nucleophicity parameter, Trans effect, cis effect, Kinetics and activation parameters, Substitution without breaking the metal ligand bond, Recimization and Isomerization reactions

Group B
3. Synthetic methodology for transition and non transition metal coumpounds (15 lectures)
Ligand design and ligand synthesis: polypyridine, Schiff base, oxime, macrocycle, tripod, podand, coronand, cryptand, octopus, tailoring and appending of pendant arm, electron reservoir, ligand topology.

Coordination compound design and synthesis: structure-directed synthesis, metallo ligand, polymeric ensembles (chain, sheet, network).

4. Chemistry of Elements: (15 lectures)
Dinitrogen and dioxygen complexes of transition metals: Syntheses, structures, bonding and reactivity. Iso- andheteropolyoxometalates with respect of V, Mo and W: Syntheses, structures, reactions and uses. Syntheses, reactions, properties, structures and bonding of molybdenum blue, tungsten blue, ruthenium blue, platinum blue, tungsten bronze, ruthenium red etc.

MCHEMET303
Organic Chemistry Special

Group A

1. Organic Synthetic Methods: (15 Lectures)

Retrosynthetic analysis; C-C bond formation reactions; ylide method, Si in C-C bond formation, organometallic; acetylides and nitriles, logistic and stereochemistry; synthesis of L-hexose (Sharpless and Masamune), synthesis of prostaglandins.

2. Coupling reactions: (15 Lectures)

Heck, Suzuki, Negishi, Sonogashira, Kumada, Stille, Hiyama, Buchwald-Hartwig, etc. Olefin metathesis.

Group B

3. Organometallic chemistry and its application in organic synthesis: (20 Lectures)

Bonding in transition metal; organometallic complexes; some common properties of organometallic complexes; fluxionality, stabilisation of reactive or unstable molecules; catalytic hydrogenation, insertion reactions; organo-Cu, -Zn, -Cd, -Hg and -Pd compounds; metallocenes (Fe, Ru, Os); carbene and carbine Complexes

4. Asymmetric Synthesis: (10 Lectures)

The chiral pool; chiral auxiliaries, reagents and catalysts; Diels-Alder reaction, alkylation of chiral enolates; dihydroxylation. Heck reaction.

MCHEMET303
Physical Chemistry Special

Group A

1. Non-equilibrium thermodynamics: (20 lectures)

Limitations of classical (equilibrium) thermodynamics, entropy production in some simple irreversible processes, the concept of forces and fluxes, linear phenomenological relations; Onsager reciprocity relation; Curie-Prigogine principle- statement and proof using one scalar and one vector force, illustrations; stationary states: variation of entropy production with time, Prigogine's criterion for establishment of stationary state, applicability of Le Chateliar's principle on stationary states.

2. Quantum Mechanics IV (10 lectures)

i) Matrix mechanics; eigenvalues-eigenvectors and diagonalisation (Jacobi's method, etc.).

ii)Approximate Quantum-mechanical methods: Variation method: Variation theorem, application to ground states of different systems, extension to excited states, linear variation.

Group B

3. Photochemistry: (20 lectures)

i. Jablonski diagram, Fluorescence and phosphorescence, Delayed fluorescence, Quantum yield, Mechanism and decay kinetics of photophysical processes. Fluoresence quenching (dynamic and static), Stern-Volmer equation. Energy transfer (Forster's dipole coupling), Electron transfer phenomenon (Marcus theory, Rehm Weller theory), Proton transfer phenomenon, complex formation phenomenon (excimer,exciplex).

ii. Interaction of electromagnetic radiation with matter, Transition probabilities, Transition moment integral and its applications. Electric and magnetic dipole moments. Selection rules. Franck-Condon principle and its violation, oscillator strength. Nature of transitions (e.g., n-$\pi^*$, $\pi$- $\pi^*$, d-d, charge transfer) solvent effect on absorption and emission spectra, Stoke's shift.

iii. Properties of electronically excited molecules: Lifetime, redox potential, dipole moment, pK values. Potential energy diagram for donor acceptor system, Polarized luminescence.

iv. Nonradiative intramolecular electronic transition, internal conversion, inter-system crossing. Crossing of potential energy surface (Franck-Condon factor). Adiabatic and non-adiabatic cross over. Kasha's rule.

v. Mössbauer and NQR spectroscopy (10 lectures)
Mössbauer spectroscopy: Principles, technique, chemical shift, quadruple effect, effect of magnetic field, applications.
NQR spectroscopy: Principle, technique, coupling in atom, applications.

MCHEMES304
Inorganic Chemistry Special Practical

1. Quantitative analysis of major and minor components in ores and alloys by gravimetric and other instrumental methods
2. Determination of composition and formation constants of selected systems by pH-metric and spectrophotometric method
3. Computational Chemistry
4. Some common coordination compounds: synthesis and analysis
5. Growing of single crystal

MCHEMES304
Organic Chemistry Special Practical

1. Separation of binary mixtures of solid-solid/liquid-solid/liquid-liquid organic compounds and identification of individual components
2. Spectroscopic analysis of organic compounds.

