Syllabus of Industrial Chemistry for the Post of Assistant Professor

Unit 1. Fluid & Heat transfer operation and their applications

Introduction of fluid and their classification, its mechanics: Fluid Statics, Pascal and Hydrostatic law, Manometers, Velocity field, Velocity gradient and Rate of shear. Boundary layer concept laminar and turbulent flow boundary layer separation. Fluid dynamics: Continuity equation, Euler equation, Mechanical energy balance equation, Bernoulli's equation, and its applications, Flow Through Straight Circular Pipe. Fourier's law of Conduction, Heat conduction and heat transfer coefficient, Forced and Free Convection, Heat transfer by Radiation: Laws of Radiation, Black body, Grey body. Velocities and Fluxes in Multi Species systems. Fick's law of diffusion.

Unit 2: Advanced Analytical Techniques

Basic concept and principle of Atomic emission spectrometry, Inductive Coupled Inductively coupled plasma mass spectrometry, Atomic Absorption spectrometry, Molecular Luminescence spectrometry: Theory of fluorescence and phosphorescence, factors affecting fluorescence and phosphorescence, Fluorometric determination of inorganic and organic species, Basic principle of chromatography, classification of chromatographic methods, Van Deemte equation optimization, column resolution, effect of selectivity factor and retention time, Gas Chromatography and its principle, Detectors-flame ionization detector, thermal conductivity detector, Electron capture detector, thermionic detector, Temperature programming in GC, Qualitative and quantitative analysis. High Performance Liquid Chromatography and its principle.

Unit 3: Advanced Organic Synthesis

Organic Synthesis Design: reaction intermediates: Generation, stability, and reactivity of carbocations, carbanions, free radicals, carbenes, benzynes and nitrenes, Functional groups inter-conversion, Protection-deprotection of functional groups such as –OH, -CHO, -C=O, -COOH and $-NH_2$, Connection and Disconnection approach, Synthesis and application of common organic reagents, Molecular Rearrangements Beckmann, Benzidine, Benzilic Acid, Claisen, Di-p-Methane, Favorskii, Fries, Hofmann, Pinacol, Stevens, Wagner–Meerwein and Wolff Rearrangement, Aldol Reaction, Baeyer–Villiger Oxidation, Heck Reaction, McMurry Reaction, Mitsunobu Reaction, Paterno–Buchi Reaction, Prins Reaction, Sharpless Epoxidation, Simmons–Smith Reaction, Stille Coupling Reaction, Stork Enamine Reaction, Suzuki Reaction, Wittig Reaction, Total synthesis of biologically important molecules: Longifolene, Fredericmycine A, Eremophilone, Taxol, vitexin, oestrone and cortisone. Heterocyclic Chemistry, synthesis, and chemical reaction.

Unit 4: Separation technologies & Green Chemistry

Introduction of separation technologies and their mechanisms and variable that affect separation process, Design controlling factors ion exchange chromatography equipment and commercial processes, recent advances, and economics. Ionic Separations: Controlling factors, applications, theory, mechanism and instrumentation of electrophoresis, dielectrophoresis and electrodialysis, Membrane separation process its mechanism (thermodynamic and kinetic) and types of membrane,Capillary flow theory; Membrane fouling, reverse osmosis, micro-, ultra-, and nanofiltration, pervaporation, liquid membrane permeation, gas permeation. Membrane reactors: Polymeric, ceramic, metal, and bio-membrane.

Principles of Green Chemistry, Prevention of Waste/byproducts; Green solvents– super critical fluids, ionic liquids. Microwave assisted reactions in water: Hofmann Elimination, methyl benzoate to benzoic acid, oxidation of toluene and alcohols. Ultrasound assisted reactions: sonochemical Simmons-Smith reaction, Combinatorial green chemistry; proliferation of solvent-less reactions; Green chemistry in sustainable development.

