SS818 ANALYTICAL TECHNIQUES 3-0-0-3

Error Analysis- Determinate and Indeterminate errors, Significant figures, Accuracy, Precision, Standard Deviation, Correlation Coefficient, Regression Curve, Confidence limits, Robustness, Ruggedness and Rejection of a result –T test and F test, Separation Techniques- Principles of chromatography, Column efficiency, High performance Liquid Chromatography (HPLC), Thin Layer Chromatography (TLC), Paper Chromatography, Size Exclusion Chromatography, lon exchange Chromatography, Gas Chromatography (GC), Gas Chromatography with Mass spectrometry (GC-MS), Liquid Chromatography with Mass Spectrometry (LC-MS), Ultra Performance Liquid Chromatography (UPLC), Thermal, Activation and Diffraction TechniquesThermo Gravimetric Analysis (TGA), Differential Thermal Analysis (DTA), Differential Scanning Calorimetry (DSC), X-ray techniques – powder, diffraction and fluorescence. Spectrophotometric and electro analytical techniques-UV/ Visible Spectroscopy, IR Spectroscopy, NMR Spectroscopy and Mass Spectroscopy-theory, instrumentation and applications: Spectrophotometric identification of organic compounds. ESCA / Auger Technique, SEM, AFM,TEM, STM and confocal AFM,TEM,STM and confocal, CV, Tafel polarization and Impedance analysis (EIS).

TEXT BOOKS/ REFERENCES:

1. Willard, Dean, Merit, Settle, *"Instrumental Methods of Analysis",* Seventh Edition, CBS Publishers and Distributors, 1996.
2. Skoog DA, FJ Holler and TA Nieman, *"Principles of Instrumental Analysis",* Fifth Edition, Harcourt Brace & Company, Saunders College Publishers, 2001.
3. C.N. Banwell; Elaine M. McCash, *"Fundamentals of Molecular Spectroscopy",* McGraw-Hill Publishing Company, 1995.
4. Robert M Silverstein, Francis X Webster, *"Spectrophotometric Identification of Organic Compounds",* Sixth Edition, *John* Wiley and Sons Inc., 2005.
5. Ernst Meyer, Hans, Josef Hug, Rolanamd Bennenitz, *"Scanning Probe Microscopy- The Lab on a Tip",* Springer Publications, 2004.

SS 819 INTRODUCTION TO PHOTOCHEMISTRY 4-0-0-4

Unit-1 Light induced processes in everyday life

The Nature of Light, Photosynthesis, Vision, Photoresponse Mechanisms in Plants and Animals, Photomedicine, Photochemical effects of Visible and UV light, Bioluminescence, Photodegradation, Imaging processes

Unit 2 - Photochemistry - Principles and Reactions

Rates of absorption, Beer Lambert's Law, Stark-Einstein Law, Fluorescence lifetimes, quantum yield; Fluorescence, Phosphorescence, Jablonski diagram, cis-trans isomerisation, Paterno-Buchi reaction, Norrish Type I and II reactions, photo reduction of ketones, di-pimethane

rearrangement, photochemistry of arenes, Hoffmann-Loffler-Freytag reaction, Barton reaction, Photochemistry of cyclohexadienones.

Unit 3- Excited state processes

Adiabatic and Non-adiabatic processes, Monophotonic and multiohotonic proceses, Primary and secondary photochemical processes,kinetics of photochemical reactions, photo-ionization , light induced electron capture and electron transfer reactions, Intramolecular and intermolecular electron transfer, Marcus-Hush Model of Electron transfer, Electronically excited molecules-Excimers and Exciplexes, Charge transfer in excited states, twisted intramolecular charge transfer state, quenching of excited states, Stern Volmer equation, electron transfer, energy transfer,paramagnetic quenching, concentration quenching, static and dynamic quenching

Unit 4-Mechanisms of Photochemical reactions

Organic Photochemistry -Quenching, Sensitization, Unimolecular and bimolecular reactions, Photoelectrochemistry-reactions at electronically excited semiconductor electrodes, Inorganic photochemistry, photochemistry and photophysics of metal complexes, Photochemistry in solids and organized assemblies, Photochemical reactions in glasses, excitons in polymers and crystals, photochemistry in micelles, photochemical reactions of free radicals

Unit 5- Light in Industry

Photographic processes-Spectral sensitization, Colour photography, Instant photography, Electrophotography, Photopolymerisation and photochemical degradation of polymers, Phototchemistry in synthesis –photochlorination of polymers, Synthesis of caprolactam, Vitamin D, Photochemistry of Dyes and Pigments, Phtochromism, Energy conversion and storage – photoelectrochemical cells,Ozone layer-its photochemical formation and degradation.

