CHEMISTRY Ph.D. Entrance Test

CSIR-UGC National Eligibility Test (NET) for Junior Research Fellowship and Lecturer-ship

CHEMICAL SCIENCES

Inorganic Chemistry

1. Chemical periodicity
2. Structure and bonding in homo- and heteronuclear molecules, including shapes of molecules (VSEPR Theory).
3. Concepts of acids and bases, Hard-Soft acid base concept, Non-aqueous solvents.
4. Main group elements and their compounds: Allotropy, synthesis, structure and bonding, industrial importance of the compounds.
5. Transition elements and coordination compounds: structure, bonding theories, spectral and magnetic properties, reaction mechanisms.
6. Inner transition elements: spectral and magnetic properties, redox chemistry, analytical applications.
7. Organometallic compounds: synthesis, bonding and structure, and reactivity. Organometallics in homogeneous catalysis.
8. Cages and metal clusters.
9. Analytical chemistry- separation, spectroscopic, electro- and thermoanalytical methods.
10. Bioinorganic chemistry: photosystems, porphyrins, metalloenzymes, oxygen transport, electron- transfer reactions; nitrogen fixation, metal complexes in medicine.
11. Characterisation of inorganic compounds by IR, Raman, NMR, EPR, Mössbauer, UV-vis, NQR, MS, electron spectroscopy and microscopic techniques.
12. Nuclear chemistry: nuclear reactions, fission and fusion, radio-analytical techniques and activation analysis.

Physical Chemistry:

1. Basic principles of quantum mechanics: Postulates; operator algebra; exactly-solvable systems: particle-in-a-box, harmonic oscillator and the hydrogen atom, including shapes of atomic orbitals; orbital and spin angular momenta; tunneling.
2. Approximate methods of quantum mechanics: Variational principle; perturbation theory up to second order in energy; applications.
3. Atomic structure and spectroscopy; term symbols; many-electron systems and antisymmetry principle.
4. Chemical bonding in diatomics; elementary concepts of MO and VB theories; Huckel theory for conjugated π-electron systems.
5. Chemical applications of group theory; symmetry elements; point groups; character tables; selection rules.

6. Molecular spectroscopy: Rotational and vibrational spectra of diatomic molecules; electronic spectra; IR and Raman activities – selection rules; basic principles of magnetic resonance.

7. Chemical thermodynamics: Laws, state and path functions and their applications; thermodynamic description of various types of processes; Maxwell's relations; spontaneity and equilibria; temperature and pressure dependence of thermodynamic quantities; Le Chatelier principle; elementary description of phase transitions; phase equilibria and phase rule; thermodynamics of ideal and non-ideal gases, and solutions.

8. Statistical thermodynamics: Boltzmann distribution; kinetic theory of gases; partition functions and their relation to thermodynamic quantities – calculations for model systems.

9. Electrochemistry: Nernst equation, redox systems, electrochemical cells; Debye-Huckel theory; electrolytic conductance – Kohlrausch's law and its applications; ionic equilibria; conductometric and potentiometric titrations.

10. Chemical kinetics: Empirical rate laws and temperature dependence; complex reactions; steady state approximation; determination of reaction mechanisms; collision and transition state theories of rate constants; unimolecular reactions; enzyme kinetics; salt effects; homogeneous catalysis; photochemical reactions.

11. Colloids and surfaces: Stability and properties of colloids; isotherms and surface area; heterogeneous catalysis.

12. Solid state: Crystal structures; Bragg's law and applications; band structure of solids.

13. Polymer chemistry: Molar masses; kinetics of polymerization.

14. Data analysis: Mean and standard deviation; absolute and relative errors; linear regression; covariance and correlation coefficient.

Organic Chemistry

1. IUPAC nomenclature of organic molecules including regio- and stereoisomers.

2. Principles of stereochemistry: Configurational and conformational isomerism in acyclic and cyclic compounds; stereogenicity, stereoselectivity, enantioselectivity, diastereoselectivity and asymmetric induction.

3. Aromaticity: Benzenoid and non-benzenoid compounds – generation and reactions.

4. Organic reactive intermediates: Generation, stability and reactivity of carbocations, carbanions, free radicals, carbenes, benzynes and nitrenes.

5. Organic reaction mechanisms involving addition, elimination and substitution reactions with electrophilic, nucleophilic or radical species. Determination of reaction pathways.

6. Common named reactions and rearrangements applications in organic synthesis.

7. Organic transformations and reagents: Functional group interconversion including oxidations and reductions; common catalysts and reagents (organic, inorganic, organometallic and enzymatic). Chemo, regio and stereoselective transformations.

8. Concepts in organic synthesis: Retrosynthesis, disconnection, synthons, linear and convergent synthesis, umpolung of reactivity and protecting groups.

9. Asymmetric synthesis: Chiral auxiliaries, methods of asymmetric induction substrate, reagent and catalyst controlled reactions; determination of enantiomeric and diastereomeric excess; enantio-discrimination. Resolution – optical and kinetic.

10. Pericyclic reactions – electrocyclisation, cycloaddition, sigmatropic rearrangements and other related concerted reactions. Principles and applications of photochemical reactions in organic chemistry.

11. Synthesis and reactivity of common heterocyclic compounds containing one or two heteroatoms (O, N, S).

12. Chemistry of natural products: Carbohydrates, proteins and peptides, fatty acids, nucleic acids, terpenes, steroids and alkaloids. Biogenesis of terpenoids and alkaloids.

