GC UNIVERSITY, FAISALABAD

Scheme of Studies

Master of Philosophy in Chemistry

04 Semester / 2 years Degree Program
for the year 2015 & onward

Department of Chemistry

M.Phil Scheme of Studies (2015 and onwards)

Semester 1 & 2

Inorganic Chemistry

Course Code	Course Title	Credit Hours
CHM-701	Solid State Chemistry	3(3 – 0)
CHM-702	Photochemical Reactions of Transition Metals	3(3 – 0)
CHM-703	Applied Transition Metal Catalytic Chemistry	3(3 – 0)
CHM-704	Chemistry of Organometallic Compounds	3(3 – 0)
CHM-705	Inorganic Electronic Spectroscopy	3(3 – 0)
CHM-706	Kinetics and Mechanism of Inorganic Reactions	3(3 – 0)
CHM-707	Bio-Inorganic Chemistry	3(3 – 0)
CHM-708	Nano Chemistry	3(3 – 0)
CHM-709	Applied Spectroscopy	3(3 – 0)
CHM-710	Extractive Metallurgy	3(3-0)
CHM-712	Metal Based Drugs	3(3-0)

Analytical Chemistry

Course Code	Course Title	Credit Hours
CHM-731	Laser and Luminescence Spectroscopy	3(3 – 0)
CHM-732	Environmental Analysis	3(3 – 0)
CHM-733	Radiopharmaceuticals and Quality Control	3(3 – 0)
CHM-734	Techniques for Surface Analysis	3(3 – 0)
CHM-735	Polymer Characterization by Hyphenated Techniques	3(3 – 0)
CHM-736	Advanced Emission Spectroscopy	3(3 – 0)
CHM-738	Chromatographic Techniques	3(3 – 0)
CHM-739	Research Methodology	3(3-0)
CHM-740	Chemoinformatics	3(3-0)

Organic Chemistry

Course Code	Course Title	Credit Hours
CHM-751	Modern Trends in Organic Synthesis	3(3 – 0)
CHM-752	Advanced Stereochemistry	3(3 – 0)
CHM-753	Physico-organic Chemistry and Reaction Mechanism	3(3 – 0)
CHM-754	Advanced Heterocycles I	3(3 – 0)
CHM-755	Chemistry of Glycosides	3(3 – 0)
CHM-756	Biosynthesis of Natural Products	3(3 – 0)
CHM-757	Advanced Nuclear Magnetic Resonance	3(3 – 0)
CHM-759	Symmetry Controlled Reactions	3(3 – 0)
CHM -760	Classics in Total Synthesis	3(3 – 0)
CHM -761	Role of Protective Groups in Organic Synthesis	3(3 – 0)
CHM-762	Advanced Heterocycles II	3(3-0)

Physical Chemistry

Course Code	Course Title	Credit Hours
CHM-781	Physical Chemistry of High Polymers	3(3 – 0)
CHM-782	Complex Extension of Quantum Chemistry	3(3 – 0)
CHM-783	Electrode Processes	3(3 – 0)
CHM-784	Magnetic Spin Dynamics	3(3 – 0)
CHM-785	Molecular Spectroscopy	3(3 – 0)
CHM-786	Photochemistry	3(3 – 0)
CHM-787	Solution Chemistry	3(3 – 0)
CHM-788	Colloids and Surfactants	3(3 – 0)
CHM-789	Theoretical and Computational Chemistry	3(3 – 0)
CHM-790	Physical Chemistry of Biomolecules	3(3 – 0)
CHM-791	Heterogeneous Catalysis	3(3 – 0)
CHM-792	Modern Aspects of Chemical Kinetics	3(3-0)
CHM-793	Environmental Chemistry and Energy Conversions	3(3-0)

Semester 3 & 4

Course Code	Course Title	Credit Hours
CHM-728	Seminar (General)	1(1 – 0)
CHM-729	Seminar (Research)	1(1 – 0)
CHM-730	Thesis	6(6 – 0)

M. PHIL CHEMISTRY

INORGANIC CHEMISTRY

CHM-701 Solid State Chemistry 3(3-0)

Classification of bonds and crystals, The effect of radius ratio and charge on crystals, Application of the isoceletronic principle, Ordered solids including interstitial compounds, Alloys, Superclustures and Storage batteries, Amorphous solids (Glass and Polymers)

Recommended Books:

1. S. Prakash, G.D. Tuli, S.K. Basu, R. D. Madan, "Advanced Inorganic Chemistry" Volume I, New Dehli (1997).
2. B. D. Cullity "Elements of X-ray diffraction" 2nd edition Addison-wasley publishing company, California (1977).
3. E. P. Bertin, "Principles and Practice of X-ray Spectrometric Analysis", Plenum Press, New York, USA (1975).

CHM-702 Photochemical Reactions of Transition Metals 3(3-0)

Introduction, Basic Photochemical processes, Photosubstitution reactions, Photoredox reactions, Reactivity of CTTM and CTTL excited states, Ligand photoreactions, Scavenging of reaction intermediates, Photoreaction and solar energy conversion, Photochemistry techniques.

Recommended Books:

1. J. G. Calvert, J. N. Pitts, "Photochemistry" John Wiley, New York, USA (1966).
2. P. Suppan, "Principles of Photochemistry", The Chemical Soc., UK (1973).
3. J. G. Calvert, J. N. Pitts, "Photochemistry" John Wiley, New York, USA (1966).
4. Wayne, P. Richard, "Photochemistry" 2nd Ed., Macmillan, UK (1988).

CHM-703 Applied Transition Metal Catalytic Chemistry 3(3-0)

Ziegler-Natta and Wacker catalyst, polymerization and Oligomerization of ethylene, propylene, olefins, cyclic olefins and alkynes, Fischer-Tropsch process, Oxidation reaction, synthesis of acrylates and related derivative.

Recommended Books:

1. N. C. Norman, "Periodicity and the S &P block elements" 2nd Revised Ed., Oxford University press, UK (1997).
2. A. Yamamoto, "Organotransition metal chemistry" John Wiley and Sons: New York, USA (1986).
3. M. Bochmann, "Orgaometallics 2, complexes with transition metal carbon π-bonds" Oxford Chemistry Primers, UK (1993).
4. G. L. Miessler, D. A. Tarr, "Inorganic chemistry" 2nd edition, Prentice Hall International, USA (1998).
5. F. A Cary, "Organic Chemistry" 7th edition, The McGraw-Hill Company, USA (2008).