MCHEMES304
Physical Chemistry Special Practical

1. Conductometric experiments**:** Titration of chromate/dichromate mixture, determination of CMC, Mixture of acetates, sulphate – bisulphate mixture, etc.
2. Potentiometric experiments**:** (i) Ag/Ag+ electrode: standard potential, determination of activity coefficient (ii) Ag/AgX electrode: standard potential, solubility product of AgX (iii) activity coefficient of HX, (iv) Potentiometric titration of halide mixture.
3. Computer applications: Solutions of simultaneous equations: Gauss elimination, Numerical integration methods.
4. Numerical differentiation methods, Finite difference method to solve Schrödinger eigenvalue problem for box and oscillator.

MCHEOET305
Open elective - Essence of Chemistry
(For students from other Departments)

1. Waste treatment/Management and Recycling
Waste classification, solid waste disposal, solid waste management, solid waste management by biotechnology, ocean dumping, waste water treatment, sludge treatment, water reuse and recycling.

2. Chemical Toxicology
Toxic chemicals in the environment, Impact of toxic chemicals on enzymes, Carcinogenes, bio-warfare agents, water borne disease, vector borne disease, factors for spread of cholera, control of cholera.

3. Greenhouse effect monitoring, Mechanistic pathways of smog formation and ozone hole, acid rain; major, minor and trace constituents of the atmosphere; water quality parameters, Biochemical effects of As, Pb, Cd, Hg,organic toxicants, pesticides ; Waste water treatment, various sources of soil pollution; noise pollution:
4. Basic principles of Green Chemistry and their illustrations with examples as: Prevention/Minimization of hazardous/toxic products; Designing safer chemicals - different basic approaches

5. Metal ions in biology.
myoglobin, heamoglobin ,biological fixation of nitrogen, chlorophyll and photosynthesis etc.

6. States of matter, solution and physicochemical transformation.
Different states of matter, change of states, energetic, equation of states, solution properties, solution and mixture, examples of physico-chemical transformation.

MCHEOPP306
Social outreach programm

Recommended Books/Journals:
S. C. Rakshit, Molecular Symmetry Group and Chemistry, The New Book Stall, Kolkata, 1988.
F. A. Cotton, Chemical Applications of Group Theory, 3rd Edn Reprint, John Wiley and Sons.
A. Vincent, Molecular Symmetry and Group Theory, John Wiley and Sons, New York, 1998.
V. Heine, Group Theory in Quantum Mechanics: An Introduction to Its Present Usage, Dover Publication.
H. -J. Butt, K. Graf and M. Kappl, Physics and Chemistry of Interfaces, Wiley-VCH, 2003.
J. H. Clint, Surface Chemistry, Blackie and Son Ltd., 1992.
W. Adamson, Physical Chemistry of Surfaces, John Wiley and Sons, New York, 1990
G. S. Mishra, Introductory Polymer Chemistry, Wiley Eastern, New Delhi, 1993.
C. Tanford, Physical Chemistry of Macromolecules, John Wiley and Sons, Inc., New York, 1961.
F. W. Billmeyer, Text Book of Polymer Science, 2nd Edn., Wiley-Interscience, New York, 1971.
H. Eyring, J. Walter and G. F. Kimball, Quantum Chemistry, Wiley, New York, 1944.
A. K. Chandra, Introductory Quantum Chemistry, Tata McGraw-Hill Publishing Co, New Delhi,1989.
F. L. Pilar, Elementary Quantum Chemistry, Tata McGraw-Hill, 1990.
P. W. Atkins, Molecular Quantum Mechanics, Clarendon Press, Oxford, 1980.
J. L. Powell and B. Crasemann, Quantum Mechanics, Addison-Wesley, London, 1961.
D. A. McQuarrie, Quantum Chemistry, Viva Books Pvt. Ltd., New Delhi, 2003
Nano: The Essentials by T. Pradeep, 2007 Tata McGraw-Hill.
Nanobiotechnology II: More Concepts And Applications by Chad A. Mirkin, Christof M. Niemeyer, 2007 Wiley-vch Verlag Gmbh.
Research articles in the journals.
C.P. Poole, and F.J. Owens, Introduction to Nanotechnology, Wiley India, 2006
G.A. Ozin, C. Andre, and L. Arsenault, Cademartiri, Nanochemistry: A chemical Approach to Nanomaterials, Royal Society of Chemistry, 2005
T. Pradeep, NANO: The Essentials, Tata-McGraw Hill, New Delhi, 2007.
K.J. Klabunde, Nanoscale Materials in Chemistry, Wiley-interscience, 2001
Bharat Bhushan (Ed.) Springer Handbook of Nanotechnology, Springer, 2007.
K. Denbigh, Thermodynamics of Steady States Katchalsky, Prigogine, Introduction to Thermodynamics of Irreversible Processes, Interscience Publishers, 1967.