13. Structure determination of organic compounds by IR, UV-Vis, ^{1}H & ^{13}C NMR and Mass spectroscopic techniques.

Interdisciplinary topics

1. Chemistry in nanoscience and technology.
2. Catalysis and green chemistry.
3. Medicinal chemistry.
4. Supramolecular chemistry.
5. Environmental chemistry.

SARDAR PATEL UNIVERSITY

Syllabus for Ph.D. Entrance Test

Ph.D. in Industrial Chemistry

Unit Operations

1. Distillation: Enthalpy Concentration diagrams, Use of Ponchon Savarit method in the design of multistage tray towers and packed towers.
2. Gas Absorption: Choice of solvent for absorption, Minimum Liquid-Gas ratio for Absorbers, HETP in continuous contact equipments.
3. Liquid-Liquid Extraction: Choice of solvent for extraction, Binodal solubility curves, Calculations for single stage and multistage cross and countercurrent extraction, Differential Extractors. Different types of extractors.
4. Drying: Rate of batch drying, Calculations for cross and through circulation drying, Rate of drying for continuous driers, Hold up in rotary driers. Different types of Driers.
5. Filtration: Theory of Filtration, Filtration Calculations, Filtration in centrifuges. Different types of Filters.
6. Boundary Layer concept, Calculations for reciprocating and centrifugal pumps, Use of air vessels in Pumps, Vapour locking and NPSH. Design of flow meters. Pressure and Vacuum producing devices. Dimensionless analysis using Rayleigh and Buckingham π method.
7. Motion of particles through fluids: Terminal settling velocity of particles settling under stokes, Intermediate and Newton's range in free and hindered settling, Mechanism of fluidization, Design of fluidized bed columns.
8. Modes of Heat Transfer: Three dimensional heat conduction equation in rectangular and cylindrical co-ordinates, Effect of variable thermal conductivity, Heat transfer from extended surfaces. Calculations for free and forced convection. Applications of Planck's distribution law, Stefan Boltzmann law and Kirchhoff's law, Radiation shields. Heat Exchangers.
9. Stoichiometry: Mass balance calculations for processes with and without chemical reactions, recycle and purge operations. Energy balance calculations for processes with and without chemical reactions.
10. Sedimentation- Batch and continuous sedimentation, Thickeners, Separation of solids based on specific properties. Clarification equipments. Cyclones. Froth flotation and Jigs.
11. Mixing, Types of mixing problems, Mixing liquids with liquids, mixing liquids with solids, Mixing solids with solids, Mixing viscous masses.

12. Conveyors and elevators-Introduction Belt conveyor, Conveyor, Screw conveyor, Pneumatic conveyor.
13. Size reduction and size separation, Primary and secondary crushers, Fine grinders, Methods of operating crusher, Size separation of solids, Industrial screens, Air separation method, Size separation by laws of setting.
14. Crystallization- approaches for crystallization, Batch and continuous crystallization, Theory of crystallization.

Unit processes:

Study of following processes with special emphasis on chemistry & chemical engineering principles

1. Halogenation
2. Oxidation
3. Alkylation
4. Hydrogenation
5. Nitration
6. Sulphonation
7. Hydrolysis
8. Esterification
9. Hydration
10. Synthesis based on Carbon Monoxide & Hydrogen

Chemical Reaction Engineering

1. Kinetics of Homogeneous reactions: Single and Multiple Reactions, Elementary and Non-Elementary reactions, Molecularity and order of reactions, Kinetic Models for non-elementary reactions, Temperature dependency and reaction rate prediction from Arrhenius, transition and collision theories. Integral and Differential analysis for constant volume and variable volume reactors-irreversible and reversible.
2. Design of reactors: Design of Ideal batch, CSTR and plug flow reactors, determination of the best system for a given conversion, residence time distribution-determination of exit age curve.
3. Kinetics of Heterogeneous reactions: Global rate of reaction, Effects of transport processes on selectivity in series and parallel reactions, Rate equations for surface reactions, Three phase reactors-slurry and trickle bed reactors. Determination of surface area, porosity, density and particle size of catalyst.

Utility Engineering

1. Steam and steam generation: Introduction and thermodynamics of steam generation, steam generators, Indian boiler act, calculations for boilers.
2. Water- Impurities and hardness of natural water, Water for steam making and industrial processes, Boiler water treatments, Calculations on water treatments.
3. Fuels-classification, advantages and disadvantages, Analysis of fuels, Heating media
4. Air- Specification for industrial uses of air. Industrial applications of CO_2, O_2, N_2 and H_2.
5. Compression equipments, Reciprocating compressor, Work of single stage reciprocating compressor, Effect of clearance, Volumetric efficiency, Multistage compression, Refrigeration, COP & refrigerating effect, Industrial refrigerants, Carnot and other refrigeration cycles.