CHM-704 Chemistry of Organometallic Compounds 3(3-0)

Nature of metal-carbon bond in organometallic compounds , transition metal organometallic complexes, naturally occurring organometallic compound, Fundamental process in reactions of organotransition metal complexes like insertion and extrusion of CO, SO_2, NO, olefins and diffraction, Experimental techniques in organometallics (techniques using Schlenk glass ware, chemical analysis, IR Raman, photoelectronic, Mossbauer and NMR spectroscopy, X-ray and neutron diffraction)

Recommended Books:

1. P. Powell, "Principles of Organometallics Chemistry", 2nd Ed, London, Chapman and Hall, New York, USA (1988).
2. A. Yamamoto "Organotransition metal chemistry" John Wiley and Sons: New York, USA (1986).
3. M. Bochmann "Orgaometallics 2, complexes with transition metal carbon π-bonds" Oxford University Press, UK (1993).
4. G. L. Miessler, D. A. Tarr, "Inorganic chemistry" 2nd Ed., Prentice Hall International, USA (1998).
5. F. A. Cary, "Organic Chemistry" 7th Ed, The McGraw-Hill Company, USA (2008).

CHM-705 Inorganic Electronic Spectroscopy 3(3-0)

Introduction, Term symbols, Russel Sanders coupling scheme, Development of correlation and Tanabe-sugano diagram, Ligand field spectra of octahedral complexes, Absorption spectra of coordination compounds, Band assignments and interpretation of absorption spectra of complexes, Charge transfer spectra, Spectra of low symmetry complexes, Magneto chemistry.

Recommended Books

1. G. D. Christian, J. E. O'Reilley, "Instrumental Analysis," 2nd Ed, Boston, USA (1986).
2. E. S. Gilreath "Fundamental concepts of inorganic chemistry" McGraw- Hill, New York, USA (1958).
3. H. H. Jaffe, M. Orchin, "Theory and Applications of Ultraviolet Spectroscopy," 1st Ed, John Wiley & Sons, New York, USA (1962).

CHM-706 Kinetics and Mechanisms of Inorganic Reactions 3(3-0)

Principles of kinetics. Steady state approximation. Determination of rate law. Inert and labile complexes. Substitution reactions of octahedral, square planer and tetrahedral complexes. Oxidation-reduction reactions of metal ions. Organotransition metal compounds. Free radical reactions.

Recommended Books:

1. J. E. Huheey, E. A. Keiter, R. L. Keiter, "Inorganic Chemistry: Principles of Structure and Reactivity", 4th Ed., Harper & Row, New York, USA (2001).
2. K. M. Mackay, R. A. Mackay, W. Henderson, "Introduction to Modern Inorganic Chemistry", 5th Ed, Stanley Thomas Publisher Ltd. USA (1996).
3. G. L. Miessler, A. T. Donald, "Inorganic Chemistry", 2nd Ed., Prentice Hall International, USA (1991).

CHM-707 Bio-Inorganic Chemistry 3(3-0)

Development and importance of bio-inorganic chemistry. Introduction to metals of biological importance. Function of metals in enzyme catalysis. Oxygen carriers; nitrogen fixation; vitamin B6 and B12. Importance of metals and nonmetals in biological systems. Metal ions and chelating agents for medicinal purposes.

Recommended Books:

1. D. F. Shriver, P. W. Atkins, C. H. Langford, "Inorganic Chemistry" 2nd Ed, Oxford University Press, UK (1994).
2. A. K. Das, "A Text Book on Medicinal Aspects of Bio-Inorganic Chemistry" CBS Publishers and Distributors. New Dehli, India (1990).
3. G. L. Miessler, A. T. Donald, "Inorganic Chemistry", 2nd Ed., Prentice Hall International, USA (1991).
4. R. W. Hay, "Bio-inorganic Chemistry" Ellis Horwood Limited, UK (1987).

CHM-708 Nano Chemistry 3(3-0)

Nanotechnology, nanomaterials, mesoporous, microporous and macroporous materials. Nanoscale, Nanometer, Nanoparticles, Nanotubes, Thin films, Nanocomposites, Nanostructured bulk materials. Synthesis of nanoparticles and composites (Bottom Up and Top Down Production). Synthesis by anodization, hydrothermal and deposition-precipiation methods. Characterization of nanomaterials by X-ray Diffraction (XRD), Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM) and Fourier Transform Infrared (FTIR) spectroscopy and applications.

Recommended Books:

1. G. B. Sergeev, "Nanochemistry" 1st Ed., Elsevier, The Netherlands (2006).
2. A. I. Kirkland, J. L. Hutchison "Nanocharacterisation" The Royal Society of Chemistry, UK (2007).
3. R. E. Hester, R.M. Harrison,"Nanotechnology: Consequences for Human Health and the Environment" The Royal Society of Chemistry, UK (2007).
4. H. Hosono, K. MacKenzie, Y. Mishima, H. Takezoe, "Nanomaterials" Elsevier Science Ltd, Netherland (2006).

CHM-709 Applied Spectroscopy 3(3-0)

UV/Visible Spectroscopy, Beer-Lamberts law, Instrumentation and application, Working of single and double beam spectrophotometer, Application of UV/Visible Spectroscopy, Infrared Spectroscopy, modes and absorption frequencies, Hooks Law, Instrumentation and sample handling, Interpretation of Infrared spectra, Applications of Infrared spectroscopy, Nuclear Magnetic Resonance**,** Spin flipping Nuclear Precession and absorption of electromagnetic radiation, Chemical shift, Sample handling and Instrumentation, Mass spectroscopy**,** Principle, Instrumentation, The mass spectrum, Modes of Fragmentation, Applications of mass spectroscopy.

Recommended Books:

1. Ault, G. Dudek, "An Introduction to Proton NMR Spectroscopy," 1st Ed., Holden Day, San Francisco, USA (1976).
2. D. L. Pavia, G. M. Lampman, G. S. Kriz, Jr., "Introduction to Spectroscopy," 2nd Ed, W. B. Saunders, USA (1979).
3. D. W. Mathieson, "Nuclear Magnetic Resonance for Organic Chemistry," Academic Press, London, UK (1967).
4. A. Douglas, F. Skoog, J. Holler, T. A. Nieman "Principles of Instrumental Analysis", 5th Ed, Saunders College Publishing, New York, USA (1997).
5. E. D. Hoffmann, V. Stroobant (Editors) "Mass Spectrometry: Principles and Applications" 2nd Ed, John Wiley & Sons; USA (2001).
6. G. D. Christian, J.E. O'Reilley, "Instrumental Analysis," 2nd Ed, Boston, USA (1986).
7. G.W. Ewing "Instrumental Methods of Chemical Analysis, 5th Ed, McGraw-Hill, New York, USA (1985).
8. H. Budzikiewitz, C. Djerassi, and D. H. Williams, "Mass Spectrometry," Holden-Day. San Francisco, USA (1967).
9. J. R. Chapman, "Practical Organic Mass Spectrometry," John Wiley and Sons, USA (1985).