G. M. Burnett and A. M. North, Transfer and Storage of Energy by Molecule, Vol.I Wiley-Interscience.
J. N. Murrell, The Theory of Electronic Spectra of Organic Molecules, John Wiley and Sons, 1963.
J. B. Birks, Photophysics of Aromatic Molecules, Wiley-Interscience, 1969.
C. N. Banwell and E. M. McCash, Fundamentals of Molecular Spectroscopy, 4th Edn, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 1994.
G. M. Barrow, Introduction to Molecular Spectroscopy, McGraw-Hill Int.Book Company.
I. Levine, Molecular Spectroscopy (Pearson)
G.Aruldhas, Molecular Structure and Spectroscopy,Prentice Hall.India
Photochemistry by J.A.Barltrop and J.D.Coyle,Wiley
J.B. Birks, Photophysics of Aromatic molecules, Wiley Interscience.
Raymond Chang, Spectroscopy.
R.P.Wayne, Photochemistry.
K.K. Rohatgi Mukherjee, Fundamentals of Photochemistry.

SEMESTER – IV

Inorganic Chemistry Special

MCHEMET401
Inorganic Chemistry Special Theory

Group A
1. Inorganic Rings, Cages and Clusters: (15 lectures)
Metal-metal bonding, Low nuclearity and high nuclearity carbonyl clusters: skeletal electron counting, Wade-Mingos-Louher rule, Application of isolobal and isoelectronic relationships, caping rule, carbide, nitride, chalcogenide and halide containing metal clusters.

2. Complexes in aqueous solution (15 lectures )
Different (pH-potentiometric, spectrophotometric, voltammetric) tools and methods (slope-ratio, mole-ratio and Job'smethod of continuous variation) of measuring stability constants of complexes, Bjerrum half n method, stability ofmixed ligand complexes and calculations; determination of composition, evaluation of thermodynamic parameters, factors influencing the stability of complexes, equilibria in biomolecular systems.

Group B
3. Diffraction study: (12 lectures)
Bravis lattices, space group and its determination, techniques in X-ray structure determination, methods of solving the phase problem, determination of crystal structures.

5. Supramolecular chemistry (18 lectures)
Definition, building block and spacer, molecular valency, self-assembly, supramolecular orbitals, non-covalent forces: pallet of hydrogen bondings, pi-pi and C-H…pi interactions, geometry setter, allosterism, proton and hydride sponges, principle of three C's, lock and key principle, host-guest interaction, self organization and self complementarity, supramolecular devices.

MCHEMET402
Inorganic Chemistry Special Theory

Group A
1. Inorganic photochemistry: (15 lectures)
Photoexcitation, fluorescence, phosphorescence, photosensitization, quenching, charge and energy transfer, excimer structure, substitution, prompt and delayed reaction, decomposition, fragmentation, isomerisation, exchange and redox reactions; chemiluminescence, photochromism; selective photochemistry using laser beams; chemical actinometry, inorganic photochemistry in biological processes and their model studies; applications of photochemical reactions of coordination compounds _ synthesis and catalysis, solar energy conversion and storage.

2. Advanced Bioinorganic Chemistry: (15 lectures)
Metal complexes interaction with DNA and RNA, Metal ions in genetic information carrier, Metal ions in metabolic energy transfer – mechanism of metal ion catalyzed and metal complex catalyzed non-enzymic ATP hydrolysis. Redox enzymes. Chemistry of iron metabolism: ferritin, transferin, siderophore and ceruloplasmin. Vitamins and Coenzymes: Vitamin B6 and B12 coenzymes, model systems.

Group B
3. Organometallic chemistry II: ( 15 lectures)
Design and synthesis; structure, bonding, stereochemistry, reaction and reaction pathways; nucleophilic addition and abstraction; application to organic synthesis, enantioselective functional group interconversion, chiral synthesis, protection and deprotection ; transmetallation and cyclisation reactions, metallo-fullerenes, bioorganometallics, organo-dendrimer, surface organometallic chemistry

4. Redox reactions and mechanism: (15 lectures)
General remark, complementary and non-complementary redox reactions, outer-sphere reaction, inner-sphere reaction, effect of bridging ligand in inner-sphere reaction, kinetics and mechanism, electron tunneling hypothesis, heteronuclear redox reaction and simplified Marcus theory; Marcus cross relationship and its application, remote attack, doubly-bridged process, ligand exchange, intervalence electron transfer, induced reaction, electron transport in biological systems and their simulations.

## MCHEMET403
## Inorganic Chemistry Special Theory

Group A
1. Luminescence, Photoacoustic, Raman and Flame atomic spectrometry: (15 lectures)
Molecular luminescence spectrometry _ theory, instrumentation and applications; photoacoustic spectrometry; light scattering techniques including nephelometry and Raman spectroscopy flame spectrometric techniques, atomic absorption, atomic emission and atomic fluorescence, theory, instrumentation and applications of these techniques.

