SYLLABUS FOR EXPERIENCED PROFESSIONALS

Project Engineer : Mechanical

Fluid Mechanics & Turbomachinery

Fluid properties; fluid statics, manometry, buoyancy, forces on submerged bodies, stability of floating bodies; control-volume analysis of mass, momentum and energy; fluid acceleration; differential equations of continuity and momentum; Bernoulli's equation; dimensional analysis; viscous flow of incompressible fluids, boundary layer, elementary turbulent flow, flow through pipes, head losses in pipes, bends and fittings.

Flow through Pipes: Introduction. Major and minor losses in pipe flow. Darcy-Weisbach equation for head loss due to friction in a pipe. Pipes in series, pipes in parallel, equivalent pipe-problems. Minor losses in pipe flow, equation for head loss due to sudden expansion. Hydraulic gradient line, energy gradient line. Pipe Networks, Hardy Cross method

Turbo machines; Momentum, and moment of momentum theory applied to moving blades; Change in total enthalpy and total pressure; Velocity triangles for radial and axial flow turbomachines; Basic aerofoil theory applied to axial flow blades; Non-dimensional performance parameters; Specific speed, flow coefficient and head coefficient.

Centrifugal compressors; Work required, polytropic efficiency, pressure rise, slip, effect of blade shape, two dimensional flow through impeller; Vaned diffuser and volute casing; Surging and choking of compressors; Compressor performance and characteristic curves.

Axial flow compressors; Cascade analysis, vortex theory, work required, polytropic efficiency, pressure rise, degree of reaction; Simple design calculations; Surging and stalling of compressors; Compressor performance and characteristic curves. Fans and Blowers; Construction and classification; Power required, pressure rise, efficiency calculations; Applications in boilers, cooling towers, and other industrial applications.

Theory of Machines

Displacement, velocity and acceleration analysis of plane mechanisms; dynamic analysis of linkages; cams; gears and gear trains; flywheels and governors; balancing of reciprocating and rotating masses; gyroscope.

Vibrations: Free and forced vibration of single degree of freedom systems, effect of damping; vibration isolation; resonance; critical speeds of shafts.

Engineering Mechanics

Free-body diagrams and equilibrium; trusses and frames; virtual work; kinematics and dynamics of particles and of rigid bodies in plane motion; impulse and momentum (linear and angular) and energy formulations, collisions.

Strength of Materials

Stress and strain, elastic constants, Poisson's ratio; Mohr's circle for plane stress and plane strain; thin cylinders; shear force and bending moment diagrams; bending and shear stresses; deflection of beams; torsion of circular shafts; Euler's theory of columns; energy methods; thermal stresses; strain gauges and rosettes; testing of materials with universal testing machine; testing of hardness and impact strength.

Metallurgy

Engineering Materials: Structure and properties of engineering materials, phase diagrams, heat treatment, stress-strain diagrams for engineering materials.

Casting, Forming and Joining Processes

Different types of castings, design of patterns, moulds and cores; solidification and cooling; riser and gating design. Plastic deformation and yield criteria; fundamentals of hot and cold working processes; load estimation for bulk (forging, rolling, extrusion, drawing) and sheet (shearing, deep drawing, bending) metal forming processes; principles of powder metallurgy. Principles of welding, brazing, soldering and adhesive bonding.

Machining and Machine Tool Operations

Mechanics of machining; basic machine tools; single and multi-point cutting tools, tool geometry and materials, tool life and wear; economics of machining; principles of non-traditional machining processes; principles of work holding, design of jigs and fixtures.

Metrology and Inspection

Limits, fits and tolerances; linear and angular measurements; comparators; gauge design; interferometry; form and finish measurement; alignment and testing methods; tolerance analysis in manufacturing and assembly.

Computer Integrated Manufacturing

Basic concepts of CAD/CAM and their integration tools.

Thermodynamics & Applications

Thermodynamic systems and processes; properties of pure substances, behavior of ideal and real gases; zeroth and first laws of thermodynamics, calculation of work and heat in various processes; second law of thermodynamics; thermodynamic property charts and tables, availability and irreversibility; thermodynamic relations.

Power Engineering: Air and gas compressors; vapour and gas power cycles, concepts of regeneration and reheat. I.C. Engines: Air-standard Otto, Diesel and dual cycles.

Refrigeration and Air-conditioning: Vapour and gas refrigeration and heat pump cycles; properties of moist air, psychrometric chart, basic psychrometric processes.

Turbomachinery: Impulse and reaction principles, velocity diagrams, Pelton-wheel, Francis and Kaplan turbines.

