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ACADEMY OF HIGHER EDUCATION
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DEPARTMENT OF CHEMISTRY

List of Courses for Ph.D. Course Work in Chemistry

POOL I Courses:

S.No	Course Code	Title of the Course	L	T	P	C
1	24CH710A	Electrochemistry: Principles and Applications	3	0	0	3
2	24CH710B	Molecular Interactions in Liquid Mixtures	3	0	0	3
3	24CH710C	Advanced Materials: Nanomaterials and Macromolecules	3	0	0	3
4	24CH710D	Chemical Separation Techniques	3	0	0	3
5	24CH710E	Advanced Organic Chemistry	3	0	0	3
6	24CH710F	Advanced Physical Chemistry	3	0	0	3
7	24CH710G	Aqueous Corrosion and Its Control (NPTEL)	0	0	3	3
8	24CH710H	Environmental Quality Monitoring & Analysis (NPTEL)	0	0	3	3

POOL II Courses:

S.No	Course Code	Title of the Course	L	T	P	C
1	24CH720A	Advanced Instrumental Methods of Chemical Analysis	3	0	0	3
2	24CH720B	Modern Aspects of Electrochemistry	3	0	0	3
3	24CH720C	Spectroscopic Techniques for Chemical Analysis	3	0	0	3
4	24CH720D	Polymer Science and Technology	3	0	0	3
5	24CH720E	Environmental Pollution and Its Control	3	0	0	3
6	24CH720F	Nanotechnology	3	0	0	3
7	24CH720G	Chemical Crystallography (NPTEL)	0	0	3	3
8	24CH720H	Physico-chemical Processes for Wastewater Treatment (NPTEL)	0	0	3	3

Note: L – Lecture, T – Tutorial, P – Practical, C – Credits, SE – Semester End Exam.

POOL I — COURSES SYLLABUS

24CH710A: Electrochemistry: Principles and Applications

Course-1: Electrochemistry: Principles and Applications

Pool-1
No. of hours: 45 **No. of credits: 3**

Unit – I: Electrochemistry Principles (9 hours)

EMF of a cell, standard electrode potential, Nernst equation and its application to chemical cells, relation between Gibbs energy change and EMF of a cell, conductance in electrolytic solutions, specific and molar conductivity, variations of conductivity with concentration, Kohlrausch's law and its applications.

Unit – II: Electrochemistry of Solutions (9 hours)

Arrhenius theory and its limitations, van't Hoff factor and its relation to colligative properties, deviation from ideal behavior of electrolytes, ionic activity, ion-solvent and ion-ion interactions, Debye-Huckel theory of strong electrolytes. Applications of Debye-Huckel limiting law - Diverse ion effect – Extent of dissociation of a weak electrolyte in the presence of an inert electrolyte.

Unit – III: Electrode Kinetics (9 hours)

Electrical Double layer - Theories of double-layer structure, diffuse-double-layer theory of Gouy and Chapman, Stern Model, Influence of double layer on charge transfer processes. Current-potential relationship – Butler-Volmer equation for one electron transfer reaction and Tafel equations, concept of over-potential.

Unit – IV: Applications of Electrodes (9 hours)

Types and applications of reference electrodes, working electrodes, Ion selective electrodes and membrane electrodes. Different types of over voltages - chemical and electrochemical over potentials, diffusion, migration and hydrodynamic modes of transports, role of supporting electrolyte, importance of Faradaic current and limiting current.

Unit – V: Electro organic reactions (9 hours)

Mechanism of electro-organic reactions: hydrogen evolution and oxygen reduction reactions, outer and inner sphere reactions, reduction of aldehydes to alcohols, nitrobenzene to aniline, acetone to isopropyl alcohol or pinacol, quinone to hydroquinone.

References

1. J.O.M. Bockris and A.K.N. Reddy, "Modern Electrochemistry" Vol. 1 & 2, Plenum Press, New York, 1970.

2. S. Glasstone, Electrochemistry, Affiliated East-West Press Pvt. Ltd., New Delhi, 1974.

3. L. Antropov, "Theoretical Electrochemistry", Mir Publications, Moscow, 1977.

4. D.A. McQuarrie and J.D. Simon, "Physical Chemistry - A Molecular Approach", Viva Books Pvt. Ltd., New Delhi, 1999.

5. J. Rajaram and J.C. Kuriakose, "Kinetics and Mechanism of Electrochemical Transformations", Macmillan India Ltd., New Delhi, 1993.