2. Molecular magnetism II: (15 lectures)
Design and synthesis of different magnetic bodies, magnetic orbital, magnetic interactions in di- and polynuclear systems, effect of counter anion in crystal packing, cryogenic experiments, mechanisms of exchange interactions, Bleaney-Bowers equation, deliberate synthetic approach of ferromagnetically coupled systems, canting, spin frustration, spinflop, metamagnetism, calculation of ground state and spin manifold, magnetization versus field studies, Single-molecule-magnets.

Group B
3. Application of IR, NMR, EPR, UV-Vis, Mossbauer, ESCA etc. techniques: (30 lectures)
Background of the spectroscopic tools, selection rules, active chemical system, elucidation of molecular structure, electronic structure, stereochemistry, bonding and reaction pathways (examples with simple and complex inorganic compounds including organomettalics and cluster compounds and bioinorganic systems).

## MCHEMES404
## Inorganic Chemistry Special Practical

1. Preparation of double salts and known coordination compounds and their analysis
2. Complexation and purification
3. Synthesis of nanomaterials and their characterizations
4. Elemental analyses (C, H, N and AAS)
5. Spectral, thermal, electrochemical and magnetic studies.

## MCHEMEP405
## Inorganic Chemistry Special Project

Project Work
Seminar lecture on project work

Organic Chemistry Special

MCHEMET401
Organic Chemistry Special Theory

Group A
1. Biosynthetic pathways from acetate to natural products, shikimate pathways leading to various group of natural products. (10 Lectures)

2. Biomimetic synthesis of alkaloid derived from tryptophan, non-aromatic polycyclic polyketide, polyprenylated phloroglucinols and xanthones, rearrangements of complex terpenoids. (10 Lectures)

3. Chemistry of Carbohydrates: (10 Lectures)
Conformational analysis of monosaccharides (pentoses and hexoses) and relative instability ratings; anomeric effect, reverse anomeric effect and their origin; mutarotation and abnormal mutarotation; Structure of dsacchharides-Sucrose and Maltose. general treatment of polysaccharide chemistry: isolation, purification, hydrolysis, methylation and periodic oxidation, Smith degradation, Barry degradation.

Group B
4. Chemistry of Amino acids, Peptides and Nucleic acids: (20 Lectures)
Peptides: structure determination, sequence analysis, End group analysis- N Terminus, C Terminus, Protection of amino and carboxyl group, strategy of peptide synthesis, Merrifield synthesis, structure determination. Nucleic acids: Introduction, classification, occurrence, nucleosides: isolation, properties and synthesis of ribosyl and deoxyribosyl nucleosides; biosynthesis of α-D ribose phosphate, nucleotides: isolation, functions, structures of ribosyl and deoxyribosyl nucleotides; biosynthesis of inosinic acid, adenylic acid, guanylic acid, cytidylic acid and uridylic acid; translation and transcription (general idea),RNA and DNA (structural composition), codon, anticodon, geneticcode, protein synthesis.

5. Advanced heterocyclic Chemistry-II: (10 Lectures)
Nomenclature of bicylic and tricyclic fused system. Introduction to chemistry of azepins, oxepins, thiepins and their aza-analogues; phosphorus-containing and selenium containing heterocycles

MCHEMET402
Organic Chemistry Special Theory

Group A
1. Pericylic Reactions II: (20 Lectures)
Symmetry properties of M.O.'s, orbital symmetry conservation and Woodward-Hoffmann rule in pericyclic reaction; frontier orbital interaction , Fukui-Hoffman theory (qualitative), Dewar theory of aromatic transition state concept (qualitative); topology of cyclo-additions, periselectivity, regioselectivity, Lewis acid catalysis; solvent effect, higher order cyclo-additions, dipolar cyclo-additions, electrocyclic reactions, sigmatropic reactions, chelotropic reaction, enereactions,selection rules.

2. Vitamins and antibiotics: (10 Lectures)
Synthesis of different type of Anbtibiotics, Penicillines, chloramphenicol, norfloxacin, ofloxacin and levofoxcin. Vitamin A, B1, B6, Vitamin C, Folic acid etc. Definition of coenzymes,

Group B
3. Organic Photochemistry: (20 Lectures)
Excited states (S1 and T1) of some photo excited organic molecules; mechanism of photo excitation; photo-induced reactivity of olefins, ketones, unsaturated ketones and various conjugated systems; photo-induced functionalisation in organic molecules involving Barton reaction, Norrish type reactions, Loeffler

reaction; photo induced substitution reaction, chemiluminescence in organic reactions, Photochemical rearrangements, photo induced disproportion in aromatic systems.

4. Radical Chemistry: (10 Lectures)
Basic Principles, C–C bond formation by various radical-radical and radical-nonradical coupling reactions. Synthesis of natural products. Various ring expansion, ring contraction, remote functionalisation and radical fragmentation reaction.