Spectroscopy and Instrumental Techniques

1. Elementary principles, Theory, Instrumentation, sampling methods and applications of FT-IR, ^{1}HNMR, ^{13}CNMR, FT-Raman
2. Mass spectroscopy for structural elucidation of organic compounds, LC-MS/MS, GC-MS
3. UV-VIS Spectroscopy
4. HPLC, GC and UPLC
5. TGA, DTA and DSC
6. ICP
7. SEM and TEM
8. XRD, XRF
9. Particle Size Analyzer

Chemical Technology:

Study of following group of Industries with respect to their classification, raw materials, manufacturing process of at least one product with special emphasis on chemistry, engineering, structural features and product analysis:

1. Polymer and resin industry
2. Surface coating industry
3. Oils and Oleochemical industry

4. Petrochemical industry
5. Pigment industry
6. Fertilizers and Agrochemical industry
7. Pharmaceutical industry
8. Adhesives
9. Surfactants

Industrial Hygiene &Safety

1. 5S concept
2. Elements of process safety management
3. Various methods of risk assessments related to safety
4. Safety procedures for handling and storage of chemicals

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SYLLABUS FOR PHD ENTRANCE IN THE SUBJECT OF

APPLIED CHEMISTRY

ADVANCED INORGANIC CHEMISTRY

1. Symmetry and Group theory: Symmetry elements and Symmetry operations, representation of Symmetry operations as matrices, definition of groups, Sets of Symmetry operations of molecules satisfying the conditions of a group, generators, classes of operations, reducible and irreducible representations, derivation of character table-C_{2v} point group, Applications of group theory - atomic orbital and Spectroscopy.

2. Organometallic Compounds: Classification based on the nature of Metal Carbon bond, ionic organometallic compounds (OMCs), compounds containing Metal-carbon bonds, Ylides, OMCs with multicenter bonds, OMCs with π bonded Ligands, Bonding in π -metal complexes, π - Metal – Olefin, π – Metal-acetylene. Bonding in Ferrocene and Reactions of Ferrocene.
   Classification of ligands in OMCs (i) Based on number of C atoms through which ligand is attached to metal atom (ii) Based on number of electrons contributed by the ligand for carbon – ligand bonding.
   Inert gas or 18 electron rule, Counting the effective number of electrons, basis for 18 electron rule, role of π – bonding ligand in stabilizing complexes, Explanation for exceptions of the 18- electron rule, Nomenclature of OMC's.

3. Magnetochemistry of Transition Metal Complexes: Basic terms used in magneto chemistry, Orbital magnetic moment, Spin magnetic moment, Types of magnetism - Diamagnetism, Paramagnetism, Ferromagnetism and Antiferromagnetism, Measurement of magnetic susceptibility, Magnetic Behavior of Transition Metal Complexes – Theoretical Background, Valence Bond approach, its limitations, Crystal Field approach, Quenching of orbital angular momentum.

4. Reaction Mechanisms in Coordination Compounds: Substitution reactions in octahedral complexes, SN^1 and SN^2 mechanism – Types of intermediates formed, Lability and Inertness of Transition Metal complexes – Valence Bond approach, Crystal Field approach, Lability of Non – transition Metal complexes, Mechanism of Acid hydrolysis in octahedral complexes under various conditions, Mechanism of Base hydrolysis – Stereochemistry of intermediates, Substitution reactions in square Planar Complexes- Trans effect - Oxidation – Reduction reactions- atom or group transfer through electron transfer – outer sphere mechanism, inner sphere mechanism, two electron transfer reactions.

5. Bioinorganic Chemistry: Importance of following Biological systems – Iron in Haemoglobin and myoglobin, cooperative effect, Zinc as ideal biosite and its role in carbonic anhydrase, Role of Alkali metals - Na^+ - K^+ pump. Biological functions and toxicity of some elements, Metal ions and ligands in therapy.

6. Inorganic Polymers: Synthesis, Structure, Properties and applications of the following: P – N based polymers; S –N based polymers and Silicones

7. Corrosion: Introduction, Dry or chemical corrosion, wet or electrochemical Corrosion, mechanism, pilling bed worth rule. Types of corrosion-galvanic corrosion, concentration cell corrosion, Differential aeration corrosion, soil corrosion, Pitting corrosion, Intergranular corrosion, Microbial corrosion, Stress corrosion, Waterline corrosion, Erosion corrosion, Factors influencing corrosion.

8. Corrosion Control and Protective Coatings: Corrosion Control: Proper designing, using pure metal, using metal alloys, cathodic protection, modifying the environment, use of Inhibitors.
   Protective coatings: Types, Paints, Pigments, drying oils, varnishes, enamels, lacquers.

ADVANCED ORGANIC CHEMISTRY

1. Advanced Organic Synthesis (Reactions and Reagents):
   Reactions : (i) Arndt Eistert Synthesis (ii) Birch Reduction (iii) Knoevenagel reaction (iv) Michael addition Reagents: (i) Diborane (ii) $LiAlH_4$ (iii) OsO_4 (iv) Dicyclohexylocarbodiimide (DCC)

2. Molecular Rearrangements-I: (i) Tiffeneau-Demjanov rearrangement (ii) Benzil-Benzilic acid rearrangement (iii) Fries rearrangement – Inter, Intra & Photo; (iv) Neber rearrangement
   Scales of acidity and basicity, Factors affecting acidity/basicity, Superacids and their applications

3. Molecular Rearrangements-II: (i) Lossen rearrangement (ii) Schmidt rearrangement (iii) Baeyer–Villiger rearrangement (iv) Dakin rearrangement.