24CH710B: Molecular Interactions in Liquid Mixtures

Course-2: Molecular Interactions in Liquid Mixtures

Pool-1
No. of hours: 45 **No. of credits: 3**

Unit-I: Basic Concepts of Thermodynamics (9 hours)

Basic concepts of thermodynamics, Zeroth law of thermodynamics, First law of thermodynamics - limitations, Spontaneous process, Second law of thermodynamics, Entropy, free energies, Gibb's Helmholtz equations, Clausius-Clapeyron equation.

Unit-II: Advanced Concepts of Thermodynamics (9 hours)

Kirchhoff's equation, Van't Hoff's equation, Maxwell equation, Clapeyron equation, Clausius-Clapeyron equation, chemical potential, Gibbs-Duhem equation, Gibbs-Margules equation, applications of these concepts.

Unit-III: Types of Molecular Interactions (9 hours)

Fundamental aspects of molecular interactions in solutions and liquid mixtures, ion-ion interactions, ion-dipole interactions, dipole-dipole interactions, ion-induced dipole interactions, dipole-induced dipole interactions, quadrupole-octupole interactions, distinction between different types of interactions with appropriate explanation and examples.

Unit-IV: Specific Interactions among Molecules (9 hours)

Hydrogen bonding – intermolecular and intramolecular hydrogen bonding, London forces, charge transfer interactions and contact charge transfer interactions, examples for these specific interactions, properties affected by molecular interactions – viscosity, density, enthalpy, etc., measurement of viscosity, ultrasonic velocity measurements for investigation of molecular interactions.

Unit-V: Thermodynamic Parameters for Studying Interactions (9 hours)

Thermodynamics of excess functions: excess molar volumes, excess molar enthalpies, excess isentropic compressibilities, excess Gibb's free energy, excess heat capacity and their significance in ascertaining molecular interactions, Interpretation of changes in

excess parameters in terms of molecular interactions in binary and ternary liquid mixtures.

References

1. Advanced Physical Chemistry, Gurudeep Raj, 24th Edition, Goel Publishing House, Meerut, 2016.

2. Physical Chemistry, Peter Atkins and J.D. Paula, 7th edition, ELBS, Low Price Edition, 2002.

3. Molecular Interactions – Concepts and Methods, David A. Micha, Wiley, 2019.

4. Principles of Physical Chemistry, B.R. Puri, Madan S. Pathania, L.R. Sharma, 49th Edition, Vishal Publishing Company, 2020.

5. Essentials of Physical Chemistry, Arun Bahl, B.S. Bahl and G. D. Tuli, S. Chand and Company, New Delhi, 2009.

24CH710C

Course-3: Advanced Materials: Nanomaterials and Macromolecules
Pool-1 **No. of hours:** 45 **No. of credits:** 3

Unit-1: Classification and Properties of Nanomaterials (9 hours)

Classification and properties of nanosized metals and alloys, semiconductors, ceramics – a comparison with respective bulk materials, Organic semiconductors, carbon materials, quantum dots, quantum wells, quantum rods, quantum wires, quantum rings; bulk nanostructured, nanocomposites, nanopolymers and nanobiomaterials.

Unit-II: Synthesis of Nanomaterials (9 hours)

Techniques based on liquid and vapour phase as the starting material, sol-gel method, hydrothermal, micro-emulsion technique, chemical reduction, and chemical vapour deposition, electro and electroless deposition with suitable examples, mechanical milling, laser ablation, microwave and ultrasound assisted synthesis.

Unit-III: Polymers and Polymerization (9 hours)

Polymers: Definition, nomenclature of polymers, functionality of monomers, degree of polymerization, types of polymerization- addition, condensation and copolymerization with examples, methods of polymerization: solution, bulk, emulsion and suspension. Principles of polymer reactivity: photolytic, photosensitized polymerization, cross-linking, graft and block copolymerization.

Unit-IV: Properties and Applications of Polymers (9 hours)

Properties: polymer crystallization, effect of crystallisability on properties, glass transition temperature (Tg) and its determination, dependence of Tg on polymer structure and other factors, applications of polymers: photo-sensitive polymers, thermally stable polymers, biodegradable polymers, conducting polymers and fire retardant polymers.

