

Bioelectronics and Biosensors

Syllabus for Pre-Ph.D. Entrance Examination –August 2019 on wards

Unit I: Nanomaterials and Applications

Introduction to Nanotechnology; Scaling Atoms, Molecules, Clusters and Supramolecules - Intermolecular Forces; Molecular and Crystalline Structures - Hierarchical Structures; Bulk to Surface transition, surface reconstruction; Properties and Size dependent chemical, optical, vibrational, thermal, electrical, magnetic and mechanical properties.

Nanomaterial Synthesis-Chemical routes -Electrochemical methods -Vapour growth-Thin film methods: Chemical vapour deposition, Physical vapour deposition (sputtering, laser ablation), Mechanical methods- Ball milling, mechanical attrition; Sol-gel methods; Special nanomaterials: fullerenes, carbon nanotubes, nanowires, porous silicon; Bio-inspired synthesis; Nanocomposite fabrication -Lithography and Nanolithography.

Applications- Nanotechnology Enabled Sensors, Environmental Applications, Photochemistry and Electrochemistry of Nanoassemblies, Electrochemistry with Nanoparticles.

Unit II: Chemical kinetics

Rates of chemical reactions, catalysts, theory of reaction rates: Arrhenius equation-collision and transition state theory, consecutive and parallel reaction-steady state approximation.

Chemical equilibria and thermodynamics: First, second and third law of thermodynamics; entropy, free energy, partial molar quantities. Motion in solution and chemical reaction: Diffusion, Brownian motion, electrophoresis, enzyme kinetics; Solid electrolyte junctions: electrode-electrolyte interfaces, Poisson –Boltzmann equation, Membrane transport, Nernst-Planck equation and solution.

Unit III: Cell biology

Prokaryotic and Eukaryotic cell; organelles; Compartmentalization; Cell organelles, cytoplasmic matrix ; Cytoskeleton-motility- Molecular organization of nucleus and nuclear transport; Hormones and receptors; Cell membrane -Membrane lipids, Membrane proteins- Biomembranes-overview-types of membranes -diffusion, osmosis-transport- cell junctions. Biological Molecules- carbohydrates, Proteins, amino acids, Nucleic acids-Biosynthesis, Phospholipids Organization- Metabolic energy-Enzyme catalysis – electrochemical potentials – resting potential – action potentials – ion channels –Types of membranes - potentiometric and amperometric membrane electrodes - biosensors constructions- Neurons and Neuronal networks – Resting potential and Action Potential –Synapses, Networks, Neurobioengineering, Silicon Neurons, Biological Applications of Nanoparticles.

Unit IV: Biomaterials and Characterization

Types of biomaterials - Metals–Ceramics- Polymeric -Composite biomaterials— Natural biomaterials- Bioresorbable and Bioerodible materials– Biodegradable polymeric materials– Biodegradable hydrogels -Tailoring properties and function through chemistry and structure modification-Material bonding-ionic and covalent-Tissue derived biomaterials-Soft tissue and Hard tissue replacements-Controlling and assessing cell biomaterial interactions at micro

and nano scale level in tissue engineering- Cardiovascular applications–Nonthrombogenic treatment-Dental implants–Ophthalmologic applications- Orthopedic applications–Drug delivery systems.

Crystallization, X-ray diffraction, Neutron diffraction, NMR spectroscopy, electron microscopy, STM, AFM; Optical activity- UV, IR, Laser Raman spectroscopy, Luminescence ; Calorimetry-TG-DTA and DSC; Spectrophotometry, Mass spectrometry, LC-MS; Chromatography-Principles of chromatography- ion exchange, gel filtration, hydrophobic interaction, affinity, GC,HPLC, FPLC; Electrophoresis.

UNIT V: Biosensors and Biomedical imaging

Biosensor – definition-Historical perspective; Sensor characteristics - calibration, dynamic range, signal to noise ratio, sensitivity, selectivity, interference; Transducer – definition- types – optical, electrochemical (amperometric, potentiometric, conductimetric) - thermal, mass – piezoelectric – acoustic wave types with examples; Immobilization on transducers; adsorption, encapsulation -(hydro-gel, sol-gel glass, etc.), covalent attachment; Biocatalysis based biosensors.

Biomedical imaging -Radiation and interaction with matter - Radiation dosimetry, risk and protection – Radiation biology - X-ray machine – Radio graphic and fluoroscopic techniques – Computer tomography –Magnetic Resonance Imaging (MRI) – Ultrasonography – Endoscopy – Thermography –Different types of bioelectrometry systems and patient monitoring – Electrical safety.

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