4. Heterocyclic Compounds: Classification, Numbering, Nomenclature and importance of Five and six membered heterocyclic compounds with two hetero atoms eg. pyrazole, imidazole, oxazole, Thiazole, Pyrimidine. Fused ring systems: Indole and Purine. (Synthesis of important heterocyclic compounds from the above classes)

5. Tautomerism and Reactivity: Cationotropy and anionotropy, Mechanism of Prototropic transformation

6. Stereochemistry: Relative stability and reactivity of diastereoisomers, Conformational analysis, Applications of Dipole moment, IR, NMR and Raman spectra in conformational analysis

7. Reactive Intermediates: Structure, stability, methods of Preparation and reactions involving following organic intermediates: (i) Free radicals (ii) Carbocations (iii) Norbornyl and other non-classical Carbocations (iv) Carbanions (v) Carbenes (vi) Arynes

8. Retrosynthetic Analysis: The disconnection approach, Logic and concepts, Synthon and Synthon equivalent, *Umpolung* methods, Linear and convergent syntheses, Control elements, Illustration of some synthetic approaches

ADVANCED PHYSICAL CHEMISTRY

1. Statistical Thermodynamics:
   Limitations of classical thermodynamics, Statistical thermodynamics. Maxwell-Boltzmann distribution, Molecular Partition functions and their significance, thermodynamic information from partition function, Sackur-Tetrode equation. Thermodynamics of living systems. (a) Chemical processes in living systems. (b) ATP hydrolysis and chemical energy.
2. Chemical Kinetics:
   Thermodynamic formulation of transition state theory, consecutive reactions, chain reactions, branching chain reactions and parallel reaction, determination of activation energy.
3. Photochemistry:
   Laws of photochemistry, symmetry rules and selection rules, Photo physical processes: Jablonski diagram and Charge transfer processes.
4. Solution behaviours of surfactants & macromolecules:
   Association colloids, micelle formation and Kraft temperature, surface films, Langmuir-Blodgett film, introduction to conformation and configuration of macromolecular chains, random coils, helices and sheets.
5. Phase Equilibrium:
   Three component systems and their graphical representation, ternary system consisting of liquids, two salts and water (a) having common ion and (b) salts forming double salt.
6. Electrochemical Processes:
   Thermodynamics and kinetics of an electrochemical metal deposition and dissolution processes. Mechanism of growth and breakdown of the passive films, Different electrochemical reactions, rapid electrochemical reactions, organic electrode processes, electro catalysis. Polarization: Its causes, decomposition voltage and concentration polarization, polarography, theory and applications, constant potential electrolysis, anodic stripping voltammetry, cyclic voltammetry.
7. Solid State Chemistry:
   Structural principles in solid state chemistry, bonding in solids-nature of packing in solids-types of sites/voids and their geometrical considerations – importance of radius ratio, structures of a few binary and ternary compounds – Types of water in crystals. (b) Defects in solids, defects in stoichiometric compounds – metal excess and metal deficient cases, detection of defects-consequences of defects-creation of F centers.
8. Surface Phenomenon:
   Adsorption, Freundlich and Langmuir isotherms, Catalysis choice with respect to reaction velocity, selectivity and economics, Heterogenised homogenous catalysis – catalysis by supported metal ion and metal complexes – shape selective catalysis – phase transfer catalysis – Biocatalysts/Enzymes as catalysts – solid acid catalysts for automobile emission control. Catalysts used in well known reactions- catalyst deactivation and reactivation – catalysts for future.

ANALYTICAL CHEMISTRY

1. Evaluation of Analytical Data:
   Terms used in evaluation of Analytical data, Significant figures, Errors-Types, Correction of errors, Precision and Accuracy, difference between Precision and accuracy. Reporting of analytical data
2. Fundamentals of Spectroscopy:
   Principles-Electronic, Rotational and Vibrational Spectra, Selection rules, energy levels, molecular vibrations, rotational and vibrational Raman Spectra of diatomic molecules, Nuclear Magnetic Resonance.
3. UV-VIS and IR Spectroscopy:
   UV-Visible spectroscopy - Laws of absorption, absorption by Organic and Inorganic Systems, Instrumentation and Applications. IR-modes of vibrations in polyatomic molecules, Instrumentation, Fourier Transform methods, Interpretation of spectra, Applications.
4. Thermal Analysis:
   Thermo gravimetric analysis (TGA, DTA), Differential Scanning Calorimetry – Instrumentation and Applications.
5. Atomic Absorption and Emission Spectroscopy:
   Atomic absorption Spectroscopy (AAS), Theoretical principles and instrumentation in Absorption flame photometry, Analytical Applications. Flame Emission Spectroscopy – Principles, instrumentation and applications. ICP-AES (Inductively coupled plasma atomic emission spectroscopy)
6. ESR and Mossbauer Spectroscopy:
   Principles, Instrumentation and Analytical applications of both the techniques.
7. Chromatography:
   Introduction, Classification, Adsorption and Partition Chromatography, Exclusion chromatography, Ion Exchange Chromatography, TLC, GC, HPLC, Applications in qualitative and quantitative analysis.
8. Mass Spectroscopy:
   Introduction to Mass Spectrometer and Fragmentation pattern of functionalized Organic molecules, McLafferty rearrangement, Application of Mass Spectrometry in Structure elucidation and Molecular Weight determination.