Unit 5: Unit Operation & their use in process utilities

Unit operations: Introduction of unit operation and its categories, phase diagram, equilibrium data generation, relative volatility, flash operation, continuous and batch distillation, McCabe Thiele method, Equilibrium data in multi component distillation, bubble point and dew point calculation, key component in multicomponent distillation, calculation of top and bottom product. Principles of continuous counter-current leaching, Basic principle of evaporation, forced circulation and falling film evaporators, climbing film (upward flow) evaporators, Wiped (agitated) film evaporator, General methods of drying: adiabatic, non-adiabatic, batch, continuous, Mechanical Separation by size reduction: Theory of crushing and grinding, Types of grinding, Laws of comminution, size reduction equipment and their selection. Fluidization and its application: classification of fluidization, Filtration: Theory and principles, filter aids, classification, and selection of filtration equipment.

Unit 6: Stereochemical and Spectroscopic Analysis

Elements of symmetry, chirality, *threo* and *erythro* isomers, methods of resolution, optical purity, enantiotopic and diastereotopic atoms, groups and faces, stereospecific and stereoselective synthesis. Optical activity in the absence of chiral carbon (biphenyls, allenes and spiranes), chirality due to helical shape. Configurational and conformational effects, and neighboring group participation on reactivity and selectivity/specificity. Conformational analysis of cycloalkanes (mono and di substituted). Stereochemistry of the compounds containing nitrogen, sulphur and phosphorus

Microwave Spectroscopy, Classification of molecules, rigid rotor model, effect of isotopic substitution on the transition frequencies, intensities, non-rigid rotor. IR spectroscopy: Simple harmonic oscillator, vibrational energies of diatomic molecules, zero-point energy, force constant and bond strengths; anharmonicity, Morse potential energy diagram, vibrational-rotation spectroscopy, Raman spectroscopy: Classical and quantum theories of Raman effect. Pure rotational, vibrational, and vibrational-rotational Raman spectra, selection rules. UV-vis: Beer-Lambert law, effect of solvent on electronic transitions, ultraviolet bands for carbonyl compounds, conjugated polyenes, Nuclear Magnetic Resonance: introduction and definition, chemical shift, spin-spin interaction, shielding mechanism, chemical shift values and correlation for protons bonded to carbon (aliphatic, olefinic, aldehydic and aromatic), ^{1}H & ^{13}C, coupling constants, DEPT, EPR, Mass Spectrometry (mass spectral fragmentation of organic compounds, McLafferty rearrangement), electron spectroscopy and microscopic techniques.

Unit 7: Chemical Reaction Engineering

Introduction to chemical reaction engineering. rate and mechanism of reaction, elementary and non-elementary reactions, molecularity and order of reaction, Chemical reactor analysis: Integral and differential methods for analyzing kinetic data, interpretation of constant volume batch reactor data for zero, first, second and third order reactions, half life period, auto catalytic reaction, interpretation of variable volume batch reactor.

Introduction to reactor design: Industrial reactors, space time and velocity, design of single ideal reactor - batch, CSTR, PFR using graphical procedure. multiple reactor system and optimum reactor size, temperature and pressure effects, adiabatic and non adiabatic reaction conditions, and conversion.

Multiple reaction system and its design: Independent, parallel and series reactions, instantaneous and over all fractional yield, choice of reactors for simple and complex reactions and multiple reactor system, Product distribution in multiple reaction system.

Unit 8: Pharmaceutical Chemistry

Introduction of drugs and its historical development, Classification and nomenclature of drugs, metabolism reactions, structure, stereochemistry, mode of action, specific clinical applications and structure activity relationships of following classes of drugs: Cardiovascular drugs, Vasodilators, Antihypertensive agents, Antiarrhythmic, drugs, Coagulants, and anticoagulants, Cardiotonic compounds, General and Local Anaesthetic drugs, Analgesics and Antitussives, Morphine and opioids, Synthetic Analgesics-Antitussives: Opium alkaloid, Morphine analogue, Synthetic non-narcotic antitussives, mucolytic agents. Diuretics: Oxmotic agents, Purines and related heterocycles, Sulfonamides, Benzothiadiazene and related compounds, Chlorothiazides and analoges, Commercial synthetic route to: Furosemide, Clorothiazide, Chlorthalidone. Meperidine, Methadone dextro-Propoxyphene, Pentazocine dextromrthorphane, Bromohexine, Levopropoxyphene. Ibuprofrn, Naproxen, Ketoprofen,

Hormones: Sex hormones and related compounds, adrenal cortex hormones, Thyroidhormones and antithyroid drugs, Pancreatic hormones, Hypothalamus hormones. Testosterone, cortisone, Progesterone.