CHM- 710 Extractive Metallurgy 3(3-0)

Introduction; Pyrometallurgy, Hydrometallurgy, Biohydrometallurgy, Leaching of Au, Ag, Pt, Pd, Rh, Ce, In, Cu, Zn, Fe from minerals; General Principle, Leaching from oxides, leaching of sulfides, leaching of phosphate, leaching of silicates, Leaching of Secondary resources; slags, smelter dusts, Ashes, electronic wastes, Treatment of leach liquor; Crystallization, Adsorption, ionic precipitation, ionic flotation and precipitate flotation, solvent extraction

Recommended Books:

- F. Habashi, Principles of Extractive Metallurgy (1998), Volume 4. Amalgam & Electrometallurgy, Métallurgie Extractive Québec, Sainte-Foy, Québec City.
- Greenwood, N. N.; & Earnshaw, A. (1997). Chemistry of the Elements (2nd Edn.), Oxford:Butterworth-Heinemann. ISBN 0-7506-3365-4.
- F. Habashi, Chalcopyrite; Its Chemistry and Metallurgy (1978), McGraw-Hill, ISBN 0-07-025-83-8.
- F. Habashi, Principles of Extractive Metallurgy, Volume 1, Gordon & Breach Science
  Publishers, ISBN 0-677-01-7707.
- Biohydrometallurgical processes: a practical approach (2010), Luis, Gonzaga Santos Sobral, Débora Monteiro de Oliveira e Carlos, Eduardo Gomes de Souza - Rio de Janeiro: CETEM/MCT, ISBN 978-85-61121-85-3

CHM-712 Metal Based Drugs 3(3-0)

Introduction, Strategic considerations, Radiodiagnostic, Biopharmaceutical properties of drugs substances, Pharmacologic Activity, Drug Design, DRUG/Receptor Interactions, Drugs Resistance and Metabolism, Lithium and Mental Health, Gold and Rheumatoid Arthritis, Platinum ammine halides, Metallocenes and their halides: Ti, V, Fe, Gold and other metal phosphines, other main group and transition-metal compounds, cis-platin, carboplatin, platinum anti cancer drugs, technetium radiopharmaceuticals, gadolinium MRI contrast agents, auranofin, Mechanism of action studies, Dose-Limiting problems: toxicology,

Recommended Books:

1. W. I. Sundquist and S. J. Lippard, Coord. Chem. Rev. 100 (1990), 293
2. H. Sigel, ed. Metal Ions in Biological Systems, Dekker, Vol. 14, 1982.
3. D. A. Brown, Metal Ions Bioi. Syst. 14 (1982), 125.
4. A. D. Young and R. W. Nobel, Methods Enzymol. 76 (1981).792.
5. J. G. Wright et al., Prog. Inorg. Chem. 38 (1990), 323.
6. J. D. Helmann, L. M. Shewshuck, and C. T. Walsh, Adv. Inorg. Biochem. 8 (1990), 331.

Analytical Chemistry

CHM-731 Laser and Luminescence Spectroscopy 3(3-0)

Introduction, principle, laser operation, spontaneous emission mission, stimulated emission, population in inversion, population inversion in two level system, three level system in four level system. Properties of laser light. Types of lasers; nitrogen laser CO2 laser, ruby laser, dye laser. Uses of lasers. Radiation in absorption fluorescence spectroscopic methods. Applications. Laser induced chemical reactions laser in industrial chemical processes.
Atomic and molecular fluorescence spectroscopy basic principle and instrumentation, structural factors, instrumentation for fluorescence and Phosphorescence Measurement, Room temperature Phosphorescence, Comparison of Luminescence and UV-Visible Absorption Methods.

Books recommended:

1. S. Stenholm, "Foundations of laser spectroscopy", John Wiley and Sons Inc., 605 Third Avenue, New York, USA (2008).
2. W. Demtroder, "Laser Spectroscopy: Basic Concepts and Instrumentation, 3rd Ed., Springer-Verlag Berlin Heidelberg New York, USA (2003).
3. D. A. Cremers, L. J. Radziemski, "Handbook of Laser-Induced Breakdown Spectroscopy", John Wiley & Sons, USA (2006).
4. C. Ronda, "Luminescence", Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim. Germany (2008).
5. B. Valeur, "Molecular Fluorescence, Principle and Application" Wiley-VCH, Weinheim, Germany (2002).
6. Ebdon, E. H. Evans (ed.), A. Fisher and S.J. Hill "An Introduction to Analytical Atomic Spectrometry" Wiley, Chichester, USA (1998).

CHM-732 Environmental Analysis 3(3-0)

Introduction, General principle and Techniques. Soil, sludge, sediment and dust analysis. Analysis of plant Material, Analysis of Atmospheric samples, Analysis of Water determination of toxic organic Chemistry. Analysis of toxic heavy metals. Biological indicators, Echo toxicology.

Recommended Books:

1. B. B. Kebbekus, S. Mitra "Environmental Chemical Analysis", 1st Ed., Blackie Academic & Professional, New York, USA (1998).
2. D. Barcelo, "Environmental analysis: Techniques, Applications and Quality Assurance", Volume 13, Elsevier B.V., Netherland (1993).
3. P. Patnaik, "Handbook of Environmental Analysis", 2nd Ed, CRC Press, Taylor and Francis Group, UK (2010).

CHM- 733 Radiopharmaceuticals and Quality Control 3(3-0)

Introduction; Structure of atom and nucleus; Radioactive decay; Unit of radioactivity; Cyclotron-produced radionuclides; Reactor-produced radionuclides; Instruments for radiation detection and measurement; Specific activity; Radionuclide generators; Radiopharmaceuticals; Formulation of radiopharmaceuticals for different organs; Characteristics of specific radiopharmaceuticals; Diagnostic uses of radiopharmaceuticals in nuclear medicine; Therapeutic uses of radiopharmaceuticals in nuclear medicine; Quality Control of Radiopharmaceuticals; Nuclear pharmacy.

