# Syllabus for Ph.D. Entrance Exam: PhD (Green Technology)

**Fundamentals of Green Chemistry**

Nature of chemicals and world chemical scenario, E-factor, Atom Economy, Less Hazardous Chemical Syntheses, Designing Safer Chemicals, Safer Solvent and Auxiliaries, Design for Energy Efficiency, Use of Renewable Feedstocks, Reduction of Derivatives, Catalysis, Design for Degradation, Real-time Analysis for Pollution Prevention, Inherently Safer Chemistry for Accident Prevention.

**Fundamentals of Catalysis**

Relevance and examples, Homogenous and heterogeneous catalysis, Fundamentals of homogeneous catalysis and mechanisms and kinetics, Fundamentals of adsorption, isotherms, Mechanisms, models and kinetics of surface reactions, Solid and surface chemistry of catalysis, Acid--base catalysis, Transition metal catalysis. Metal and supported metal catalysis, Nature and type of supports, Solid acid catalysis, Solid base catalysis. Clay and modified clays, resins, Zeolites and zeotypes, Inorganic-organic catalysts, zeozymes, Electrochemical catalysis, Photocatalysis, Synergistic catalysis. Bio-catalysis: Microbes and enzymes, Phase transfer catalysis, Micellar catalysis, Microemulsion catalysis, Electron transfer catalysis, Homogeneous polymer catalysis, Heterogenisation of homogeneous catalysts, Catalysis by microwaves and ultrasound. Catalyst design, Poisoning, promotion, deactivation and selectivity. Catalyst recovery and reuse.

**Chemical Reaction Engineering**

Reaction kinetics, Reactor types, batch and continuous operation, types of reactions with examples, application of industrial importance. Reactor design, Reactor safety, fluidized beds, bubble columns, slurry reactors spray columns, loop reactors and mechanically agitated contactors.

**Separation Processes**

Selection of separation process. The chemistry of adsorption. Adsorbents. Adsorption Equilibria. Yield and Purity. Batch adsorption. Adsorption Kinetics. Discrete stage analysis. Design and scale-up of adsorption and chromatography equipment. Reactive distillation, Principle of separations through membranes. Micro filtration. Ultrafiltration. Reverse Osmosis. Pervaporation. Selection of membranes. Mechanism of fouling. Electro dialysis and isoelectric focusing. Chemical, physical and biochemical aspects of isolation and purification of biomolecules. Product release from a cell. Concentration and separation methods: Distillation, Liquid-liquid extraction, ion exchange, crystallization, Precipitation Chromatographic methods of purification.

**Instrumental Methods**

Basics and laws related to Fourier Transform Infrared Spectroscopy, infrared spectrophotometry. Ultraviolet and Visible Spectrophotometry, Nuclear Magnetic Resonance, X-ray Diffraction, Chemical analysis by X-ray diffraction, electron microscopy, Particle Size Analysis, Particle size sampling, conventional techniques of particle size measurement, light

scattering, Chromatography, ion chromatography, Basic theory of separation, efficiency, resolution; Liquid chromatography, high performances liquid chromatography; Gas chromatography columns and detectors; Qualitative and quantitative analysis. Mass Spectroscopy: Basic principle, ionization of a molecule on electron impact, fragmentation processes in organic compounds, interpretation of mass spectra, molecular weight, molecular formula.

**Green Biotechnology**

Biotechnology, Applications of green concepts in biotechnology Biochemistry and microbiology, Enzymatic reactions, Supported Enzyme Catalysis, Enzyme engineering, enzyme modifications, stability, reactivity and selectivity considerations, Bioreactor design, Scale up of bioreactions/reactors, Downstream processing in biochemical industry, Organic synthesis using supported microbes and enzymes.

**Nanotechnology in Green Chemistry**

Fundamentals of nanomaterials, examples and applications, synthesis and characterization, Nanoparticle Catalysis and Electrocatalysis, selected examples, Model Systems - From Single Crystals To Nanoparticles, Synthetic Approaches In Nanoparticle Catalysis And Electrocatalysis: Particle Size, Support, and Promotional Effects,

**Environmental Engineering and Pollution Prevention**

Air pollution: Definition of pollutants. Standards and limits of pollutants. Sources and sinks of pollutants. Meteorology. Problems associated with dispersion. Sampling techniques. Control techniques for removal of particulate and gaseous pollutants. Water pollution: Characterization of industrial wastewaters. Standards and limits of pollutants. Preliminary primary, secondary and tertiary treatment methods. Separation technique for removal and recovery of pollutants. Solid waste treatment. End of pipe solutions, Life cycle analysis of plastics, papers, tins; Identification of wastestreams from processes, Waste minimization strategies, Prioritizing pollution prevention options, Selecting environmentally compatible materials, Design of unit operations for pollution prevention, Economics of pollution prevention.

**Industrial Safety and Hazard Analysis**

Introduction ISO standards with reference to chemical industry, Safety aspects pertaining to the design of chemical plants. Industrial hygiene and safety aspects related to toxicity, noise, pressure, temperature, vibrations, radiations, etc. Explosions including dust, vapour cloud and mist explosions. Hazard identification, assessment and safety audit, HAZOP, HAZAN and consequence analysis. Safety aspects related to (i) transport handling and storage of flammable liquids and gases and toxic materials (ii) Process equipment including piping (fire, static electricity, pressure, temperature, etc.), Safety aspects at process development and design stage. Reliability engineering. Hazard mitigation systems Emergency planning. Case studies. Life cycle analysis of chemicals