Unit-V: Characterization of Nanomaterials and Polymers (9 hours)

Nanomaterials: Techniques of characterization of size of nano powders/ particles using BET method and laser diffraction, various spectroscopic techniques like optical spectroscopy, UV visible and IR spectroscopy, Raman spectroscopy, X-ray photoelectron spectroscopy (basic understanding of each technique with special emphasis on

characterization at nano scale). Characterization of polymers: Molecular weight determination by light scattering, osmotic, centrifuge and viscosity methods. Analysis and testing of polymer by FT-IR, NMR, XRD, TGA/DTA/DSC (basic understanding of each technique with special emphasis on characterization of polymers).

References

1. Naomaterials and Nanochemistry by Brechignac C., P. Houdy, M. Lahmani, Springer publication, 2007.

2. Nanostructures and Nanomaterials, synthesis, properties and applications by Guozhong Cao, Imperial College Press, 2004.

3. Nanomaterials – Handbook by Yury Gogotsi, CRC Press, Taylor & Francis group, 2006. NSC.

4. The elements of polymer science and engineering. An introductory text for engineers and chemists, Academic Press, New York, 1982.

5. A Textbook of Polymers. Vol I. S.Chand & Company Ltd 2004.

6. A Text Book of Polymer Chemistry, Singapore: John Wiley & Sons 1994.

24CH710D

Pool-1 **Course-4: Chemical Separation Techniques**
No. of hours: 45 **No. of credits:** 3

Unit-I: Thin Layer Chromatography (9 hours)

Principle, classification of chromatographic techniques, nature of adsorbents, eluents, Rf values, factors affecting Rf values, Thin Layer Chromatography: Principle, experimental set-up, preparation of plates, adsorbents and solvents used, process of development of chromatogram, detection of spots, applications of TLC and advantages of TLC.

Unit-II: Paper Chromatography and Column Chromatography (9 hours)

Paper Chromatography: Principle, experimental set-up, choice of paper and solvents, various modes of development – ascending, descending, radial and 2D, applications of paper chromatography. Column Chromatography: Principle, classification of column chromatography, experimental procedure, applications, factors affecting column efficiency.

Unit-III: Gas Chromatography and HPLC (9 hours)

Gas Chromatography: Basic principles, different types of gas chromatographic techniques, instrumentation, detectors – thermal conductivity detector, flame ionization detector, Rf values, applications of gas chromatography. High Performance Liquid Chromatography: Basic principles, normal and reversed phases, instrumentation, detectors – RID, UV detector, Rf values, reverse phase HPLC, applications.

Unit-IV: Separation by Distillation and Extraction (9 hours)

Simple distillation, fractional distillation, extractive distillation, steam distillation, vacuum distillation, sublimation, heating devices and columns involved in distillation techniques. Solvent extraction: distribution law, distribution ratio, various techniques and solvents used for extraction, extractions involving solvents heavier as well as lighter than water.

Unit-V: Separation by Other Techniques (9 hours)

Separations involving membranes: Osmosis and reverse osmosis, dialysis and electrodialysis, filtering and sieving. Separations involving electric fields: Electrodeposition,

electrophoresis. Miscellaneous techniques: density gradients, solubility and centrifugation.

References

1. Instrumental Methods of Chemical Analysis, B. K. Sharma, Krishna Prakashan Media Pvt. Ltd., 2014.

2. Quantitative Analysis, R. A. Day Jr. and A. L. Underwood, 6th Edition, Pearson Education India, 2015.

3. Vogel's Quantitative Chemical Analysis, J. Mendham, R. C. Denny, J. D. Barnes, M. Thomas, B. Sivasankar, 6th Edition, Pearson Education, 2009.

4. Chemical Separations – Principles, Techniques and Experiments, Clifton E. Meloan, Wiley Interscience Publication, 1999.

24CH710E

Course-5: Advanced Organic Chemistry

Pool-1
No. of hours: 45 **No. of credits:** 3

Course Content

Unit-I: Structure and Reactivity of Heterocyclics (9 hours)

Structure and reactivity of Pyridine, Quinoline, Benzofuran, Benzothiophene, Coumarins, Pyrazole, Oxazoles, Isoxazoles, Thiozoles, Isothiozoles, Pyridazine, Pyrimidine, and Pyrazine.