Books Recommended:

1. Gordon, Breach, "Textbook of Radiopharmacy, Theory and Practice" 3rd Ed, Science Publishers, Netherland (1999).
2. Prekeges, Jennifer, "Nuclear Medicine Instrumentation" 1st Ed, Society of Nuclear Medicine, New York, USA (2004).
3. Gunderson, L. L. Tepper, "Clinical Radiation Oncology" 2nd Ed. Elsevier, Netherland (2007).

CHM-734 Techniques for surface analysis 3(3-0)

Introduction, Theory, Principle and Instrumentation of Auger Electron Microscopy, Scanning Electron microscopy, Vibrational spectroscopy from surfaces, Scanning Probe Microscopy. XRD. Applications of surface analytical techniques.

Books Recommended:

1. J. C. Vickerman, I. Gilmore, "Surface Analysis, the Principle techniques", 2nd Ed, John Wiley and Sons, New York, USA (2009).
2. D. J. O' Connor, B. A. Sexton, "Surface Analysis Methods in Material Science", Volume 23, 2nd Ed, USA (2003).
3. J. M. Walls, "Methods for Surface Analysis, Techniques and Applications" Press, University of Cambridge, UK (1990).
4. J. F. Watts, J. Wolstenholme, "An Introduction to the Surface Analysis by XPS and AES", John Wiley and Sons, New York, USA (2003).
5. H. A. Liebhafsky, H. G. Pfeiffer, E. H. Winslow, P. D. Zemany, "X-Rays, Electrons, and Analytical Chemistry", Wiley-Interscience, New York, USA (1972).

CHM-735 Polymer Characterization by Hyphenated Techniques 3(3-0)

Introduction to polymers, Properties of Polymers, Thermal analysis of polymers, Chemical analysis of polymers, Hyphenation in polymer analysis, Hyphenation of size exclusion chromatography with selective detectors, two dimensional liquid chromatography, Combination of High performance liquid chromatography HPLC and Mass spectrometry (Matrix Assisted Laser Desorption Time of Flight Mass spectrometry). Spectroscopic techniques, FTIR, NMR for polymer analysis.

Books Recommended:

1. T. Provder, H. G. Barth, M. W. Urban, "Chromatographic Characterization of Polymer, Hyphenated and Multidimensional Techniques", American Chemical Society, Washington DC, USA (1995).
2. Snyder, J. J. Kirkland," Introduction to Modern Liquid Chromatography", 2nd Ed, Wiley, New York, USA (1979).
3. Stock, Rice, "Chromatographic methods," 2nd Ed, Chapman and Hall, UK (1967).
4. R. P. W. Scott, "Techniques and Practices of Chromatography," 2nd Ed, Marcel Dekker, UK (1995).

CHM-736 Advanced Emission Spectroscopy 3(3-0)

Introduction, principles and instrumentation of plasma emission spectroscopy. The direct current plasma spectroscopy. Principle, Introduction and instrumentation of Inductively coupled plasma ICP. ICP-AES instrumentation, application of plasma emission spectroscopy and Inductively coupled plasma.

Recommended Books:

1. K. C. Thomspon, R. J. Reynold, "Atomic Absorption, Fluorescence and Flame Emission Spectroscopy" 2nd Ed. John Wiley and Sons, USA (1978).
2. A. Fisher, S. J. Hill, Ebdon, E.H. Evans (ed.), "An Introduction to Analytical Atomic Spectrometry" Wiley, Chichester, USA (1998).
3. Dowden, Hutchinson, Ross, "Emission Spectroscopy", Barnes, R. M. (Ed.,) Stroudsburg, Pa:Dowden, Hutchinson & Rose New York, USA (1976).

CHM-738 Chromatographic Techniques 3(3-0)

Introduction theory, instrumentation and Applications of High performance Liquid Chromatography. Gas Chromatography-Mass spectrometry and Supercritical Fluid Chromatography. Introduction, Theory, instrumentation and applications Ion Chromatrography, HPTLC, Flow Injection Analysis and Field flow fractionation.

Recommended Books:

1. R. P. W. Scott, "Techniques and Practices of Chromatography," 2nd Ed., Marcel Dekker, UK (1995).
2. H. G. Cassidy, "Fundamentals of Chromatography" New York, Interscience Publishers, USA (1957).
3. S. Gerhard "Gas Chromatography-A Practical Course" VCH, Germany (1990).
4. Snyder, J. J. Kirkland," Introduction to Modern Liquid Chromatography", 2nd Ed, Wiley, New York, USA (1979).

CHM- 739 Research Methodology 3(3-0)

Research Methodology

What is Research? Research Concepts, Research Ethics and Integrity, Quantitative Research Methods, The Scientific Method, Design of Quantitative Surveys, Introduction to Qualitative Research and Research Approaches, Qualitative Research Methods, Data Analysis and Theory in Qualitative Research Articles, Mixed-Methods Design, Introduction to Mixed Methods Research, Design of Mixed Methods Research, Evaluation of Mixed Methods Research

Recommended Books:

1. Ben Kei Daniel. Methods and Techniques for Studying Virtual Communities: Paradigms and Phenomena. Volume 1, Information Science Reference. Hershey • New York

1. Dawson, Catherine, 2002, Practical Research Methods, New Delhi, UBS Publishers'Distributors

2. Kothari, C.R.,1985, Research Methodology- Methods and Techniques, New Delhi, Wiley Eastern Limited.

3.Kumar, Ranjit, 2005, Research Methodology-A Step-by-Step Guide for Beginners,(2nd.ed.),Singapore, Pearson Education.