CHEMICAL PROCESS INDUSTRIES-I

1. Chemical Processing and Routes to Synthesis of Inorganic Materials:
   Chemical Processing – general concepts; Soft chemistry routes - Sol-gel method of synthesis, intercalation, ion exchange method. Deposition of thin films-CVD technique, Liquid phase epitaxy, vapour phase epitaxy, molecular beam epitaxy, Spray pyrolysis, High purity crystal growth, Microwave assisted synthesis.
2. Paints and Inorganic Pigments:
   Pigments - Manufacture of white, black and basic colour Inorganic Pigments, characteristics. Constituents of paints, formulation of paints for various purposes, manufacture of paints, Special paints, Emulsion paints.
3. Ceramics:
   Manufacture and uses of following classes of ceramic materials - Refractories, Abrasives, Pottery and Porcelain, Enamels.
4. Glass Manufacture:
   Basic concepts in glass making - role of network formers, network modifiers and

intermediate glass making oxides. Manufacture of ordinary glass – melting, Shaping, Annealing; Varieties of glass, Special glasses.

5. Industrial Carbon:
Manufacture of various carbon modifications - Lamp black, carbon black, Acetylene black activated carbon by chemical activation and gas activation process. Reactivation, regeneration of activated carbon, Applications. Manufacture of graphite – and amorphous carbon electrodes, carbon fibres.

6. Advanced Cementitious Materials:
Manufacture of Portland cement-Setting and hardening of cement, Special cements, Colored cements, Blended cements- additives (plasticisers, organic additives) for quality improvements.

7. Water Conditioning for Industry:
Sterilization and disinfection of water chemical and physical methods of sterilization, desalination, Demineralisation, Electrodialysis.

8. Nuclear Industries:
Nuclear reactions, Nuclear Fuels, Nuclear reactors, Processing nuclear materials, Isotopes and Isotope separation, Heavy water.

CHEMICAL PROCESS INDUSTRIES-II

1 Complete yeast dissimilation, Factors for successful fermentation process and abilities of selected microorganisms, manufacturing processes of industrial alcohol, acetone & butanol and penicillin by fermentation methods.

2. Penicillin by Fermentation:
Introduction, Terminology of various penicillins, Therapeutic uses, chemistry of penicillin, chemical changes during fermentation, commercial production of penicillin – surface culture and submerged culture fermentations. Recovery of penicillin, Disposal of wastes.

3. ManMade Fibers:
Chemistry, manufacturing and uses of Nylons (6 and 66), Polyesters, Acrylics.

4. Cellulose Industries:
Introduction – structure, chemical and physical properties, Derivatives (esters, ethers) of cellulose, Rayon Manufacturing.

5. Petroleum Refining Operations:
Crude oil exploration, theories of origin of petroleum, Bubble tower refining, chemical purification of refined fractions, Knocking, Octane and Cetane number.

6. Petroleum Reforming Operations:
Methods to increase octane number of Gasoline, Pyrolysis and cracking – fixed bed and moving bed catalytic cracking, reforming and isomerization.

7. Explosives:
Characteristics, synthesis, physical, chemical biological effects and uses. Explosives – Dynamite, TNT, TNT AN, RDX, PETN etc.

8. Military Gases;
Characteristics, synthesis, physical, chemical and biological effects and uses
Military gases – Nitrogen mustard, phosgene, organo phosphoric compounds, screening smokes, Hexachloro ethane

MATERIALS SCIENCE

1. Strength of Materials:
   Elastic, anelastic and viscoelastic behavior, stress-strain curves, anelastic behavior, viscoelastic behavior, spring-dashpot models, fracture in solids, ductile fracture and brittle fracture, methods of protection against fracture
2. Science of Nanomaterials I:
   Behavior of materials at nanometer scale, chemical methods of synthesis of nanomaterials, gold nanoparticles, carbon nanotubes
3. Science of Nanomaterials II:
   Introduction to supramolecular chemistry, self assembly and supramolecular interactions, bionanotechnology, characterization of nanomaterials, AFM, STM, TEM.
4. Membrane Materials and Membrane Technology:
   Types of materials for membrane applications, polymeric membranes, asymmetric membranes, surface modifications for membrane applications, concepts of reverse osmosis, ultrafiltration and electrodialysis
5. Liquid Crystalline Materials– Chemistry and Applications: Thermotropic & Lyptropic liquid crystals, structure and property relationship, Smectic, nematic & cholestric liquid crystals, globular and discotic liquid crystals, liquid crystalline polymers. Applications of liquid crystals in chemistry, electronics, medicine and non-destructive testing.
6. Lubricants:
   Characteristics, Functions, Classification of lubricants: solid, semi-solid and liquid lubricants and their properties. Different types of Lubricants: Synthesis and Applications, bio lubricants.
7. Macrocyclic Materials I:
   Chemistry, Methods of preparations and Applications of Fullerenes
8. Macrocyclic Materials II:
   Chemistry, Methods of preparations and Applications of Calixarenes and Cyclodextrins

DRUGS

1. Anitviral Agents:
   Agents involving inhibition of early stage of viral replication; Agents interfering with viral nucleic acid replication; Agents affecting translation on cell ribosomes
2. Antihypertensive Agents;
   Drugs acting at or near post – ganglionic nerve endings; Adrenergic neuron blocking agents; Drugs acting directly on smooth muscles; Centrally acting sympathomimetic agents; β – adrenergic blocking agents
3. Hypoglycemic Agents;
   Biguanides, Sulfonyl ureas, plane and mixed insulin
4. Antibiotics;
   Natural and semisynthetic Penicillins, Cephalosporins, Tetracyclins, Macrolides, Aminoglycosides.
5. Antimalarials:
   Cinchona Alkaloids, 4–Aminoquinolines, aminoacridines, 8–Aminoquinolines, Pyrimidines, Biguanides, Sulfones
6. Anti-histaminic Agents:

(i) H_1–Antagonists - Aminoalkylether Derivatives; (ii) H_2 – Antagonists

7. Antipyretics and Analgesics:
   Salicylic acid derivatives, Antipyrine, Melubrin, Novalgin, Amidone, Pethidine

8. Narcotics and Non-Narcotic Analgesics:
   Morphine, codeine, Heroin; Paracetamol, Phenylbutazone, Ibuprofen; Piroxicam (Non selective COX inhibitors); Nimesulide, Meloxicam (Selective COX–2 inhibitors)

PETROCHEMICALS

1. General Principles Involved in the Production of Petrochemicals: Petrochemicals obtained from synthesis gas and natural gas (mainly methane) Methanol, Chloro methanes.

2. Petrochemicals obtained from Synthesis Gas and Natural Gas: Formaldehyde and Perchloroethylene

3. Products obtained from Acetylene, Trichloroethylene: Vinyl chloride and Acetaldehyde

4. Products obtained from Ethylene: Ethylene oxide, Ethanol amines, Ethylene chloride.

5. Products obtained from Propylene/Propane: Acrylonitrile, Chemicals by Oxo process

6. Products obtained from Propylene/Propane: Isopropyl benzene (Cumene), Isopropanol, Isoprene, Acetone

7. Products obtained from Butane: Butadiene

8. Aromatic Products: Phenol by Cumene process Phenol by Raschig process Benzene

SURFACTANTS

1. Introduction:
   General considerations, Economic considerations, Problems of surfactant industries, technical considerations, trade names, classification of surfactants.

2. Anionic Surfactants:
   Synthesis and manufacturing processes- Carboxylic acids, Sulphuric acid esters, Alkane sulphonates, Mahogany and petroleum sulphonates.

3. Cationic Surfactants:
   Synthesis and manufacturing process, Non–quaternary nitrogen bases, Quaternary nitrogen bases – other bases.

4. Nonionic,Amphotheric and NovelSurfactants:
   General Review, Hydrophilic intermediates, Polyethylenoxy surfactants, Polyhydroxy surfactants, Ampholytic surfactants. New surfactant types: Organosilicon compound, Highly Fluorinated compounds, Polymeric surfactants,

Gemini surfactants: synthesis and properties.

5. Physical and Colloidal Chemistry of Surfactants:
Some recent advances in surface physics
   a. Solid interfaces
   b. Liquid interfaces
   c. Liquid–Liquid interfaces
   d. Solid–Liquid interfaces
6. Bulk Properties of surfactants:
Foaming, wetting and related gross effects
7. Emulsification:
Dispersion and Detergency, Special Physical forms of surfactants
8. Practical Applications of Surfactants:
Washing of fabrics & textile materials, medical & cosmetic applications, surfactants in metal & minerals technology, Surfactants in Rubber, polymers, plastics and paints, Surfactants in petroleum and chemical process industries

HEAVY CHEMICALS

1. Sulphuric acid Industries:
Methods of Production (Contact process): Physicochemical principles involved, catalysts used, major engineering problems, economics.
2. Nitrogen Industries:
Ammonia – methods of production (Haber's process): Physicochemical principles involved, catalysts used, major engineering problems, economics.
Nitric acid: methods of production (Arc process, Birkland and Eyde's process), Physicochemical principles involved, catalysts used, major engineering problems, economics.
3. Chloroalkali Industries:
Caustic soda, Soda ash and Chlorine-methods of production, physico chemical principles involved, major engineering problems, economics.
4. Manufacture of Catalysts:
Preparative methods, Metals as catalysts, supported metal as catalyst; Synthesis of support materials; Oxides, mixed oxides, monolithic supports. Forms of catalysts and extrusion processes.
5. Phthalic Anhydride Industry: Manufacture and Uses.
6. Caprolactam:
   (a) Raw materials, Manufacturing based on cyclohexane
      (i) Hydrogenation of benzene (ii) Oxidation of cyclohexane (iii) Dehydrogenation of Ketone alcohol (KA-oil) mixture (iv) Oxidation of cyclohexanone and Beckmann rearrangement. (v) Synthesis of various oximating agents.
   (b) Direct photo-oximation of cyclohexane
7. Acetic Acid Industry:
   i) Manufacture from acetaldehyde by oxidation.
   ii) Manufacture from methanol by carbonylation
   iii) Applications
8. Production of paracetamol and other related drugs, Manufacturing process and uses

INDUSTRIAL CHEMISTRY

Introduction; Calorific value and its determination; Characteristics of a good fuel; Classification; Advantages and disadvantages of solid, liquid and gaseous fuels; Coal: Definition, selection, Analysis – proximate and ultimate; Gaseous fuels: Producer Gas, Water Gas ; carbureted water gas; biogas.