Unit-II: Molecular Rearrangements & Named Reactions (9 hours)

Nucleophilic, electrophilic, and free radical rearrangements: Wagner-Meerwin, Pinacol, Benzil-Benzilic acid, Favorski, Fries, Neber, Hoffmann Curtius, Beckmann, Schmidt, Bayer-Villiger, Stevens rearrangements; Wittig, Suzuki, Sonogashira reaction, Michael addition, Mannich reaction, Diels-Alder reaction, Hydroboration, Clemmensen, and Birch reductions.

Unit-III: Pericyclic Reactions & Photorearrangements (9 hours)

- **Diels-Alder cyclo-addition reaction:** Regiochemistry, Stereochemistry, Intramolecular, Retro, Asymmetric, 1,3-Dipolar reactions, Electrocyclic reactions, Sigmatropic rearrangements.
- **Photorearrangements:** Rearrangements of Enones, Dienones, Epoxy ketones, in aromatic compounds, by alkenes.
- **Photoreduction and Photooxidation:** Photoreduction of carbonyl compounds, aromatic hydrocarbons; Photochemical oxidation and Photooxidation of alkenes and polyenes.

Unit-IV: Stereochemistry (9 hours)

Classification of Isomers; optical Isomerism - elements of symmetry and chirality; configuration of optically active molecules; DL- and RS-notations; relative and absolute configurations; Resolution of racemic mixtures; Absolute asymmetric synthesis; Stereospecific and regiospecific synthesis; Cram's rule; Dynamic enantiomerism; Cis-

and trans-isomerism; E-Z configuration; Interconversion of geometrical isomers; Beckmann rearrangement; conformational analysis of ethane, n-butane, and cyclohexane.

Unit-V: Green Chemistry (9 hours)

Green Chemistry - Need and principles of green chemistry; Green reactions: Arndt-Eistert synthesis & mechanisms; Barbier reaction under sonication and applications; Baker-Venkataraman Rearrangement; Phase Transfer catalyzed synthesis of flavones and its applications; Bouveault reaction; Dakin reaction; Darzen reaction in the presence of PTC; Dickmann condensation; Mukaiyama reaction in the aqueous phase; Ullmann reaction and its applications.

References

1. Modern Methods of Organic Synthesis, W. Carruthers, 3rd edition, Cambridge Low Price Edition, 1996.
2. Advanced Organic Chemistry: Reactions, Mechanism and Structures, Jerry March, 7th Edition, McGraw Hill, 2015.
3. Named Organic Reactions, Thomas Laue and Andreas Plagens, 2nd Edition, John Wiley & Sons, Ltd., 2005.
4. Molecular Reactions and Photochemistry, C. H. DePuy and D. Chapman, Prentice Hall, 1972.
5. Organic Chemistry, Morrison Boyd and Bhattacharjee, 7th Edition, Pearson, 2010.
6. Green Chemistry: Environmentally Benign Reactions, V. K. Ahluwalia, Springer, 2022.
7. Heterocyclic Chemistry, J. Joule, K. Mills, and G. Smith, 3rd Edition, CRC Press, 1995.

24CH710F

Course-6: Advanced Physical Chemistry

Pool-1
No. of hours: 45 **No. of credits:** 3

Course Content

Unit-I: Solid State Chemistry (9 hours)

Types of solids, isotropy and anisotropy, symmetry of crystals, Miller indices, coordination number of crystal lattice, X-ray crystallography, Bragg's equation, measurement of diffraction angle, rotating crystal method, powder method, ionic crystals (e.g., NaCl, CsCl), molecular crystals, metallic crystals, crystal defects, liquid crystals and their applications.

Unit-II: Chemical Kinetics (9 hours)

Reaction rates, units of reaction rates, order and molecularity of reactions, zero, first, second, and third order reactions, half-life of a reaction, determination of order of a reaction, collision theory of reaction rates, limitations of collision theory, transition state theory, activation energy, and catalysis.