TEXT BOOKS / REFERENCES:

1. Modern molecular photochemistry- N. J. Turro (University Sci. 1991)
2. Chemistry and Light- P. Suppan (RSC 1999)
3. Organic and Inorganic Photochemistry; Volume 2 of Molecular and supramolecular photochemistry - V. Ramamurthy, Kirk S. Schanze (M. Dekker, 1998)
4. Organic Photochemistry- James Morriss Coxon, Brian Halton, (Cambridge University Press, 1987)
5. Principles of Organic Synthesis- R.O.C. Norman & Coxon (CRC Press; 1993)
6. Fundamentals of Photoinduced Electron Transfer- G. J. Kavarnos (Wiley-VCH, 1993)
7. Essentials of Molecular Photochemistry - A Gilbert and J Baggott (Blackwell,1991)
8. Principles and applications of photochemistry- R. P. Wayne (OUP 1988)
9. Photochemistry - C. E. Wayne and R. P. Wayne (OUP Primer

SS 820 FRONTIERS OF PHOTOCHEMISTRY 4-0-0-4

Unit 1 Spectrophotometry, Measurements in Solution

The Absorption Spectrum,The General Absorption Characteristics of Molecules ,Qualitative Analysis, Quantitative Treatment of the Absorption Intensity ,Quantitative Analysis ,The Method of the Standard Additions, Analysis of Mixtures of Absorbing Species,Spectrophotometric Titrations ,Instrumentation,The Light Source,The Monochromator ,The Sample Holder ,The Detector ,The Spectrophotometers ,The Sample Measurement. ,The Instrumental Precision ,Experimental Examples

Unit 2 Photochemical Techniques

Photochemical Apparatus, Light Sources , Selection of the Exciting Radiation , Reaction Cells,Optical Material , Control of Temperature and Stirring, Photoreaction Quantum Yield ,Chemical Actinometers, Potassium Ferrioxalate ,Potassium Reineckate, Azobenzene , Aberchrome 540 ,A Photochromic Diarylethene Compound ,Irradiation Experiments.

Unit 3 Spectrofluorimetry, Spectroelectrochemistry & CD spectroscopy

Spectrofluorimetry ,Reference Standards for the Determination of Fluorescence Quantum Yields ,Reference Standards for the Determination of Phosphorescence Quantum Yields, Luminescence Measurements on Solid Samples , Sample Inhomogeneity ,Concentration Effects , SpectroelectrochemistryAbsorption and Emission Spectroscopy with Polarized Light , Linear and Circular Dichroism Spectroscopy , Polarized Light, Birefringence and Circular Dichroism, Linear Dichroism, Observables in Circular Dichroism Spectroscopy

Unit 4 Transient Absorption Spectroscopy

Transient Absorption with Nanosecond Resolution, Measure of Absorbance Change,The Sample Compartment , The Optical System ,The Electronic Detection System, Transient Absorption Spectroscopy in Supramolecular Systems ,Fullerene Derivatives ,Ligand–Protein Complexes , Sub-Nanosecond Transient Absorption ,Shortening the Laser Pulse, Ti: Sapphire Laser ,Chirped Pulse Amplification , Regenerative Amplification, Ultrafast Transient Absorption Spectroscopy, Femtochemistry ,Pump and Probe Experiments ,Photoinduced Electron Transfer in a Multichromophoric System, Femtosecond Systems, Experimental Suggestions

Unit 5- Supramolecular Photochemistry

Definition of a Supramolecular System , Photoinduced Energy and Electron Transfer in Supramolecular Systems , Excimers and Exciplexes ,Electron Transfer Processes,Marcus Theory, Quantum Mechanical Theory ,Optical Electron Transfer , Energy Transfer Processes,Coulombic Mechanism, Exchange Mechanism,The Role of the Bridge in Supramolecular Systems

TEXT BOOKS/ REFERENCES:

1. The Exploration of Supramolecular Systems and Nanostructures by Photochemical Techniques -Paola Ceroni Springer, 2012.