## MCHEMET403
## Organic Chemistry Special Theory

Group A
1. Structure elucidation and synthesis of Terpenoids (caryophyllene, abietic acid, amyrins, lanosterol, carotenes), Steroids (nomenclature and stereochemistry, cholesterol, ergosterol, bile acids), prostaglandins. (10 Lectures)

2. Supramolecular Chemistry: (10 Lectures)
From molecular to Supramolecular chemistry, non-covalent interaction. Synthetic molecular reports and their functions – crown ethers, cyclophanes, calixarenes, cyclodextrins, dendrimers etc. Supramolecular reactivity and catalysis, switching devices, molecular self assembly-supramolecular aggregates.

3. Green methodologies for organic synthesis: (10 Lectures)
Twelve principles of Green Chemistry, Green synthetic methods, Organic reactions in aqueous medium, Organic reactions using supported reagents, Solvent-free organic reactions ,Micro-wave assisted organic reactions with special emphasis on biologically important compounds. Use of ionic liquid, supercritical fluids and nanoparticles as catalyst.

Group B
4. Structure elucidation and synthesis of Alkaloids (ephedrine, nicotine, morphine, quinine), Flavanoids and Coumarns. (12 Lectures)

5. Medicinal Chemistry: (18 Lectures)
Drugs: Introduction, classification of drugs, brief discussion of drug targets, drugs based on enzyme inhibition: Drug design and synthesis of Drugs, Sulfa drugs, aspirin, paracetamol etc., Drug targets on nucleic acids, Definition of antagonist, agonist, prodrugs, pharmacokinetics and pharmacodynamics, Concept of structure-activity relationship (SAR) and quantitative structure and relationship (QSAR).

## MCHEMES404
## Organic Chemistry Special Practical

1. A. Multistep synthesis of organic compounds
   B. Isolation of some common natural products
2. Internal assessment

## MCHEMEP405
## Organic Chemistry Special Project

Project Work
Seminar lecture on project work

Recommended Books/Journals:

J. A. Joules and K. Mills, Heterocyclic Chemistry (5th edition), published by Chichester, Wiley-Blackwell.
T. Eicher and S. Hauptmann, The Chemistry of Heterocycles, Wiley-VCH, Weinheim, 2003.
R. M. Acheson, An Introduction to the Chemistry of Heterocyclic Compounds (3rd edition), Wiley India.
T.L. Gilchrist, Heterocyclic Chemistry, Prentice Hall, 1997.
Song, C. E.; Cinchona Alkaloids in Synthesis and Catalysis: Ligands, Immobilization and Organocatalysis, Wiley-vch Verlag Gmbh, 2009
Online Journals: Journal of the American Chemical Society; Journal of Medicinal Chemistry http://pubs.acs.org/action/showPublications?display=journals)
Nature Reviews Drug Discovery (http://w ww.nature.com/nrd/index.html)etc.,
S. Sankararaman, Pericyclic Reactions- A text Book, Wiley VCH, 2005.
K. K. Rohatgi, Mukkerjee, Fundamentals of Photochemistry, Wiley Eastern Ltd., 1992.
I. Fleming, Frontier Orbitals and Organic Chemical Reactions, Wiley, London, 1976.
N. J. Turro, V. Ramamurthy and J. C. Scaiano, Modern Molecular Photochemistry of Organic Molecules, University Science Books, CA, 2010.
Modern Molecular photochemistry by Nicholas J. Turro
J. M. Berg, J.L. Tymoczko, L. Stryer, Biochemistry (6th edition) W.H. Freeman and Company, 2006.
M.M. Cox, D. L. Nelson, Lehninger Principles of Biochemistry (5th edition), W.H. Freeman and Company, 2008, ISBN 9780230226999.
P. T. Corbett, J. Leclaire, L. Vial, K. R. West, J.-L. Wietor, J. K. M. Sanders, S. Otto, Chem. Rev. 2006.
R.B.Silverman, The Organic Chemistry of Drug Design and Action, 2nd Edition, Elsevier, New York.
G. L. Patric, An Introduction to Medicinal Chemistry, 4th Edition, Oxford University Press, 2009.
S. V. Bhat, B. A. Nagasampagi, and S. Meenakshi, Natural Products Chemistry and Applications, Narosa Publishing House, 2009.
E. L. Eliel and S. H. Wilen, Stereochemistry of Organic Compounds, John Wiley & Sons, New York.
Nasipuri, D., Stereochemistry of Organic Compounds, New Age Publications, 2nd Ed, 1994
Nogradi, M.; Stereoselective Synthesis: A Practical Approach, Wiley-VCH, 2nd Ed. 1994.
List. B. et.al. Asymmetric Organocatalysis, Springer 1st Ed. 2010
W. Carruthers and I. Coldham, Modern Methods of Organic Synthesis, First South Asian Edition 2005, Cambridge University Press.
F. A. Carey and R. A. Sundberg, Advanced Organic Chemistry, Part A: Structure and Mechanisms (5th edition), Springer, New York, 2009.
F. A. Carey and R. A. Sundberg, Advanced Organic Chemistry, Part B: Reactions and Synthesis (5th edition), Springer, New York, 2009.
J. March and M. B. Smith, March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure (6th Edition), Wiley, 2007.
W. Carruthers, Modern Methods of Organic Synthesis, Cambridge University Press, 1996.
L. Kuerti and B. Czako, Strategic Applications of Named Reactions in Organic Synthesis, Elsevier Academic Press, 2005.
R. Noyori, Asymmetric Catalysis in Organic Synthesis, John Wiley & Sons, 1994.
T. H. Lowry and K. S. Richardson, Mechanism and Theory in Organic Chemistry (2nd edition), Harper & Row, New York, 1981.
M. B. Smith, Organic Synthesis (2nd Edition), McGraw Hill, 2010.
J. Clayden, N. Greeves, S. Warren and P. Wothers, Organic Chemistry, Oxford University Press, 2001.
I. Ojima, Catalytic Asymmetric Synthesis (2nd edition), Wiley−VCH, New York, 2000
N. S. Isaacs, Physical Organic Chemistry, ELBS, Longman, UK, 1987.
S. Warren, Organic Synthesis, The disconnection Approach, John Wiley & Sons, 2004.
E. J. Corey and X. M. Cheng, The Logic of Chemical Synthesis, John Wiley & Sons, 1995.
E. M. Carreira and L. Kvaerno, Classics in Stereoselective Synthesis, Wiley VCH, 2009.
K. C. Nicolaou and S. A. Snyder, Classics in Total Synthesis-II, VCH, 2003.
K. C. Nicolaou and E. J. Sorensen, Classics in Total Synthesis, VCH, 1996.
R. E. Gawley, J. Aube, Principles of Asymmetric Synthesis Pergamon Title, Annotated Ed. 2004,