Unit-III: Catalysis (9 hours)

Types of catalysts, homogeneous catalysis, heterogeneous catalysis, characteristics of catalytic reactions, autocatalysis, catalytic poisoning, promoters, negative catalysis, theories of catalysis: intermediate compound formation theory, adsorption theory, acid-base catalysis, mechanism of acid catalysis, enzyme catalysis and mechanism.

Unit-IV: Surface Phenomena (9 hours)

Mechanism of adsorption, types of adsorption, adsorption of gases by solids, adsorption isotherms, Langmuir adsorption isotherm, derivation of Langmuir adsorption isotherm, Freundlich adsorption isotherm, adsorption of solutes from solutions, applications of adsorption, ion-exchange adsorption, cationic and anionic exchange, and applications of ion-exchange adsorption. Recent advances in adsorption.

Unit-V: Colloidal Chemistry (9 hours)

Lyophilic and lyophobic colloids, characteristics of lyophilic and lyophobic sols, preparation of sols, dispersion methods, aggregation methods, purification of sols, dialysis,

optical properties of sols, Tyndall effect, kinetic properties of sols, Brownian movement, electrical properties of sols, stability of sols, emulsions – micro and macro emulsions, gels, and applications of colloids.

References

1. Essentials of Physical Chemistry, Arun Bahl, B.S. Bahl, and G. D. Tuli, S. Chand and Company, New Delhi, 2009.

2. Physical Chemistry, Peter Atkins and J. D. Paula, 7th Edition, ELBS, Low Price Edition, 2002.

3. Solid State Chemistry and its Applications, R. West, John Wiley and Sons, 1984.

4. Introduction to Surface Chemistry and Catalysis, G. A. Somorjai, 2nd Edition, Wiley-Blackwell, 2010.

24CH720A

Course-1 Advanced Instrumental Methods of Chemical Analysis

Pool-2
No. of hours: 45 **No. of credits:** 3

Course content

Unit-I: Assessment of Analytical Data

(9 hours)
Basic concepts and terminology – accuracy, error, uncertainty, precision, reliability, readability, reproducibility, sensitivity, selectivity, variance, standard deviation, confidence interval, t-test, rejection criteria Q-test, F-test, significant figures, limits of detection, nature and origin of errors, random or indeterminate errors.

Unit-II: Polarization, Impedance and Voltammetric Techniques

(9 hours)
Potentiostatic Polarization Studies: Experimental setup, potential (E) vs log current (I) plots. EIS: electrode-electrolyte interface, EIS basics, electrical elements, impedance data in Bode and Complex plane plots, data analysis – electrical equivalent circuits, impedance parameters. Voltammetric Techniques: Principle involved in cyclic voltammetric technique, cyclic voltammogram for reversible and irreversible processes, Pulse Voltammetric techniques: Normal and Differential pulse voltammetry (NPV and DPV), Stripping voltammetry.

Unit-III: Microscopic Methods of Analysis

(9 hours)
Scanning Electron Microscopy (SEM): working principle, instrumentation and applications. Transmission Electron Microscopy (TEM): working principle, instrumentation and applications. Scanning Probe Microscopy (SPM): Scanning Tunneling Microscopy (STM) - study of the surface topography and electronic structure and Atomic Force Microscopy (AFM) – operation modes, study of surface topography, surface hardness.

Unit-IV: X-Ray Methods of Analysis

(9 hours)
Generation of X-Rays, primary and secondary or fluorescent X-rays. X-Ray Diffrac-

tometry (XRD): X-ray diffraction of solids, indexing the planes of powder X-ray diffractograms, Applications of XRD; X-ray Fluorescence (XRF): Energy dispersive, Wavelength dispersive and non-dispersive techniques, Applications of XRF.

Unit-V: Thermal Methods of Analysis

(9 hours)
Thermogravimetric Analysis (TGA) - study of mass changes of materials like polymers, glasses, ceramics, etc., such as evaporation, decomposition, gas absorption, desorption, dehydration, etc. Differential Thermal Analysis (DTA) - study of exothermic and endothermic behavior of clay materials, ceramics, ores, etc. Differential Scanning Calorimetry (DSC) - Principles, Instrumentation and study of glass transition temperature.