CHM-740 CHEMOINFORMATICS 3(3-0)

Chemoinformatics, Scientific Origins, Fundamental Concepts, Compound Classification and Selection, Cluster analysis, Similarity Searching, Structural queries and graphs, Pharmacophores, Fingerprints, Machine Learning Methods, Library Design, Quantitative Structure-Activity Relationship Analysis, Virtual Screening and Compound Filtering, Database design, Compound selection for a specific purpose, Computational hit identification, Practice and Products like ACD Labs, Barnard Chemical Information Ltd, BioByte, CambridgeSoft, CAS/Scifinder, ChemAxon etc

Recommended Books

1) B. A. Bunin, B. Siesel, G. A. Morales, J. Bajorath (auth.); *Chemoinformatics-Theory, Practice, & Products* 2007. Published by Springer, Netherlands.
2) Andrew R. Leach, V.J. Gillet; *An Introduction to Chemoinformatics* 2007 Published by Springer, Netherlands.
3) Johann Gasteiger and Thomas Engel; *Chemoinformatics: A Textbook*. 2003 Wiley-VCH Verlag GmbH & Co. KGaA.
4) Eduardo A. Castro and A. K. Haghi; *Advanced Methods and Applications in Chemoinformatics: Research Progress and New Applications* 2012 by IGI Global.
5) Jürgen Bajorath; *Chemoinformatics Concepts, Methods, and Tools for Drug Discovery* 2004 Humana Press Inc. Totowa, New Jersey
6) Jean-Loup Faulon, Andreas Bender *Handbook of Chemoinformatics Algorithms* 2010 Chapman & Hall/CRC Boca Raton, FL
7) Roberto Todeschini and Viviana Consonni *Molecular Descriptors for Chemoinformatics* 2009 WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim

ORGANIC CHEMISTRY

CHM-751 Modern Trends in Organic Synthesis 3(3-0)

Introduction to retero synthesis and disconnection approach, synthesis of aromatic compounds. One and two group C-X disconnections. Donor and acceptor synthesis and concepts of Umpulung. C-C disconnections and disfunctionalized compounds compounds. Devising synthetic schemes for unknown molecules and some natural products.

Books Recommended:

1. R. O. C. Norman "Principles of Organic Synthesis", 3rd Ed, Blackie Academic & Professional, Glasgow, UK (1993).
2. G. M. Loudon, "Organic Chemistry", 3rd Ed. Addison Wesley, London Company, UK (1995).
3. S. H. Pine, "Organic Chemistry", 5th Ed., McGraw Hill, New York, USA (1987).
4. G. M. Loudon, "Organic Chemistry", 2nd Ed., Addison Wesley, London, UK (1998).

CHM-752 ADVANCED STEREOCHEMISTRY 3(3-0)

Prostereoisomerism, Concept of Re and Si face, Homotopic, Enantiotopic and Diastereotopic ligands and faces, Stereoselectivity and Stereospecificity, Configuration and conformation of cyclic molecules, Stereochemistry and conformational analysis of cyclohexane system, six- membered sp^2-hybridized cyclic systems and six membered saturated heterocycles. Stereochemistry and conformational effects in small, common and medium rings. Bicyclic and polycylic fused rings systems. Bridged rings and stereochemical restrictions. Chiroptical properties, Optical Rotatory Dispersion and Circular Dichroism.

Books Recommended:

1. K. Mislow "Stereochemistry", 2nd Ed., W. A. Benjamin Inc., New York, USA (1965).
2. E. L. Eleil, S.H. Wilen, L.N. Mander, "Stereochemistry of Organic Compounds", 4th Ed, John Wiley & Sons, USA (1994).
3. E. L. Eliel, S. H. Wilen, M. P. Doyle "Basic Organic Stereochemistry", John Wiley & Sons, USA (2001).

CHM-753 Physico-Organic Chemistry and Reaction Mechanism 3(3-0)

Chemical reactions and energy changed; qualitative aspects of collision. Transition state theories, rates and equilibria; tracer techniques, trapping of intermediates. Interpretation of kinetic data. Correlation of structure with reactivity,; Linear free energy relationship, stereochemical and spectroscopic evidences. Study of reaction mechanism of some recent reactions.

Books Recommended:

1. S. H. Pine, "Organic Chemistry", 5th Ed., McGraw Hill, New York, USA (1987).
2. G. M. Loudon, "Organic Chemistry", 2nd Ed., Addison Wesley, London, UK (1998).
3. J. Clayden, N. Greeve, S. Warren, P. Wothers, "Organic Chemistry", Oxford University Press, Oxford, UK (2001).
4. P. Sykes, "A Guide Book in Modern Organic Chemistry", 6th Ed., Longman, London,UK (1986).
5. H. O. House "Modern Synthetic Reactions", Benjamin, California, USA (1972).
6. K. I. Rinehart, "General Oxidation Reaction of Orgainc Compounds", Prentice Hall, New Jersey, USA (1973).

CHM-754 Advanced Heterocycles I 3(3-0)

Three membered heterocycles:

Nomenuclature, Physical properties, Synthesis, Chemical reactions and medicinal importance of Aziridine, Oxirane, Thiirane, Diazirine, Oxaziridine, Dioxirane.

Four membered heterocycles:

Nomenuclature, Physical properties, Chemical reactions and medicinal importance of Azetidine, Oxetan, Thietane, Diazetidine, Dioxetane, Dithietane

Seven membered heterocycles

Nomenuclature, Physical properties, Chemical reactions and medicinal importance of Azepane, Oxepane, Thiepane, Thiazepene

Recommended Books:

1) J. Clayden, N. Greeves, S. Warren, "Organic Chemistry", 2nd Ed., Oxford University Press Inc., New York (2012).
2) J. S. Clark "Heterocyclic Chemistry", by J. Stephen Clark.
3) J. A. Joule, K. Mills, G. F. Smith, "Heterocyclic Chemistry", 3rd Ed.,Chapman & Hall, UK (1995).
4) T. L. Gilchrist, "Heterocyclic Chemistry", 3rd Ed., Oxford Primer Series,(1997)
5) A. R. Katritzky, "Handbook of Heterocyclic Chemistry", Pergamon press, New York (1985).

CHM-755 Chemistry of Glycosides 3(3-0)

Glycosides of flavonoids, coumarins and saponinsIsolatins, detection and chromatographic separation; acid, alkaline and enzymatic hydrolysis to aglycones; identification of sugar residue. Spectroscopic determination of aglycone and glycoside structures. Derivatization, structural elucidation and biological importance of glycosides.

Books Recommended:

1. B. A. A. Borm, "Introduction to Flavonoids", Harwood Academic publishers Canada (1998).
2. J. B. Harborn, "The Flavonodids-Advance in Research" Chapman & Hall. London, UK (1994).
3. K. Nakanishi, "Natural Products Chemistry", Vol. I., Academic press, New York, USA (1974).