2. Electrochemistry of Functional Supramolecular Systems (The Wiley Series on Electrocatalysis and Electrochemistry) -Paola Ceroni, Alberto Credi, Margherita Venturi Wiley-Interscience, 2010.
3. Supramolecular Photochemistry- Vincenzo Balzani, Springer, 1987.
4. Designing Dendrimers - Sebastiano Campagna, Paola Ceroni, Fausto Puntoriero,Wiley, 2011.
5. Electron Transfer in Chemistry: Molecules-level electronics, imaging and information, energy and the environment; Volume 5 of Electron Transfer in Chemistry- Vincenzo Balzani, Wiley- VCH, 2001

SS 821 PHOTOVOLTAICS 3-0-0-3

Photovoltaic Effect, History of Solar cells, Solar Radiation, Radiation Absorption and Reflection, Photo action spectrum – impedance spectroscopy – shunt resistance.

Semiconductor Properties: Semiconductor Energy band diagram, extrinsic semiconductors – doping and carrier concentration, diffusion and drift of carriers, transport equations, minority carrier diffusion length, continuity equation. Generation and Recombination in Semiconductors: Dark I-V equation of p-n junction, junction under illumination, generation and recombination, optical processes, photogeneration rates, radiative recombination, Shockley Reed Hall recombinations, Auger recombinations. Solar Cells: Solar cell parameters, production of silicon solar cells – fabrication and design, optimization of process parameters, measurements of solar cell parameters-short circuit current, open circuit voltage, fill factor, efficiency. Optical losses, electrical losses, surface recombination velocity, quantum efficiency-external and internal, Thermodynamic and balance of limit efficiency, solar cell thermodynamics, I-V characteristics. Monocrystalline Solar Cells: Silicon solar cell design, strategies to - enhance absorption, reduce series resistance, surface recombination, Alternatives to Silicon, III-V materials for PV, GaAs cells. Thin film Solar cells: Amorphous Si for PV, Materials properties, fabrication, stability, polycrystalline thin film PV materials, CdTe and CIGS solar cells. Third Generation Solar Cells: Tandem cells, Hybrid solar cells, *Organic Solar cells* – energy levels in molecular materials, exciton formation, diffusion, dye sensitized solar cells, bulk hetero-junction and hybrid solar cells.

TEXT BOOKS / REFERENCES:

1. Ben G Streetman , *"Solid State Electronic Devices"*, Prentice-Hall of India Pvt. Ltd., 1995.
2. Nelson J, *"The Physics of Solar Cells"*, Imperial College Press, 2006.
3. Wenham SR, *"Applied Photovoltaics",* Second Edition, Earthscan Publications Ltd., 2007.
4. Green MA*, "Third Generation Photovoltaics: Advanced Solar Energy Conversion"*, Springer-Verlag, 2007.

SS822 HETEROCYCLIC CHEMISTRY 3-1-0-4

Five-membered hyeterocycles with one heteroatom – pyrroles, furans and thiophenes – nomenclature, synthesis and applications. Five-membered hyeterocycles with two heteroatoms – imidazoles, pyrazoles, thiazoles, isothiazoles, oxazoles and isoxazoles – nomenclature,synthesis and applications.

Six-membered hyeterocycles with one heteroatom – pyridines – nomenclature, synthesis and applications. Six-membered hyeterocycles with two heteroatoms – pyridazines, pyrimidines and pyrazines – nomenclature, synthesis and applications.

Seven-membered hyeterocycles with one heteroatom – Azepines, oxepines and thiepins. Fused heterocycles – indoles, quinolines, isoquinolines, coumarines, benzofurans and purines.