References:

- Douglas A. Skoog, Donald M. West and F. James Holler, *Fundamentals of Analytical Chemistry*, Cengage Learning, 9th Edition, 2013.
- F. W. Fifield and D. Kealey, *Principles and Practice of Analytical Chemistry*, 5th Edition, Blackwell Science Limited, 2000.
- J. Bassett, R.C. Denny, G. Jeffery and J. Mendham, *Vogel's Textbook of Quantitative Chemical Analysis*, Longman group Ltd, 5th Edition, 1989.
- M.E. Orazem, B. Tribollet, *Electrochemical Impedance Spectroscopy*, John Wiley & Sons, New York, 2011.
- Werner Funk, Vera Damman, Gerhild Donnervert, *Quality Assurance in Analytical Chemistry*, VCH Publishers, New York, 2nd Edition, 2006.

24CH720B

Course-2 Modern Aspects of Electrochemistry

Pool-2
No. of hours: 45 **No. of credits:** 3

Course content

Unit-I: Electrified Interfaces

(9 hours)
Structure of metal-solution interface, concept of electrical double layer, Helmholtz-Perrin theory, Gouy-Chapman theory, Stern theory, Graham's theory, concept of specific adsorption, concept of self-assembled monolayers, Langmuir-Blodgett films.

Unit-II: Electrode Kinetics

(9 hours)
Electron transfer at the metal/solution interface, concept of overpotential, derivation of basic equation of electrode kinetics – The Butler-Volmer equation, low field and high field approximations, derivation of Tafel equation.

Unit-III: Potentiostatic Polarization Studies

(9 hours)
Experimental setup, potential (E) vs. log current (I) plots for potentiostatic polarization studies, determination of corrosion potential (Ecorr) and Tafel slopes, determination of corrosion rates from polarization data, interpretation of the data to ascertain the nature of inhibitors.

Unit-IV: Impedance Spectroscopy

(9 hours)
Principle involved in AC impedance technique, applications of this technique for corrosion studies, Nyquist plots and Bode plots, data analysis – electrical equivalent circuits, calculation of impedance parameters namely charge transfer resistance, double layer capacitance, constant phase element, mechanism of corrosion and corrosion inhibition with the help of Nyquist plots and Bode plots.

Unit-V: Cyclic Voltammetry

(9 hours)
Principle involved in cyclic voltammetric technique, cyclic voltammogram for reversible and irreversible processes, applications of this technique in corrosion studies especially for mild steel and copper, Pulse Voltammetric techniques: Normal and Differential pulse voltammetry (NPV and DPV), Stripping voltammetry.

References:

- J.O.M. Bockris and A.K.N. Reddy, *Modern Aspects of Electrochemistry*, Volume 2, Plenum Press, New York, 1985.
- Joint publication of the Electrochemical Society of India, *Corrosion Handbook*, Associate Publishers Pvt. Ltd, Hyderabad, 1998.
- V. S. Sastri, *Corrosion Inhibitors: Principles and Applications*, John Wiley & Sons, 1998.
- Hans-Jurgen Butt, Karlheinz Graf, Michael Kappl, *Physics and Chemistry of Surfaces*, Wiley-VCH, 2003.

24CH720C

Course-3 Spectroscopic Techniques for Chemical Analysis

Pool-2
No. of hours: 45 **No. of credits:** 3

Course content

Unit-I: UV-Visible and Infrared Spectroscopy

(9 hours)
Principle, types of electronic transitions, effect of solvents, different types of shifts, instrumentation, Lambert-Beer's law – derivation and numericals, applications of UV-Visible spectroscopy, principle of IR spectroscopy, types of vibrations, selection rule, vibrational modes of atoms, instrumentation, sampling techniques, FTIR spectroscopy, ATR spectroscopy, applications of IR spectroscopy.

Unit-II: NMR Spectroscopy

(9 hours)
Principle, modes of nuclear spin, relaxation process, chemical shifts, shielding and deshielding effects, factors affecting chemical shift, anisotropic effects, splitting of signals, spin-spin coupling, proton-exchange reactions, coupling constants, complex spin-spin interactions, double resonance, instrumentation, interpretation of NMR spectra.

Unit-III: Mass Spectrometry

(9 hours)
Principle, chemical ionization, molecular ion, general rules for predicting prominent peaks in a spectrum, types of ions produced in a mass spectrometer, fragmentation pattern, fragmentation modes, Retro-Diel's-Alder reaction, hydrogen transfer rearrangement, general rules for fragmentation patterns, nitrogen rule, ring rules, instrumentation, mass spectrometers, applications of mass spectrometry.