Heat & Mass transfer

Modes of heat transfer; one dimensional heat conduction, resistance concept and electrical analogy, heat transfer through fins; unsteady heat conduction, lumped parameter system, Heisler's charts; thermal boundary layer, dimensionless parameters in free and forced convective heat transfer, heat transfer correlations for flow over flat plates and through pipes, effect of turbulence; heat exchanger performance, LMTD and NTU methods; radiative heat transfer, Stefan-Boltzmann law, Wien's displacement law, black and grey surfaces, view factors, radiation network analysis.

Production Planning and Control

Forecasting models, aggregate production planning, scheduling, materials requirement planning.

Inventory Control

Deterministic models; safety stock inventory control systems.

Operations Research

Linear programming, simplex method, transportation, assignment, network flow models, simple queuing models, PERT and CPM.

Machine Design

Design for static and dynamic loading; failure theories; fatigue strength and the S-N diagram; principles of the design of machine elements such as bolted, riveted and welded joints; shafts, gears, rolling and sliding contact bearings, brakes and clutches, springs.

Contract Management

Contract and agreement, Essential elements of a valid contract, Discharge of a contract, Remedies in breach of a contract, Special contracts

Project Management

Project Management and Contract Administration, Initiation, Planning, Implementation, Hand Over/ Completion, Review & Close Out

WORK EXPERIENCE RELATED SYLLABUS

Pipelines

Process Diagrams (PFD, P&ID), Codes and Standards, Oil and gas terminology, Type of platforms, Pipeline Elements, Pipeline Materials, Pipeline Materials, Material Take off, Pipeline Drawings- Field layouts, Alignment sheet, Riser and spool GAD's, Crossing details, Trench details, Anode details, Monel sheathing,

Pipeline Wall Thickness Calculation, Cathodic protection, Valves, Specialties, Pipeline Supports and Clamps, Configuration of equipment, Pipeline Installation methods, Free span calculation

Terminals & Station Piping

General: Process Diagrams (PFD, UFD, P&ID, Line List etc.), Codes and Standards, Pipe Fittings, Pipe Flanges, Process Mechanical Equipments – Static equipments & Rotary equipments, Layouts- Preparation of Plot Plan, Preparation of Equipment Layouts, Preparation of Piping General Arrangement Drawings, Preparation of Cross Sectional Drawings, Piping Isometric Drawings & Material Take off, Pipe Supports, Preparation of Piping Material Specification, Valve Material Specification, Familiarity with ASME B31.3, Pipe Wall thickness Calculations, Preparation of Special Items Datasheets, Pressure Design of Miter Bends – Single & Multiple Miters, Pressure Design of Blanks, Branch reinforcement calculations, Overview of Technical Queries and Technical Bid Evaluations, Stress Analysis- Types of stresses, Significance of forces and moments, Introduction to Stress Analysis, Expansion Loop types, Bellows – Types

Process

Process Gas Compression System with Air cooling, Man-hours Estimation for the project, Relief and flare System, Storage tank Piping System, Distillation System, Storage tank Piping System, Distillation System, Pipe Materials, Pipe Supporting concepts, Support Spanning Calculation, Stress Analysis Concepts, Heat Exchanger Design, Evaluation of Control Valves, Pressure Relief Devices, HAZOP and HAZID Study, Basics of pipe selection, Sizing and specifications of various pressure vessels, Pump Design.

Project Engineer : Civil

Section 1 : Engineering Mathematics

Linear Algebra: Matrix algebra; Systems of linear equations; Eigen values and Eigen vectors.

Calculus: Functions of single variable; Limit, continuity and differentiability; Mean value theorems, local maxima and minima, Taylor and Maclaurin series; Evaluation of definite and indefinite integrals, application of definite integral to obtain area and volume; Partial derivatives; Total derivative; Gradient, Divergence and Curl, Vector identities, Directional derivatives, Line, Surface and Volume integrals, Stokes, Gauss and Green's theorems.

Ordinary Differential Equation (ODE): First order (linear and non- linear) equations; higher order linear equations with constant coefficients; Euler -Cauchy equations; Laplace transform and its application in solving linear ODEs; initial and boundary value problems.

Partial Differential Equation (PDE): Fourier series; separation of variables; solutions of one- dimensional diffusion equation; first and second order one-dimensional wave equation and two -dimensional Laplace equation.

Probability and Statistics: Definitions of probability and sampling theorems; Conditional probability; Discrete Random variables: Poisson and Binomial distributions; Continuous random variables: normal and exponential distributions; Descriptive statistics - Mean, median, mode and standard deviation; Hypothesis testing.