CHM-756 Biosynthesis of Natural Products 3(3-0)

Introduction to biosynthesis. Biosynthesis of fatty acids, polyketides, isopernoids, amino acids and alkaloids, Metabolites from shikimic acid (ArC1 ARC2 and ARC3 metabolites) and of mixed biosynthetic origin (metabolites derived from acetate and mevalonate,)

Books Recommended:

1. Mann, "Secondary Metabolism", 2nd Ed, Oxford Science Publication, UK (1987).
2. J. D. Bu Lock, "The Biosynthesis of Natural Products", McGraw-Hill, London, UK (1965).
3. D. Ranganathan, S. Ranganathan, "Art in Biosynthesis", Academic Press, New York, USA (1976).
4. I. I. Finar "Organic Chemistry", Vol. II, 5th Ed. Longman, London, UK (1975).

CHM-757 ADVANCED NUCLEAR MAGNETIC RESONANCE 3(3-0)

Theoretical principles. Chemical shift and spin coupling in ^{1}H and ^{13}C nuclei, factors affecting chemical shift and spin coupling in different spin systems. DEPT, INEPT, SINEPT, Homonuclear 2D NMR techniques COSY, NOESY, INADEQUATE, TOCSY, ROESY, 2D J-resolved spectroscopy, Heteronuclear 2D techniques HMQC, HMBC, DOSY, Structure elucidation by using NMR techniques.

Books Recommended:

1. H. Friebolin "Basic one and two dimensional NMR Spectroscopy", 2nd Enlarged Edition, VCH, Germany (1988).
2. G. E. Martin, A. S. Zektzer "Two Dimensional NMR Methods for Establishing Molecular Connectivity", VCH, Germany (1988).
3. W. Voelter, "Carbon-13 NMR Spectroscopy", 3rd Ed., VCH, Germany (1990).
4. Atta-ur-Rahman "Nuclear Magnetic Resonsance Spectroscopy", UGC press, Islamabad, Pakistan (1989).

CHM-759 Symmetry Controlled Reactions 3(3-0)

Huckel moleculars orbital-and perturbation orbital theories; Frontier orbitals (HOMO-LUMO) concept; orbital symmetry; alternate and non-alternate hydrocarbons, Huckel and Mobious systems, Classes of peicyclic reations: electrocyclic, cycloaddition, sigmatropic and chelotropic reactions and their interpretation through (a) orbital symmetry conservation (b) frontier orbital treatment and (c) Huckel-Mobious approach Applications to organic synthesis.

Books Recommended:

1. E. A. Halevi "Orbital Symmetry and Reaction Mechanism", 1st Ed., Springer Verlag, Germany (1992).
2. G. M. Loudon, "Organic Chemistry", 3rd Ed. Addison Wesley London Company, UK (1995).
3. P. Sykes, "A Guide Book in Modern Organic Chemistry", 6th Ed., Longman, London, UK (1986).
4. H. O. House, "Modern Synthetic Reactions", 2nd Ed., Benjamin, California, USA (1972).

CHM-760 Classics in Total Synthesis 3(3-0)

Basic Concepts, Retro synthesis, Multistep total Synthesis of natural products, Pencillins, Prostaglandins, Estrone, Menthol, Quinine, Ajmaline.

Books Recommended:

1. R. T. Morrison, R. N. Boyd, "Organic Chemistry," Prentice-Hall,. 6th Ed., New Jersey, USA (1992).
2. F. A. Carey, R. J. Sunberg, "Advanced Organic Chemistry". Part A & B, 3rd Ed., Plenum Press, New York, USA (1990).
3. G. March "Advanced Organic Chemistry" 4th Edition, John Wiley and Sons, New York, USA (1999).
4. S.V. Bhat, B. A. Nagasampagi, M. Sivakumar, "Chemistry of Natural Product" Narosa Publishing House, New Dehli, India (2005).

CHM 761 Role of Protecting Groups in Organic Synthesis 3(3-0)

Introduction

(i) Protection of Carboxylic Acid Group

By ester formation, By diazotization, By salt formation, by reaction with $SOCl_2$ by hydroxamic acid etc.

(ii) Protection of Hydroxyl Group

Both for alcoholic and phenolic by ether formation, by ester formation by acetal and ketal formation

(iii) Protection of Carbonyl Group

By Acylation

By phthaloyl group and their related deprotecting Groups.

(iv) Protection of Amine Group

By acetal and ketal formation.

By hydrazone formation.

Books Recommended:

1. S. H. Pine, "Organic Chemistry", 5th Ed., McGraw Hill, New York, USA (1987).
2. G. M. Loudon, "Organic Chemistry", 2nd Ed., Addison Wesley, London, UK (1998).
3. F. A. Carey, R. J. Sunderg. "Advanced Organic Chemistry". Part A & B, 3rd Ed., Pleman Press, New York, USA (1990).
4. F.W. Greene, "Protective Groups in Organic Synthesis". 3rd Ed., Wiley and Sons New York, USA (1999).
5. G. March "Advanced Organic Chemistry" 4th Edition, John Wiley and Sons, New York, USA (1999).

CHM-762 Advanced Heterocycles II 3(3-0)

Five membered heterocycles:

Nomenuclature, Physical properties, Synthesis, Chemical reactions and medicinal importance of Pyrrole, Thiophene, Furan, Indole, Benzo[b]Thiophene, Benzo[b]furan, Isoindole, Benzo[c]Thiophene, Isobenzofuran, 1,3-azoles, (Imidazole, Thiazole, Oxazole), 1,2-azoles (pyrazole, Isothiazole & Isoxazole) and their Derivatives

Six membered heterocycles:

Nomenuclature, Physical properties, Synthesis, Chemical reactions and medicinal importance of Pyridine, Quinoline, Isoquinoline, Pyryliums, 2- and 4-Pyrones, Benzopyryliums, Benzopyrans, Diazines (Pyridazine, Pyrimidine & Pyrazine) and their derivatives

Recommended Books:

1) J. Clayden, N. Greeves, S. Warren, "Organic Chemistry", 2nd Ed., Oxford University Press Inc., New York (2012).
2) J. S. Clark "Heterocyclic Chemistry", by J. Stephen Clark.
3) J. A. Joule, K. Mills, G. F. Smith, "Heterocyclic Chemistry", 3rd Ed., Chapman & Hall, UK (1995).
4) T. L. Gilchrist, "Heterocyclic Chemistry", 3rd Ed., Oxford Primer Series, (1997)
5) A. R. Katritzky, "Handbook of Heterocyclic Chemistry", Pergamon press, New York (1985).

PHYSICAL CHEMISTRY

CHM-781 Physical Chemistry of High Polymers 3(3-0)

Molecular forces and chemical bonding in polymers, configuration and conformation of polymer chains, theories of polymer solutions; phase separation and fractionation, plasticization, molecular size measurement, spectroscopic analysis, thermal analysis, morphology and order in crystalline polymers, polymer reheology, electrical and magnetic properties of polymers.