Unit-IV: Atomic Absorption Spectroscopy

(9 hours)
Introduction, working principle, classification of AAS methods, measurement and instrumentation of AAS, sensitivity and detection limits, advantages, disadvantages and applications of AAS, analysis of alkali and alkaline earth metals in dilute solutions at trace levels by AAS.

Unit-V: Atomic Emission Spectroscopy

(9 hours)
Introduction, working principle, measurement of light intensity, instrumentation, advantages, disadvantages and applications of AES, analysis of alkali and alkaline earth metals in dilute solutions at trace levels by AES, Fluorometry: principle of atomic fluorescence, instrumentation and applications of Fluorometry.

References:

- Douglas A. Skoog, Donald M. West and F. James Holler, *Fundamentals of Analytical Chemistry*, Cengage Learning, 9th Edition, 2013.
- H. Kaur, *Spectroscopy*, Pragathi Prakashan, 1st Edition, 2001.
- J. Bassett, R.C. Denny, G. Jeffery and J. Mendham, *Vogel's Textbook of Quantitative Chemical Analysis*, Longman group Ltd, 5th Edition, 1989.
- R. M. Silverstein, F. X. Webster, D. J. Kiemle and D. L. Bryce, *Spectrometric Identification of Organic Compounds*, 8th Edition, John Wiley Sons Inc., 2014.

24CH720D

Course-4 Polymer Science and Technology

Pool-2 No. of hours: 45 **No. of credits: 3**

Course content

Unit-I: Basic Concepts of Polymer Chemistry

(9 hours)
Definition, nomenclature of polymers, functionality of monomers, degree of polymerization, percentage conversion, chain transfer agents, Mayo's relation, inhibitors, modifiers, and retarders, types of polymerization: addition, condensation and copolymerization, mechanism of free radical, cationic and anionic polymerization, Copolymerization: free radical and ionic.

Unit-II: Polymerization Reactions and Techniques

(9 hours)
Principles of polymer reactivity: Photolytic, photosensitized polymerization, electroinitiated, cross-linking, graft and block copolymerization, polymer reagents, polymer catalysis, Stereochemistry of polymerization: Types of stereoisomerism in polymers, stereospecific polymerization, Ziegler-Natta polymerization, various methods of polymerization: solution, bulk, emulsion and suspension, recycling of polymers.

Unit-III: Crystal Structure and Properties of Polymers

(9 hours)
Polymer crystallization, factors affecting crystallisability, effect of crystallisability on the properties of polymers, glass transition temperature (Tg) and its determination, dependence of Tg on polymer structure, melting temperature, physical and mechanical properties of crystalline and amorphous polymers.

Unit-IV: Characterization of Polymers

(9 hours)
Number average, weight average and viscosity average molecular weights of polymers, molecular weight determination by light scattering, osmotic, centrifuge and viscosity methods, gel permeation chromatography, analysis and testing of polymer by FT-IR, NMR, XRD, TGA/DTA/DSC.

Unit-V: Specialty Polymers

(9 hours)
Applications of polymers in catalysis and drug delivery systems, thermo-sensitive and photo-sensitive polymers, thermally stable polymers, biodegradable polymers, conducting polymers, fire retardant polymers, polymer electrolytes, liquid crystalline polymers, dendrimers, adhesives, foams and fibres.

References:

- *Textbook of Polymer Science*, Wiley Interscience, 1984.
- *The Elements of Polymer Science and Engineering: An Introductory Text for Engineers and Chemists*, Academic Press, New York, 1982.
- *A Textbook of Polymers*, Volume I, S. Chand Company Ltd, 2004.
- *A Textbook of Polymer Chemistry*, Singapore: John Wiley Sons, 1994.
- *Introduction to Polymer Chemistry*, Taylor Francis, Inc., 2006.

24CH720E

Course-5 Environmental Pollution and its Control

Pool-2 No. of hours: 45 **No. of credits: 3**

Course content

Unit-I: Air Pollution and its Control (9 hours)

Atmosphere-composition and its pollution; air pollutants: C, S, N oxides and hydrocarbons; acid rain, greenhouse effect and photochemical smog; ozone effect on environment and health; CFCs; effect of gasoline, lead; reducing toxic emissions from the fuel combustion in vehicles, NO emissions and its control; Catalytic control device for automobiles.