Physical Chemistry Special

MCHEMET401
Physical Chemistry Special Theory

Group A

1. Quantum Mechanical Perturbation Theory: (15 lectures)

i) Time independent formalism: Rayleigh-Schrödinger theory of non-degenerate systems; applied to systems like anharmonic oscillator, non-rigid rotor, He atom, etc.; degenerate perturbation theory, Stark effect. ii) Time dependent formalism: Transition probability, Fermi golden rule, Einstein transition probabilities; spontaneous and induced emission.

2. Biophysical Chemistry (15 Lectures)

Introduction: The cell and its constituents, proteins, nucleic acids, RNA and DNA, enzymes etc., molecular basis of life. Bioenergetics and Thermodynamics: Molecular interpretation of Energy and Enthalpy, Non-covalent reactions, hydrophobic interactions, Protein and Nucleic Acids. Biochemical Applications of thermodynamics, Thermodynamics of Metabolism, Role of ATP in biological Systems.

Biological Membranes, Membrane Equilibrium, Transport through cell membrane, Active and Passive Transport, Osmosis and Diffusion, Muscle Contraction, Energy Generation.

Group B

3. Spectroscopy: (18 lectures)

Transition between states, selection rules and forbidden transitions; NMR: Relaxation and exchange phenomena, theories of chemical shift and nuclear spin-spin coupling in 2-spin systems with applications, pulsed NMR (spin echo). Electronic: n-π*, π- π* and CT transitions; vibrational: simple polyatomic molecules, normal modes, influence of nuclear spin on vibration-rotation spectra of polyatomics; Raman: classical and quantum treatment of rotational and vibrational Raman spectra, polarization and depolarization of Raman lines, resonance Raman spectroscopy.

4. Angular momentum: (12 lectures)

Angular momentum operators, their commutation properties, step-up and step-down operators, commutation properties between angular momentum operators and Hamiltonian operator of single and multi-electron atom. Eigen-ket ladder and formulation of spherical harmonics from angular momentum rules, spin angular momentum, Pauli spin matrices and determination of spin eigenfunctions.

MCHEMET402
Physical Chemistry Special Theory

Group A

1. Statistical Mechanics: (30 lectures)

Microcanonical, canonical and grand canonical ensembles, statistical distribution and properties of distribution function, the H theorem and approach to equilibrium; Maxwell-Boltzmann (MB), Bose-Einstein (BE) and Fermi-Dirac (FD) distributions, the derivation of thermodynamic relations, thermodynamic and characteristic features of MB, BE and FD systems (ideal cases), black body radiation and photon gas; applications: (i) statistical thermodynamics of ideal systems (effect of nuclear spin and electronic angular momentum), (ii) specific heat of solids — Debye treatment, (iii) non-ideal gas.

Group B

2. Chemical Kinetics II: (15 lectures)

Introduction, autocatalysis, chain reactions: branched and non-branched kinetic rate equations, Semenov treatment for branched chain reactions; explosion: population explosion, upper and lower ignition/explosion limits; thermal ignition and ignition temperature; chemical oscillation.