Numerical Methods: Accuracy and precision; error analysis. Numerical solutions of linear and non- linear algebraic equations; Least square approximation, Newton's and Lagrange polynomials, numerical differentiation, Integration by trapezoidal and Simpson's rule, single and multi- step methods for first order differential equations.

Section 2: Structural Engineering

Engineering Mechanics: System of forces, free -body diagrams, equilibrium equations; Internal forces in structures; Friction and its applications; Kinematics of point mass and rigid body; Centre of mass; Euler's equations of motion; Impulse- momentum; Energy methods; Principles of virtual work.

Solid Mechanics: Bending moment and shear force in statically determinate beams; Simple stress and strain relationships; Theories of failures; Simple bending theory, flexural and shear stresses, shear centre; Uniform torsion, buckling of column, combined and direct bending stresses.

Structural Analysis: Statically determinate and indeterminate structures by force/ energy methods; Method of superposition; Analysis of trusses, arches, beams, cables and frames; Displacement methods: Slope deflection and moment distribution methods; Influence lines; Stiffness and flexibility methods of structural analysis.

Construction Materials and Management: Construction Materials: Structural steel - composition, material properties and behaviour; Concrete - constituents, mix design, short-term and long -term properties; Bricks and mortar; Timber; Bitumen. Construction Management: Types of construction projects; Tendering and construction contracts; Rate
analysis and standard specifications; Cost estimation; Project planning and network analysis - PERT and CPM.

Concrete Structures: Working stress, Limit state and Ultimate load design concepts; Design of beams, slabs, columns; Bond and development length; Prestressed concrete; Analysis of beam sections at transfer and service loads.

Steel Structures: Working stress and Limit state design concepts; Design of tension and compression members, beams and beam - columns, column bases; Connections - simple and eccentric, beam - column connections, plate girders and trusses; Plastic analysis of beams and frames.

Section 3: Geotechnical Engineering

Soil Mechanics: Origin of soils, soil structure and fabric; Three-phase system and phase relationships, index properties; Unified and Indian standard soil classification system; Permeability - one dimensional flow, Darcy's law; Seepage through soils- two-dimensional flow, flow nets, uplift pressure, piping; Principle of effective stress, capillarity, seepage force and quicksand condition; Compaction in laboratory and field conditions; One- dimensional consolidation, time rate of consolidation; M ohr's circle, stress paths, effective and total shear strength parameters, characteristics of clays and sand.

Foundation Engineering: Sub-surface investigations -scope, drilling bore holes, sampling, plate load test, standard penetration and cone penetration tests; Earth pressure theories - Rankine and Coulomb; Stability of slopes - finite and infinite slopes, method of slices and Bishop's method; Stress distribution in soils -Boussinesq's and Westergaard's theories, pressure bulbs; Shallow foundations - Terzaghi's and Meyerhoff's bearing capacity theories, effect of water table; Combined footing and raft foundation; Contact pressure; Settlement analysis in sands and clays; Deep foundations - types of piles, dynamic and static formulae, load capacity of piles in sands and clays, pile load test, negative skin friction.

Section 4: Water Resources Engineering

Fluid Mechanics: Properties of fluids, fluid statics; Continuity, momentum, energy and correspondingequations; Potential flow, applications of momentum and energy equations; Laminar and turbulent flow; Flow in pipes, pipe networks; Concept of boundary layer and its growth.

Hydraulics: Forces on immersed bodies; Flow measurement in channels and pipes; Dimensional analysis and hydraulic similitude; Kinematics of flow, velocity triangles; Basics of hydraulic machines, specific

speed of pumps and turbines; Channel Hydraulics - Energy-depth relationships, specific energy, critical flow, slope profile, hydraulic jump, uniform flow and gradually varied flow

Hydrology: Hydrologic cycle, precipitation, evaporation, evapo-transpiration, watershed, infiltration, unit hydrographs, hydrograph analysis, flood estimation and routing, reservoir capacity, reservoir and channel routing, surface run- off models, ground water hydrology - steady state well hydraulics and aquifers; Application of Darcy's law.

Irrigation: Duty, delta, estimation of evapo -transpiration; Crop water requirements; Design of lined and unlined canals, head works, gravity dams and spillways; Design of weirs on permeable foundation; Types of irrigation systems, irrigation methods; Water logging and drainage; Canal regulatory works, cross-drainage structures, outlets and escapes.