TEXT BOOKS / REFERENCES:

1. Raj K. Bansal, " *Heterocyclic Chemistry*", New age International Pvt. Ltd., New Delhi, fourth edition, 2005.
2. Jerry March, " *Advanced Organic Chemistry: Reactions, Mechanisms and Structure*", John Wiley and Sons Inc, fourth edition, 2007.
3. R.O.C. Norman and J. M. Coxon, "*Principles of organic synthesis*", Nelson Thrones, third edition, 2005

SS823 POLYMER CHEMISTRY 3-1-0-4

FUNDAMENTALS**:**Basics of polymers – polymer c,assifications based on occurrence, types, process, structure and end uses. Polymer microstructure – chemical and geometrical structure – ladder, star and telechelic polymers – interpenetrating networks – tacticity – crystalline and amorphous nature – crystallization and crystallizability – effect on properties – thermal transitions – TGA and DSC.

REACTION MECHANISMS: Reactive intermediates – carbocations, carbanions and free radicals. Nucleophilic aliphatic substitution -sN1, sN2. Electrophilic aliphatic and aromatic substitutions – orientation and reactivity in mono-substituted benzene rings, applications like nitration, sulphonation and halogenation.

POLYMERIZATION METHODS**:**Kinetics and mechanism of free radical, cationic, anionic and coordination polymerization – Ziegler Natta catalysts – monometallic mechanism – stereo regular polymerization – chain transfer reaction and constant – living polymers – alfin catalysts.

STEP GROWTH POLYMERIZATION AND COPOLYMERIZATION**:** Polycondensation polymerization – copolymerization – kinetics – copolymer equation – composition of

copolymers by NMR – monomer reactivity ratios and their significance – polymerization reactions – metathetical, electrochemical, GTP and ring opening.

MOLECULAR WEIGHT, SOLUBILITY AND FRACTIONATION OF POLYMERS**:**Number, weight and viscosity average molecular weights – polydispersity – molecular weight distribution – determination of molecular weight by GPC and viscometry – polymer dissolution – thermodynamics of polymer dissolution – solubility parameter – fractionation of polymers – reactions of polymer molecules with specific groups like OH, CHO, CO, COOH, NH_2 – polymer crosslinking, cyclisation – polymer degradation – thermal, mechanical, photo and radiation.

TEXT BOOKS / REFERENCES:

1. F. W. Billmayer, Text Book of Polymer Science, 3rd edition, John Wiley and sons, New York, 2002.
2. M. S. Bhatnagar, A Textbook of Polymers (Chemistry and Technology of Polymers), Vol. I, II and III, 1st edition, S. Chand and Company, New Delhi, 2007.
3. R. J. Young, Introduction to Polymers, Chapman and Hall Limited, London, 1999.
4. George Odeon, Principles of Polymerization, 4th edition, McGraw Hill Book Company, New York, 2004.

SS824 CORROSION AND ITS CONTROL 3 1 0 4

Introduction- Thermodynamics of corrosion- mechanism of electrochemical corrosion- different forms of electrochemical corrosion. Kinetic aspects of corrosion. Corrosion behavior of metals - ferrous and non ferrous metals and alloys. Rate of corrosion – determination of corrosion by electrochemical methods-- Linear polarisation (LPR)- Tafel- A C impedance spectroscopy–units of corrosion**.**

Metallic coating – hot dipping - galvanizing- tinning - cladding- electroplating and electroless plating-PVD- CVD- spraying- arc spray-plasma - flame spray.Non- metallic coating- Inorganic coatings – anodizing, phosphating and chromating- chemical conversion coating. Corrosion inhibitors - passivators and vapor phase inhibitors. Corrosion protection by surface modification.

Review:

Polymer coatings- types (high viscosity polymer, nano polymer, bio-polymer, CVD polymerized coating)- methods of applying polymer coating (single and multi layer coating)- Spray coating and Powder Spray coatings, Electro-coating (E-coat)- anodic and cathodic, Fluidized Bed coating, Dip coating, Spin coating, sol- gel coating- binders- Thermosets (Alkyds, Epoxies, Urethanes, Formaldehyde resins, Alkyds -Thermoplastics (latexes)- Acrylics, Vinyls, styrene polymer coating -significance.