2. High Polymers:
   Manufacture of polyacrylonitrile, polysulfones, polyacetylene for different applications, elastomers, structural requirements, synthetic rubbers like polyurethane, neoprene, polysulphide rubbers, and polymers for electronic and photonic applications, azobenzene based polymers, liquid crystalline polymers.
3. Vitamins:
   Classification and nomenclature; Vitamin activities; metabolic, physiological or biological functions of vitamins; Vitamin A, Vitamin B complex; Vitamin C: occurance and sources, isolation, absorption, storage and excretion, diseases caused by deficiency, requirements and structure.
4. Fats, Oils and Waxes:
   Distinction between fats and oils; Properties; Classification; Manufacture of cotton seed and soya bean oil. Waxes – classification of waxes, some common waxes.
5. Synthesis, Properties and Applications of the following Materials:
   Superconducting materials - concepts, types, high Tc superconductor, Fast ion conductors (NAFION and NASICONS), inorganic
   materials in the electronic industry.
   Insulating materials- concept, dielectric properties, insulating materials, thermal insulators, semiconductors.
6. Industrial Zeolites and its Applications:
   MELS (Molecularly Engineered Layered Structures) – pillared layered compounds, clay materials, Zeolites, Feldspars, Clathrasils, Zeosils, porosils, micro and meso porous compounds – Hetero and iso-poly acids and their salts.
7. Patents in Industries:
   Understanding Intellectual Property Rights (IPR), IPR Tools, Patents related to Pharmaceuticals, Parts of Patent, Filing a patent application and its prosecution in India, Indian patent Act, 1970; American and European Patent Systems
8. Copyright in Industries:
   Introduction of copyrights, Importance of Trade Marks, Matter not protected under Trade Mark, Registration of Trade Mark, Infringement and Remedies and Case Laws

CHEMICAL ENGINEERING KINETICS AND PROCESS CONTROL

1. Introduction to Chemical Kinetics, classification of chemical reactions, concept of rate of reaction, variables affecting rate of reactions. Kinetics of homogeneous reactions, concentration and temperature dependency of reaction, Molecularity and order of reaction, concept of activation energy

2. Formulation and analysis of simple and complex rate equations interpretation of rate data using integral and differential method of analysis in constant volume system and varying volume systems concept of catalysed reactions

3. Introduction to reactor design concept of ideal reactors. Classification of reactors: concept of space time and space velocity holding time and space time for flow reactors. Development of design expression for flow reactors. Development of design expression for ideal batch reactor, steady state plug flow reactor. Steady state mixed flow reactor and stirred tank reactors for single reaction

4. Introduction to heterogeneous reaction systems. Essentials of heterogeneous catalysis, Constructional aspects of packed bed reactors

5. Importance of controls in the process industry, Basic components of control system, block diagram representation of control loop

6. Elements of control dynamics

7. Control strategies, Distributed control systems, programmable logic controllers etc

8. Instrumentation symbols & labels, instruments for measurement of process variables: temperature, flow, liquid level and pressure

AGROCHEMICALS AND FERTILIZERS

1. Biocide Chemistry-I:
   Pesticides: Definition, formulations, classification,
   (i) Fungicides Inorganic: Copper fungicides, Sulphur fungicides; Organic: Carbamic acid derivatives, Chlorinated aromatics and heterocyclic fungicides; Systemic fungicides
2. Biocide Chemistry-II:
   (i) Insecticides - Inorganic: Stomach poisons, contact poisons, Organic: Organochlorines, organophosphorus, carbamates, nitrophenols.
   Attractants/pheromones, repellents and antifeeding compounds, fumigants
   (ii) Rodenticides
   (iii) Herbicides – classification and Chemistry, Plant growth hormones
   (iv) Biopesticides
3. Methods of Pesticidal Applications and Control Release Systems
4. Agrochemicals for future and Biofertilizers
5. Introduction to Inorganic Fertilizers: Classification, Nutrient requirement of crops and function, soil condition, Overview of fertilizer industry, basic raw materials for fertilizer manufacture
6. Phosphatic Fertilizers:
   Manufacture of phosphoric acid, Manufacture of ordinary super phosphate and triple super phosphates
7. Mixed Fertilizers:
   Bulk Blending, intermediates used in bulk blending, fluid mixtures, solution fertilizers and suspension fertilizers. Compound fertilizers, Nitro phosphate and ammonium phosphates (mono- and di-)
8. Nitrogenous Fertilizers:
   Manufacturing process and agrochemicals properties of Urea
   Calcium cynamide (slow release nitrogen fertilizer)

DYES AND TEXTILE AUXILIARIES

1. Introduction:
   Historical development of synthetic Dyes - Introduction, Nomenclature, Color and constitution
2. Classification of Dyes:
   (i) Based on structure, (ii) Based on mode of application to fibers
   (iii) Types – Acid dyes, Basic dyes, Direct dyes, Mordant dyes, Vat dyes, Food dyes
3. Dye Intermediates–I:

Unit processes for Nitration – Nitrating agents, kinetics and mechanism of Nitration, Nitration of benzene, chlorobenzene and Toluene
Continuous and batch Nitration processes
Amination by reduction, methods of reduction, commercial manufacture of Aniline and m-nitro aniline