Antibacterials its types: Pencillines, Cephalosporine, Tetracyclines, Chloramphenicol, Polyene antibiotics. Trimethoprim Thiourea, Thiosemicarbonazones, Pyraazinamide, Anthionamide, Dapsone, Tetracyclins. Antiamoebic and Antiprotozoal Drugs: Cinchona alkaloids, 4-Aminoquinolines, Aminoacridines, Biguanides, Pyramidines and Mefloquin, Metronidazole, Diloxanide furoate, Sodium stibogluconate, Furazolidone. Antifungal Drugs: Fatty acids and their derivatives, Salicyclic acid, Fluconazole, Itraconazole, Polyene antibiotics, Dithranol, Naftidine, Tolnaftate, Flucytosin.

Unit 9: Catalysis & Corrosion

Corrosion, its classification and its significance, dry corrosion and its mechanism, types of oxide films, Pilling Bedworth rule, electrochemical corrosion, electrode potential and its measurement, electrode reactions, electrochemical cell, Nernst equation, electrochemical and galvanic series and their importance, mechanism of electrochemical corrosion, corrosion control methods, material selection, cathodic and anodic protection, metallic coatings (methods of applications, hot dipping, galvanizing, tinning), organic Coatings notably paints.

Catalysis: Activation energy concept, types of catalysis, comparison of homogeneous & heterogeneous catalysis, enzyme catalysis, green catalysis, nano catalysis, autocatalysis, phase transfer catalysis, promoters, poisons and their examples.

Characterization of solid catalysts: Surface area, structure, surface morphology, porosity, pore volume, particle size, X-ray diffraction, SEM, TEM, X-ray absorption spectroscopy, XPS and Auger spectroscopy, TPD, TPR for acidity and basicity of the catalysts, boundary layer theory, Wolkenstein theory, Blanding's approach.

Unit 10: Chemical Reaction Dynamics and Plant Design

Non-Ideal behavior of chemical reactions, basic concepts of non-ideal flow, introduction of residence time distribution (RTD) of fluid in vessels, RTD for ideal and non-ideal reactors, RTD measurement, Conversion from RTD in non-ideal reactors. introduction to heterogeneous reaction, non-catalytic heterogeneous reaction, kinetics of fluid particle non catalytic reaction: unreacted core model and shrinking core model, external and internal diffusion effects in catalytic reactions, rate controlling step.

Process synthesis and development hierarchy of process design: principle and approaches, large scale low cost processing systems, reaction path synthesis, choice of reactors and separators, process selection, process design development, general design considerations, plant site selection, plant layout, plant operations and control, cash flow for industrial operations, factors effecting investment and production cost, capital investments, estimation of capital investments, cost indices, cost factors in capital investment.

Unit 11: Polymer & Plastic Technology

Introduction to advanced polymer and its structure-property relationship: factors influencing T_g and T_m, relation between T_m and T_g, dependence of T_m and T_g on copolymer composition, effect of chain length and crystallinity, viscoelastic behaviour of polymers, rubber elasticity, mechanical properties of polymers, molecular weight and chemical reactions of polymers, specialty polymers: liquid crystalline polymers, piezoelectric polymers, conductive polymers, temperature resistant polymers, polymer adhesive, biomedical polymers. analysis and testing of polymers, fibers and elastomer, elastomer properties, and compounding, vulcanization, reinforcement.

Unit 12: Environmental Chemistry

Introduction, components, chemical and physical characteristics of the atmosphere, environment pollution, classification of pollutants, structure and function of ecosystems, productivity, decomposition, energy flow, ecological efficiencies, global pattern of productivity, nutrient cycling (Carbon, Nitrogen and Phosphorus). definition of toxicology, its history and scope, dose-response relationship, absorption, distribution, and excretion of toxic materials, toxicity of metal ions, (Pb, Hg, Al, Ni, As) organic toxicants such as Halogenated hydrocarbons, pesticides, and solvents, ecology: introduction, scope, ecosystem, bio-geochemical cycles, homeostasis.

----------X----------X----------X---------