Unit-II: Water Pollution and its Control (9 hours)

Water and its role in environment-Hydrological cycle, water pollutants, DO measurements; Waste chemicals; Oil spills, waste water treatment-Primary, secondary (aerobic and anaerobic) and tertiary treatments, effect of water pollution; physicochemical, biological, toxic and pathogenic effects.

Unit-III: Soil Pollution and its Control (9 hours)

Types of soils, classification of soil pollutants; source and classification of solid waste and its disposal on land and sea; pollutants from industries like plastics, paper, pulp, drugs and pharmaceuticals, effect and control of asbestos pollution, techniques of recycling of solid waste, types of mining operations, impact of mining on environment.

Unit-IV: Pesticide Pollution and its Control (9 hours)

Classification of pesticides; persistence of pesticides; pesticide kinetics in environment and water; modes of action and toxicity; pesticidal accumulation and its toxicity to aquatic organisms; environmental implications; alternate methods of pest control; pesticide pollution and its control.

Unit-V: Heavy Metal and Radioactive Pollution (9 hours)

Heavy metals and their sources; accumulation of metals in environment; toxicity of metals to organisms; toxic effects of Pb, Hg, Cd, Cr, As and Cu on environment

and human beings; control of heavy metal pollution; Sources of radioactivity in environment, explosions, nuclear power plants, other waste from nuclear power plants, biological effects of radiation; control of radioactive pollution.

References:

1. Water pollution: Causes, Defects and Control, P.K. Goel, New Age International Publishers Pvt. Ltd., New Delhi, 2001.

2. Environmental Chemistry, V.P. Kudesia, Pragathi Prakashan, Meerut, 2003.

3. A Text Book in Environmental Science, V. Subramanian, Narosa Publishing House Pvt. Ltd., New Delhi, 2002.

4. Environmental Chemistry, A.K. De, New Age International Publishers, New Delhi, 2003.

24CH720F

Course-6 Nanotechnology

Pool-2 No. of hours: 45 **No. of credits: 3**

Course content

Unit-I: Classification of Nanomaterials (9 hours)

Classifications and types of nanomaterials as nanoparticles: Organic semiconductors, carbon materials, quantum dots, quantum wells, quantum rods, quantum wires, quantum rings; bulk nanostructured, nanocomposites, nanomachines and devices, nanosized metals and alloys, semiconductors, ceramics–a comparison with respective bulk materials.

Unit-II: Novel Properties of Nanomaterials (9 hours)

Properties and size dependence of properties: Size and shape dependent optical, emission, electronic, transport, photonic, refractive index, dielectric, mechanical, magnetic, non-linear optical properties; transition metal sols, origin of plasmon band, Mie theory, influence of various factors on the plasmon absorption, catalytic properties.

Unit-III: Nano Synthesis Techniques (9 hours)

Nano synthesis techniques based on liquid and vapour phase as the starting material, study of wet chemical method like sol-gel method, hydrothermal, micro emulsion technique, chemical reduction, decomposition of organometallic precursors and chemical vapour deposition, metallo-organic chemical vapour deposition. Electro and electroless deposition. Mechanical milling, laser ablation, microwave and ultrasound-assisted synthesis, sputtering and microwave plasma, photolysis.

Unit-IV: Characterization of Nanomaterials (9 hours)

Techniques of characterization of size of nano powders/particles using BET method and laser diffraction. Various spectroscopic techniques like optical spectroscopy, UV-visible and IR spectroscopy, Raman spectroscopy, X-ray photoelectron spectroscopy. Basic understanding of each technique with special emphasis on characterization at nano scale. XRF, XRD and small angle X-ray scattering principles.

Unit-V: Applications of Nanomaterials (9 hours)

Applications of Nano-electronics, Nano optics, Nanoscale chemical and biosensing, biological/biomedical applications, photovoltaic, fuel cells, batteries and energy-related applications, high strength nanocomposites, nanoenergetic materials.

References:

1. The Physics and Chemistry of NanoSolids, Frank J.Owens, Charles P. Poole Jr, Wiley-Interscience, 2008.

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