Recommended Books:

1. Flory, "Principle of Polymer Chemistry" Cornell University press, New York, USA (1953).
2. Fried J. R. "Polymer Science and Technology"2nd Ed., Prenitce Hall, USA (1995).
3. Young, R.J. "Introduction to Polymers". 2nd Ed., Chapman and Hall Ltd, UK (1981).

CHM-782 Complex Extension of Quantum Chemistry 3(3-0)

Revision of basic quantum (Historic background, Uncertainty principle, Time-dependent/Time-independent Schrödinger equation, Probability, complex number, Particle in one dimensional box, Tunneling, Operators) Particle in three dimensional box, Requirements of an acceptable wave function, The Harmonic oscillator (one-dimensional harmonic oscillator, Vibration of molecules, Numerical solution of one-dimensional Schrödinger equation), Angular momentum, The Hydrogen atom , Theorems of quantum mechanics (Hermitian operator, Parity, Matrices), The Variation Method (Variation theorem, Determinants, Linear variation methods), Perturbation Theory (Non-degenerate perturbation theory, Perturbation treatment of the Helium atom ground state, perturbation theory for a degenerate energy level).

Recommended Books:

1. I. N. Levine. "Quantum Chemistry, fifth edition" Prentice-Hall, Inc. Upper Saddle River, New Jersey, USA (1991).
2. J. P. Lowe, K. A. Peterson. "Quantum Chemistry" 3rd Ed, Elsevier Academic Press, Netherland (2006).
3. P. A. Cox, "Introduction to Quantum Theory and Atomic Structure", Oxford University Press, UK (2002).
4. P. W. Atkins. "Molecular Quantum Mechanics" Oxford Univ. Press, Oxford, England (1983).
5. M. Muller. "Fundamentals of Quantum Chemistry", Kluwer Academic Publishers, Boston, USA (2001).

CHM-783 Electrode Processes 3(3-0)

Theories of electron transfer reactions, electron transfer process, electroanalytical techniques, methods for studying homogeneous and heterogeneous electron transfer reactions. semiconductor electrochemistry. Industrial electrochemistry. Eletro-chemical energy conversion systems.

Recommended Books:

1. J. Albert, "Electrode Kinetics" Clarendon, Oxford, UK (1975).
2. A. Bard, L. R. Faukner, "Electrochemical Methods, Fundamentals and Application" 2nd Ed., John Wiley and Sons, New York, USA (2001).
3. M. Mohammad, M. Amjad, "Principles of Electrode Kinetics" Rooha Printers, Lahore, Pakistan (2001).

CHM-784 Magnetic Spin Dynamics 3(3-0)

Revision of basic magnetic spin dynamics (Classical, quantum and spin angular momentum, nuclear spin and nuclear Zeeman splitting, quadruple nuclei with integer and half integer spin, magnetism, macroscopic and microscopic magnetism, simple pulse sequence, in homogeneous broadening, chemical shift, heteronuclear decoupling). The NMR spectrometer(the magnet, transmitter section, the duplexer, the probe, the receiver section, overview of radiofrequency section, Pulse gradient section), Fourier transform NMR (heteronuclear experiments, Arrayed experiments, two dimensional spectroscopy, three dimensional spectroscopy), mathematical techniques, Quantum mechanics (functions, operators, eigen functions, eigen values, eigen vectors, diagonalization, exponential operators)

Recommended Books:

1. M. H. Levitt. "Spin Dynamics, Basics of Nuclear Magnetic Resonance" John Wiley and Sons, New York, USA (2008).
2. N. E. Jacobsen. "NMR spectroscopy explained" John Wiley and Sons. New York, USA (2007).
3. R. S. Macomber. "A complete introduction to modern NMR Spectroscopy" John Wiley and Sons, New York, USA (1998).

CHM-785 Molecular Spectroscopy 3(3-0)

Microwave, infrared and Raman Spectroscopy. Normal coordinate analysis. Electronic spectra of diatomic and simple polyatomic molecules. Molecular symmetry, group theory and applications in chemistry. Applications of spectroscopy in structural chemistry

Recommended Books:

1. C. N. Banwell, "Fundamentals of Molecular Spectroscopy" 3rd Ed., Tata McGraw Hill, USA (1992).
2. G. M. Barrow, "Introduction to Molecular Spectroscopy," 2nd Ed., McGraw-Hill, New York, USA (1962).
3. J. D. Graybal, "Molecular Spectroscopy," McGraw-Hill, New York, USA (1988).

CHM-786 Photochemistry 3(3-0)

Principle of photochemistry. Sources of radiation, actinometry (both physical and chemical), primary and secondary photochemical processes, quantum yields, experimental techniques, photolytic studies of aqueous and non-aqueous systems, effects of radiation on solids. Kinetics, mechanism, energetics of photochemical reactions.

Recommended Books:

1. D. Neckers, G.N.V.B, Nau, "Advances in Photochemistry" Volume 27, John Wiley & Sons, New York, USA (2002).
2. P. Suppan, "Chemistry and Light" The Royal Society of Chemistry, London, UK (1994).
3. R. P. Wayne, "Principles and Applications of Photochemistry, Oxford University Press, UK (1998).

CHM-787 Solution Chemistry 3(3-0)

Physicochemical characteristics of solvents. Solute-solvent interaction, salvation of ions, preferential salvation. Thermodynamic properties of solute in bare solvents and mixed solvents. Transport properties of solutions, concept of association constant of ions in solution. Study of solute-solvent-solute interactions by spectroscopic techniques.

Recommended Books:

1. R. A. Alberty, J. S. Robert, G. B. Moungi, "Physical Chemistry". 4th Ed, John Wiley and Sons, New York, USA (2004).
2. D. W. Ball, "Physical Chemistry" 1st Ed., Brooks/Cole Co. USA (2003).
3. Smith, E. Brian, "Basic Chemical Thermodynamics" 5th Ed, Imperial College Press, UK (2004).
4. B. R. Stephen, S. A. Rice, J. Ross, "Physical Chemistry" 2nd Ed, Oxford University Press, UK (2000).
5. W. Jurg, "Basic Chemical Thermodynamics" 4th Ed., W. A. Benjamin (1969).
6. R. G. Mortimer. "Physical Chemistry" 3rd Ed, Elsevier Academic Press, UK (2008).