4. Dye Intermediates–II:
Sulfonation– Sulfonating agents, chemical and physical factors in sulfonation, sulfonation of benzene, toluene, Naphthalene and Anthraquinone
Continuous and Batch Sulfonation
Halogenation, mechanism, chlorination of paraffinic hydrocarbons– benzene and toluene, Alkylation
5. Study of few typical Members (non-benzidine) of Various Classes of Dyes:
   (i) Acidic azodyes –tartrazine (ii) Azodyes – Direct red 23
   (iii) Basic dyes – saframine, malachite green (iv) Vat dyes
   (v) Indigoid and thioindigoid dyes (vi) Heterocyclic dyes
   (vii) Reactive dyes (viii) Disperse dyes
6. Non–Textile Uses of Dyes:
Dyes in medicine, leather, paper, color photography and electro photography, food and drugs, cosmetics, displays and laser dyes
7. Types of fibres and theories of dyeing methods
8. Textile Auxiliaries:
Fluorescent brighteners and optical whitening agents, crease resistant agents, water repellent finishing agents, fire proofing agents

INDUSTRIAL POLLUTION

1. Green Chemistry: Clean synthesis using alternative reaction media; Super critical solvents in industrial applications, scale up & industrial applications of clean synthesis including asymmetric synthesis
2. Chemical Toxicology: Biochemical effects of Hg, Cd, Pb, As, Cu and their speciation, Biochemical effects of cyanide and pesticides, DDT in the food chain, MIC
3. Waste Water Treatment Technologies: Terminologies, water pollutants– sources, criteria for detection-pH, acidity, alkalinity, Dissolved solids. - TS, TDS, TSS, DO, BOD, COD, TOC – Treatment levels - pretreatment, primary, secondary and tertiary treatment, sludge disposal
4. Air Pollution: Air pollutants and their toxic effects– CO, CO_2 (greenhouse effect) NO_x, SO_x, H_2S, Ozone–effects on ozone layer by NO_x and fluorocarbons, particulates – sources, toxic effects, smog – classical, photochemical, sampling and monitoring of air pollutants – control of air pollutants. Motor vehicular pollution and control
5. Radiological Contamination and Impact of large Radiation Sources on the Environment: Sources of contamination–Natural, Man Made –Breeder reactors, Fuel reprocessing, Nuclear weapons. Radioactive contamination in Drinking water, Regulation and control. Medical applications Radiopharmaceuticals, Radioprotiens Isotope power pace makers, Isotope satellite power unit – summary of benefits and environmental impact
6. Thermal Pollution and Environment: Sources–central power station, return of irrigated water, sewage water, different water ways, thermophillic bacteria, Mechanism of heat dissipation, techniques of heated water discharges, cooling towers, benefits of waste heating cooling ponds
7. Carbon Capture and Sequestration: Global warming and Climate change, Concept of Carbon Credit and Carbon Footprint, Carbon capture techniques, Carbon dioxide sequestration, Design of Green Belt and its advantages
8. Waste Management and Recycling- Case Studies:
Plastic Recycling, Dye Industry, Evaluation of VOC recovery Systems, Utilisation of Fly ash, Fine chemicals

POLYMERS, PLASTICS AND RESINS

1. Chemistry of Polymerization:
   Chain polymerization, Step polymerization, miscellaneous polymerization, Copolymerization.
2. Polymerization Techniques and Synthesis:
   Bulk, Emulsion, Dispersion, Melt and Solution polymerization. Synthesis of some Polymers– isolation, purification and fractionation, Elastomers, Plastics– Thermoplastic and Thermosetting resins
   Polymer Reactions: Hydrolysis, Acidolysis polymer degradation and anti oxidants.
4. Molecular Weight (MW) Determination and Size of Polymers:
   Number average (M_n), Weight average (M_w), Sedimentation average (M_2) and Viscosity average (M_v) molecular weights
   Derivation of M_n and M_w. MW and degree of Polymerization, Polydispersity and Mw distribution curves. Determination of MW – Osmometry, Viscometry, Sedimentation, Cryoscopy, Ebulliometry, Chemical and geometrical Structure of Polymers, Glass transition temperature (GTT), factors effecting GTT, MW and melting point
   Polymers and X-ray Diffraction– degree of Crystallinity in Polymers, Polymer crystallization, Crystallisability, Factors affecting crystallinity in Polymers, Spherulites, Helix Structure, Effect of Crystallinity on the properties of polymers
5. Kinetics of Polymerization:
   Free radical, Cationic, Anionic, condensation polymerization, Copolymerization.
6. Polymer Solutions:
   Thermodynamic treatment of dissolution process, Flory–Huggins theory of polymer solutions, size and shape of polymers in solution, light scattering.
7. Polymer Processing:
   Calendering, die casting, rotational casting, film casting compression moulding, blow moulding etc.
8. Polymer Technology:
   Manufacture of polymers, polyethylene and polypropylene, Ziegler – Natta catalysis.

INSTRUMENTAL METHODS OF CHEMICAL ANALYSIS

1. Evaluation of Analytical data, problems-based on significant figures, Precision accuracy, Errors, F-test, Q-test, t-test, Basic concepts in gravimetric and volumetric analysis– expression of metal ion concentration as pM at various stages of titration
2. Thermal analysis-- TGA, DTA, DSC. Problems based on calculation of weight loss, identification of endotherms, exotherms, interpretation of thermograms
   Chromatographic methods of analysis– HPLC, GC. Problems based on basic concepts, retention time, progress of reactions, % yield etc. AAS, UV – problems based on concepts
3. Interpretation and Application of the following spectral technique towards Structure elucidation of organic compounds- Mass spectroscopy, UV Spectroscopy, Infrared spectroscopy, ^{1}H-NMR Spectra, ^{13}C-NMR Spectra
4. Structure elucidation using a combination of UV, IR, NMR and Mass Spectral data