TEXT BOOKS/ REFERENCES:

1. Raj Narayana, “An Introduction to Metallic Corrosion and its Prevention”, Eleventh Edition, Wiley Publication, 1981.
2. Fontana and Mars,G, “Corrosion Engineering”, Third Edition, Mc Graw Hill Publications, 1987.
3. Edward Mc Cafferty, “Introduction to Corrosion Science”**,** Springer, 2010.
4. H.H.Uhlig and R.W. Reviees, “Corrosion and its Control”, Wiley Publication, 1985.
5. ASM Metals Handbook, “Corrosion”, ASM Metals Park, Ohio, USA, 1994.
6. D Gabe, “Principles of Metal Surface Treatment and Protection”, Merlin Books, 1993.

SS825 PRINCIPLES OF SPACE RADIATION INTERACTIONS 3 0 0 3

Space Radiation Environmental Effects: The Natural Space Environment, Plasma, Geomagnetic Field, Solar Environment, and Ionizing Radiation. **Sources of radiation in Earth space:** Plasma, Trapped Particles, Solar Particles, Galactic (Cosmic) Rays. Potentials of surfaces in space

Space "Radiation" Effects: Spacecraft Charging (S/C), Total Ionizing Dose (TID), Displacement Damage, Single Event Effects (SEEs)

Effect of radiation on Materials: Metals, Alloys, and Metal-to-Metal Bonds, Polymers: Thermosetting Plastics, Thermoplastics, Adhesives, Elastomers. Ceramics, Graphite, and Glasses, Thermal-Control Coatings. Mechanical properties, Thermophysical properties.

Solar Radiation and its effects on Atmosphere: Solar radiation at the top of atmosphere, attenuation of solar radiation in the atmosphere, radiative transfer, thermal effects of radiation, photochemical effects of radiation.

TEXT BOOKS / REFERENCES:

1. Handbook of Radiation Effects Hardcover, Andrew Holmes-Siedle, Len Adams, Oxford University Press, 2nd Ed. 2002.
2. Spacecraft Environments Interactions: Space Radiation and its Effects on Electronic Systems, J. W. Howard, Jr., D. M. Hardage, NASA Technical documents, 1999.
3. Space Radiation Effects on Graphite-Epoxy Composite Materials, Scott Milan Milkovich, Carl T. Herakovich, George F. Sykes., NASA Technical document, 1984.

SS826 BIOMATERIALS AND ITS APPLICATIONS 3 1 0 4

Introduction to Materials: Metals Properties - Thermal Treatments on metals -Strengthening by alloying, work hardening, oligo elements, Strengthening by thermal treatments, and order disorder transformation.Ceramics - Properties - Bio active ceramics - Ceramic and polymeric carbons - Biological glasses – Coatings - A Survey on the Adhesion of Ceramic to Bone Tissue.Composites – Classifications – Properties –Testing On Composite Materials - Ultrasonic

techniques, Sensing of deformation and damage (health monitoring) - Environmental Effects - Applications of Composites.

Biomaterials and its properties: Definition - classification of bio-materials, Metallic implant materials, Co- Ti-based alloys, ceramic implant materials, aluminum oxides, hydroxyapatite-glass ceramics - medical applications. Implementation problems - inflammation, rejection, corrosion, structural failure. Surface modifications for improved compatibility. biological effects of implants.Mechanical properties, visco elasticity, wound-healing process, Application of biomaterial for the human body., body response to implants, blood compatibility.

Characterization techniques: X-ray diffraction and molecular structure – EDAX- Nuclear Magnetic Resonance – Scanning tunneling microscope – Atomic force microscopy –SEM – TEM – optical tweezers – spectroscopy methods differential thermal analysis, Laser Raman spectroscopy, FTIR, differential thermo gravimetric analysis – NDT methods.