3. Molecular interactions: (15 lectures)

Hamiltonian in absence and presence of external fields, quantum mechanical virial theorem and Hellmann-Feynmann theorem; their application to systems like harmonic oscillator, H-like atom, etc. Perturbative treatment of electric polarisability, intermolecular interactions - calculation of dispersion energy, the London formula.

MCHEMET403
Physical Chemistry Special Theory

Group A

1. Catalysis: (30 lectures)

Fundamentals of adsorption and catalysis: Physical and Chemical adsorption – adsorption isotherms: evaluation, chemisorption on metals and metal oxides. Catalysis: concept of activity, selectivity, poisoning, promotion and deactivation. Types of catalysis: homogeneous, heterogeneous. Heterogeneous catalysis and catalytic kinetics: concept of Langmuir-Hinshelwood

Preparation and Characterization of Catalyst: general methods for preparation of catalysts: precipitation, sol-gel, hydrothermal, impregnation, hydrolysis, vapour deposition. Activation of catalysts: calcinations, reduction. Catalyst characterization: surface area, pore size distribution, particle size determination, XPS, AES, UV-Vis, FT-IR and thermal methods.

Nanomaterials and Catalysis: General definition, Nanochemistry basics, distinction between molecules, nanoparticles and bulk materials. Physico-chemical considerations of nanomaterials. Size-dependent properties.

Catalysis in green chemistry and environmental applications: Purification of exhaust gases from different sources: auto-exhaust catalysts (petrol vehicles, diesel vehicles), VOC removal; ozone decomposition; photocatalysis in effluent treatment.

Photo-catalysis: Photoprocesses at metals, oxides and semiconductors: concepts and mechanism. Photocatalysis application in organic pollutant degradation present in water and air.

Application of Heterogeneous catalysis: Food industry, fine chemicals, petroleum industry, petrochemical industry, heavy inorganic chemicals, catalysis in atmospheric pollution (at least one example of application should be discussed).

Group B

2. Chemical Kinetics III: (12 lectures)

Unimolecular reactions: Lindemann, Hinshelwood and RRK theory. Absolute rate theory, Expression for rates in terms of atomic and molecular partition functions. Study of fast reactions - flow process and relaxation techniques, and their implementation.

3. Quantum chemistry: (18 lectures)

Antisymmetry of many electron wave function, spin and spatial orbitals. The independent particle model: applied to He atom, demerits. Hartree vs. Hartree-Fock method. Slater determinant. Coulomb and exchange integrals with their properties; vertical ionization potential and Koopman's theorem; variational solution of the closed-shell wave function — formulation of the Hartree-Fock equations, properties of Hartree-Fock operator and wave functions, discussion of electron correlation.

Theories of valence: VB and MO theories with emphasis on the nature of functions and their properties. The $H_2^+$ and $H_2$ problem.

MCHEMES404
Physical Chemistry Special Practical

Kinetic experiments: Activation energy, effect of solvent dielectric constant, effect of ionic strength and micellar effect on rate.

Spectrophotometric experiments: determination of $pK_{in}$, salt effect, solvent effect.

Phase diagram of ternary mixtures. Synthesis of nanomaterials.