CHM-788 Colloids and Surfactants 3(3-0)

Liquid interfaces, surface tension and adsorption from solution, insoluble surface monolayer (Langmuir-Blodgett films). Surfactant, detergency, organized molecular assemblies (micelles, vescicles and membranes). Micro and macroemulsions. Colloidal dispersions, coagulation and flocculation. Optical properties of colloids.

Recommended Books:

1. M. J. Rosen, "Surfactants and Interfacial Phenomena" Marcel Dekker Inc., New York, USA (1989).
2. P. C. Hiemenz, R. Gopalan, "Principles of Colloid and Surface Chemistry" 3rd Edition, Marcel Dekker Inc., New York, USA, (1997).
3. D. F. Evans, "The Colloidal Domain", VCH, Weinheim, Germany (1994).

CHM-789 Theoretical and Computational Chemistry 3(3-0)

Molecular orbital calculations. Essential concepts, semiempirical and Ab-initio methods. Reactivity. Configuration interaction method. Potential energy surfaces. Quantitative structura-activity relationship (QSAR). Molecular mechanics. Energy minimization force field parameterization and conformational analysis. Computer programming and three dimensional graphics using standard packages.

Recommended Books:

1 C. J. Crammer, "Essentials of Computational Chemistry" John Wiley and sons, New York, USA (2002).
2 F. Jenson, "Introduction to Computational Chemistry" Wiley, USA (2000).
3 K. B. Lipkowitz, D. B. Boyd, "Reviews in Computational Chemistry ", VCH, New York, USA (1991).

CHM- 790 Physical Chemistry of Biomolecules 3(3-0)

Introduction and principles of biophysical chemistry, stability of native states. Methods for determining size, shape and molar mass of macromolecules. Thermodynamics of proteins, bioenergetic reactions, macromolecular solubility, understanding biological systems using physical chemistry, signal transduction, membrane potentials, transporters, and channels. Molecular imaging, kinetics of enzyme catalysis, inhibition and activation. Bioluminescence.

Recommended Books:

1. Templer R.H, Leatherbarrow R.J, 2003. Biophysical Chemistry:Membranes and Proteins. Royal Society of Chemistry, UK.
2. Oshima, H.2010. Biophysical Chemistry of Biointeerfacesw, John Wiley and Sons, New York USA.
3. James, P. Allen, 2008. Biophysical Chemistry, Wiley Blackwell Publishers, New York, USA.
4. Bruce, M.R.2001. Introducation to Biophysical Chemistry. McGraw-HillCompany, New York, USA.
5. Chang, R.1991. Physical Chemistry with applications to Biological Systems. Macmillan Publishing Co, Inc. New York, USA.
6. Marshal, A.G. 1998. Biophysical Chemistry. John Wiley and Sons, New York, USA.

CHM- 791 Heterogeneous Catalysis 3(3-0)

Introduction to catalysis, Classification of catalytic systems, classification of solid catalysts, adsorption of molecules at the solid surfaces, adsorption isotherms, surface area and porosity, adsorbed states of molecules on metal surfaces, potential energy curves for adsorption, descriptive chemistry of chemisorptions on metals, quantitative aspect of chemisorptions on metals, sorption on oxide surfaces, the band theory of solids, adsorption on insulator oxides, kinetics of heterogeneous reactions, mass transport limitation of catalyzed reactions. Catalysis in energy conversion and in the production of hydrocarbon feed stock, Oxidation catalysis: The Petrochemical Industry, Catalysis in the inorganic chemical industry, Catalysis in Atmospheric Pollution Control

Recommended books:

1. Bowker, M. "Basics and Application of Heterogeneous Catalysis" Oxford, 1998.
2. Gates, B.C. Catalytic Chemistry, John Wiley, 1992.
3. Bond, G.C. Heterogeneous Catalysis: Principals and applications, Oxford, 1987.
4. Boudart, M. and Mariadassou, G.D. "Kinetics of Heterogeneous Catalytic Reactions" Princeton, 1984.

CHM-792 Modern Aspects of Chemical Kinetics 3(3-0)

Chemical Kinetics, Development and modern use of chemical kinetics. Potential energy surfaces, statistical and quantum mechanical approaches for the study of unimolecular decomposition rate. Transition state theory and microscopic reversibility. Applications of transition state theory. Effect of temperature, Pressure, volume, Solvent and salt on rate of a reaction and determination of their respective kinetic expression. kinetic isotopic effects. Composite rate constants, isokinetic relationship. Catalysis and application of kinetics study for the production of enzymes. Kinetics of photochemical reactions. Kinetics of very fast reactions. Application of kinetics in modern industries. Kinetics study of drug (in-vivo and in-vitro). Importance of kinetics for military applications

Books Recommended:

1. R. Alberty, "Physical Chemistry" 17th Ed, John Wiley and Sons, New York, USA (1987).
2. P. W. Atkins, "Physical Chemistry" 6th Ed, W. H. Freeman and co. New York, USA (1998).
3. K. J. Laidler, "The World of Physical Chemistry" 1st Ed., Oxford University Press, UK (1993).
4. K. J. Laidler, H. M. John, C. S. Bryan, "Physical Chemistry" 4th Ed., Houghton Mifflin Publishing Company Inc., USA (2003).
5. M. G. Barrow, "Physical Chemistry" 5th Ed., Mc Graw Hill, USA (1992).

CHM-793 Environmental Chemistry and Energy Conversions 3(3-0)

Environmental Chemistry: global perspective, Earth atmosphere, study of reactions in regions of atmosphere. Chemistry of ozone formation and decomposition, ozone depletion. Air pollution, acidifying agents in rain, adverse effects and prevention. Chemistry of urban atmosphere. Indoor air pollution. Water pollution and chemistry of wastewater treatment methods (Physical, chemical and biological). Solid waste and Nuclear waste management. Nomenclature & Chemistry of CFC's. Experimental techniques for environmental monitoring. Renewable energy resources with reference to green fuels. HAARP technology.

Books Recommended:

1. G. W. Vanloon, S. J. Duffy, "Environmental Chemistry", A Global perspective, Oxford University press INC., UK (2000).
2. S. E. Manahan, "Environmental Science and Technology" Lewis Publishers, New York, USA (1997).
3. J. W. Moore, E. A. Moore, "Environmental Chemistry", Academic Press Inc., New York, USA (1990).
4. A. D. Kumar, "Environmental Chemistry", 2nd Ed, Wiley Eastern Ltd. India (1993).

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