Applications: Materials for bone and joint replacement –dental metals and alloys – dental restorative materials – dental amalgams.– cardiovascular materials – cardiac prosthesis; vascular graft materials – cardiac pacemakers – cardiac assist devices – materials for ophthalmology contact lens – intraoccular materials – materials for drug delivery. Nano Biomaterials -matrix and filler materials

TEXT BOOKS / REFERENCES:

1. D. F. Williams (editor), Material Science and Technology - A comprehensive treatment, Vol. 14, Medical and Dental Materials, VCH Publishers Inc., New York, 1992.
2. Jonathan Black, Biological Performance of materials, Fundamentals of Biocompatibility, Marcel Dekker Inc., New York, 1992.
3. H. H. Willard, L. L. Merritt, J. A. Dean and F. A. Settle, Instrumental Methods of Analysis, CBS Publishers, New Delhi, 1986.
4. Vasantha Pattabhi and N.Gautham, Biophysics, Alpha science International Ltd. UK, 2002.
1. Rodney M J Cotterill, Biophysics an introduction, John Wiley & sons Ltd., NY, 2002

SS827 WASTEWATER TREATMENT TECHNOLOGIES AND BIOREMEDIATION

3 0 1 4

Sewage and Wastewater Treatment System - sewage characteristics, primary, secondary and tertiary treatments, efficiency measurements, and environmental pollution control. Biofilms-wastewater treatment, development and Kinetics, aerobic biofilms.

Industrial Wastewater Treatment - primary, secondary, advanced, physical, chemical and biological unit processes, aerobic, anaerobic attached and suspended growth processes, sources of heavy metal pollution. Advanced wastewater treatment - carbon adsorption, ion exchange, membrane processes and pollution control in selected process industries – tannery, textile, paper, sugar and distillery units.

Bioremediation - in *situ* and *ex situ* bioremediation, constrains, priorities and evaluating bioremediation, bioremediation of VOCs, biodegradation, factors affecting process of biodegradation - methods in determining ,contaminant availability for biodegradation, microbial interactions with inorganic pollutants, microbial metal resistance, microbial transformation, accumulation and concentration of metals, and heavy metal pollution.

TEXT BOOKS / REFERENCES:

1. Raina M. Maier, Ian L.Pepper and Charles P. Gerba, "Environmental Microbiology", Academic Press, 2000.
2. Martin Alexander, "Biodegradation and Bioremediation", Second Edition, Academic Press, 1999.
3. Gabriel Bitton, "Wastewater Microbiology", Second Edition, Wiley- Liss, 1999.
4. S. P. Mahajan, "Pollution Control in Process Industries", Tata McGraw Hill, 2001.

SS828 PHYSICS OF SOLAR CELLS 4-0-0-4 Module I(10hrs)

Introduction to Semi conductors: Basic Concepts, Electronic States in Semiconductors-Band structure, Density of States, electron and hole currents, Electron distribution function, Fermi Dirac Statistics, Boltzmann approximation, Types of semiconductors-intrinsic , extrinsic, Semiconductor under bias, Drift and Diffusion currents

Module II (12hrs)

Generation and recombination of charge carriers: Semiconductor transport equations. Types of Generation and Recombination, Formulation of transport problem, Origin of photovoltaic actions, metal semiconductor junction, Semiconductor –semiconductor junctions, Electro chemical junction, Junctions in organic materials.

Module III (12hrs)

Analysis of the P-N-Junctions: Formation of p-n Junctions, Depletion approximation, Calculation of carrier and current densities, General solution for current density, p-n junction under dark and under illumination, effect on junction characteristics, Other device structures.

Module IV (10 hrs)

Photovoltaic cell and power generation, Characteristic of the Photovoltaic Cell. The Solar Resource and types of solar energy converters, Work available from a photo voltaic device, requirements of an ideal photoconverter

Module V (12)

Principles of a solar cell design, material and design issues, Silicon material properties, and its solar cell design, III-V semiconductor material properties, Semiconductor solar cell

design(GaAs), Thin film solar cells, requirements for suitable materials, Hetero junctions in thin film solar cell design, Managing light in solar cells(qualitative): Light confinement, photon recycling

TEXT BOOKS / REFERENCES:

1. Physics of Solar cells-Jenny Nelson, Imperial College Press(2006)
2. Solid State Physics-Structure and properties of materials-M.A.Wahab(Narosa)
3. Solid State Physics-N.W.Aschroft and N.D.Mermain.
4. Optical properties of thin films—O.S Heavens (Dover)