MCHEMEP405
Physical Chemistry Special Project

Project Work

Seminar lecture on project work

Recommended Books/Journals

C. N. Banwell and E. M. McCash, Fundamentals of Molecular Spectroscopy, 4th Edn, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 1994.
G. M. Barrow, Introduction to Molecular Spectroscopy, McGraw-Hill International Book Company. A. E. Derome, Modern NMR Techniques in Chemical Research, Pergamon Press, Oxford, 1987.
W. Kemp, NMR in Chemistry: A Multinuclear Approach, Macmillan Press, 1986.
J. K. M. Sanders, E. C. Constable and B. K. Hunter, Modern NMR Spectroscopy: A Workbook of Chemical Problems,O xford University Press, Oxford, 1993.
H. Gunther, NMR Spectroscopy: Basic Principles, Concepts and Applications in Chemistry, Wiley.
P. Hendra, C. Jones and G. Warnes, FT-Raman Spectroscopy, Ellis-Harwood, 1991.
K. Nakamoto, Infrared and Raman Spectra of Inorganic and Coordination Compounds, 5th Edn, Part B, John Wiley and Sons, Inc., New York, 1997.
A. K. Chandra, Introductory Quantum Chemistry, Tata McGraw-Hill Publishing Co, New Delhi.
F. L. Pilar, Elementary Quantum Chemistry, Tata McGraw-Hill, 1990.
P. W. Atkins, Molecular Quantum Mechanics, Clarendon Press, Oxford, 1980.
E. Merzbacher, Quantum Mechanics, John Wiley and Sons, 1970.
L. I. Schiff, Quantum Mechanics, McGraw-Hill, 1985.
L. Pauling and E. B. Wilson, Introduction to Quantum Mechanics, McGraw-Hill, 1939.
I. N. Levine, Quantum Chemistry, 4th Edn., Prentice Hall of India Pvt. Ltd., New Delhi, 1995
J. L. Powell and B. Crasemann, Quantum Mechanics, Addison-Wesley, 1961.
D. A. McQuarrie, Quantum Chemistry, Viva Books Pvt. Ltd., New Delhi, 2003
G. C. Schatz and M. A. Ratner, Quantum Mechanics in Chemistry, Dover Publication, Inc, NY. 2002.
H. L. Strauss, Quantum Mechanics, Eastern Economy Edition, Prentice Hall of India Pvt. Ltd.
F. Reif, Fundamentals of Statistical and Thermal Physics, McGraw-Hill, 1965.
S. K. Ma, Statistical Mechanics, World Sci., 1985.
E. S. R. Gopal, Statistical Mechanics and Properties of Matter, Ellis Horwood, England, 1974.
R. K. Pathria, Statistical Mechanics, Butterworth-Heinemann, 1996.
F. L. Pilar, Elementary Quantum Chemistry, Tata McGraw-Hill, 1990.
P. W. Atkins, Molecular Quantum Mechanics, Clarendon Press, Oxford, 1980.
D. W. Davies, The Electric and Magnetic Properties of Molecules.
A. J. Stone, The Theory of Intermolecular Forces, Clarendon Press, Oxford, 1996.
C. J. F. Böttcher, Theory of Electric Polarisation, Elsevier Scientific Publishing Co., New York, 1973 (Vol. 1 & 2).
W. Adamson, Physical Chemistry of Surfaces, Wiley Intersciences, 1990 (5th edition) 1990.
Bond, G C, Heterogeneous Catalysis: Principles and Application. Oxford University Press 1987
D.K. Chakrabarty and B. Viswanathan, Hetergogeneous Catalysis, New Age.
B.C. Gates, Catalytic Chemistry, John Wiley and Sons Inc. (1992).
G. Cao, Nanostructures and Nanomaterials - Synthesis, Properties and Applications.
P.T. Anastas and J.C.Warner, Green Chemistry, theory and practice,
Nick Serpone and Ezio Pelizzetti, Photocatalysis: Fundamentals and Applications, Wiley, NewYork.
Heterogeneous catalysis principles and application, G.C.Bond.
Introduction to zeolite science and practice, H. Van Bekkum, E. M. Flanigen, P. A. Jacobs and J. C. Jansen (Elseviver Pub. Amsterdam, 2001)
Catalysis: Principles and Applications, B.Vishwanathan, S. Sivasankar and A.V.Ramaswamy (Narosa Pub. House, New Delhi, 2004)
Advanced material in catalysis, James J. Burton and Robert L.Garten, Academic press, New York.
F.W. Billmeyer, Jr., Text Book of Polymer Science, 3rd edition (1984), Wiley Interscience, New York.
G. Odien, Principles of Polymerization, 3rd edition (1991) John Wiley & Sons, Singapore.
P. Bahadur and N.V. Sastry, Principles of Polymer Science, (2002) Narosa, New Delhi.
A. K. Chandra, Introductory Quantum Chemistry, Tata McGraw-Hill Publishing Co, New Delhi 1989.
F. L. Pilar, Elementary Quantum Chemistry, Tata McGraw-Hill, 1990.
P. W. Atkins, Molecular Quantum Mechanics, Clarendon Press, Oxford, 1980.
E. Merzbacher, Quantum Mechanics, John Wiley and Sons, 1970.
L. I. Schiff, Quantum Mechanics, McGraw-Hill, 1985.

L. Pauling and E. B. Wilson, Introduction to Quantum Mechanics, McGraw-Hill, 1939.
I. N. Levine, Quantum Chemistry, 4th Edn., Prentice Hall of India Pvt. Ltd., New Delhi, 1995
S P. C. W. Davies, Quantum Mechanics, ELBS, 1985.
J. L. Powell and B. Crasemann, Quantum Mechanics, Addison-Wesley, 1961.
S. Glasstone, An Introduction to Electrochemistry, D. Van Nostrand Company, 1962.
J. O'M. Bockris and A. K. N. Reddy, Modern Electrochemistry, Vol. I, Plenum Press, 1970.
K. J. Laidler, Reaction Kinetics, Vols. I & II, Pergamon Press, London, 1970.
K. J. Laidler, Chemical Kinetics, Tata McGraw-Hill Publishing Company Ltd, New Delhi, 1988.
M. R. Wright, Fundamental Chemical Kinetics, Horwood Publishing, 1999.
P. C. Jordan, Chemical Kinetics and Transport, John Wiley and Sons, Inc., 1979.
M. J. Pilling and P. W. Seakins, Reaction Kinetics, Oxford University Press, 1995

MCHEACT406
Add-on Course