Section 5: Environmental Engineering

Water and Waste Water: Quality standards, basic unit processes and operations for water treatment. Drinking water standards, water requirements, basic unit operations and unit processes for surface water treatment, distribution of water. Sewage and sewerage treatment, quantity and characteristics of wastewater. Primary, secondary and tertiary treatment of wastewater, effluent discharge standards. Domestic wastewater treatment, quantity of characteristics of domestic wastewater, primary and secondary treatment. Unit operations and unit processes of domestic wastewater, sludge disposal.

Air Pollution: Types of pollutants, their sources and impacts, air pollution meteorology, air pollution control, air quality standards and limits.

Municipal Solid Wastes: Characteristics, generation, collection and transportation of solid wastes, engineered systems for solid waste management (reuse / recycle, energy recovery, treatment and disposal).

Noise Pollution: Impacts of noise, permissible limits of noise pollution, measurement of noise and control of noise pollution.

Section 6: Transportation Engineering

Transportation Infrastructure: Highway alignment and engineering surveys; Geometric design of highways - cross-sectional elements, sight distances, horizontal and vertical alignments; Geometric design of railway track; Airport runway length, taxiway and exit taxiway design.

Highway Pavements: Highway materials - desirable properties and quality control tests; Design of bituminous paving mixes; Design factors for flexible and rigid pavements; Design of flexible pavement using IRC: 37 -2012; Design of rigid pavements using IRC: 58 -2011; Distresses in concrete pavements.

Traffic Engineering: Traffic studies on flow, speed, travel time - delay and O -D study, PCU, peak hour factor, parking study, accident study and analysis, statistical analysis of traffic data; Microscopic and macroscopic parameters of traffic flow, fundamental relationships; Control devices, signal design by Webster's method; Types of intersections and channelization; Highway capacity and level of service of rural highways and urban roads.

Section 7: Geomatics Engineering

Principles of surveying; Errors and their adjustment; Maps- scale, coordinate system; Distance and angle measurement- Levelling and trigonometric levelling; Traversing and triangulation survey; Total station; Horizontal and vertical curves. Photogrammetry - scale, flying height; Remote sensing -basics, platform and sensors, visual image interpretation; Basics of Geographical information system (GIS) and Geographical Positioning system (GPS).

PROJECT ENGINEER : ELECTRICAL

Equipment specifications & Design ;Engineering for Procurement & Construction; Improvement in Tender specifications ;Standardization of Specifications ; Technical evaluation of bids ;Review of vendor drawing & data ; Understanding the Single line diagram ;Motor testing (Motor Checker, IR, Moisture Absorption, PI etc) ;Termination of Motor (HT & LT) ;Hi-Pot testing of HT cable. ; Testing of transformer (Ratio/Magnetic balance etc.) ;Switchboard panel Control & Power circuit Drawing reading & understanding ;GIS maintenance procedure; Construction details of Generator, Exciter etc ; DAVR operation & troubleshooting ;Generator Protection System and GRP ; Brushless excitation system ;Working Principle of UPS system & types of UPS ;Working Principle of Battery Charger system ;Ni-Cd and Lead acid battery bank Maintenance & Commissioning ; Basic Principle of Variable Frequency Drive ;Monitoring of variable Frequency Drive from front display ;Trouble shooting and Repair of VFD ;Auto Transformer starting of HT Motors ;OISD and IS standard on industrial Lighting ;Basics of different protective devices such as ELCB, MCB etc ;Requirement of Earthing system ;Earth Resistance Measurement ;Construction of Earth pit & accessories ; Monitoring of parameters through relays, resetting etc ;Checking Relay settings, Binary inputs etc;
Programming of MOV, limit switch settings, commissioning etc ; Layout and monitoring of exchange for communication ; Trouble shooting on FCS, MCS and Exchange Card replacement ;Principle of CP systems ;Identification of Sacrificial anodes, replacement etc ;Principle of Heat tracing System ;Choice of heat tracing wrt the temperature requirement ;Understanding of Various types of Heat Tracing tapes and their usage ; Basic Knowledge on Area Classification basis Gas group, Zone, Temperature etc ;Knowledge on various types of flameproof equipment's and usage in particular area ;Knowledge on acceptability of various Flameproof equipment's ;Basics of Relay Coordination system ;CT and PT – selection & Testing ; Fault Level Calculation ;Type - II coordination for starter module ;Motor Protection Theory ; Transformer Protection ; Generator Protection Theory ;Unit Protection theory ;Bus Bar differential protection ;Overall Relay Coordination ;Basic knowledge on all available OISD standards ;Knowledge on OISD STD-113 ; Knowledge on OISD STD-105, 137, 173 ; Knowledge on OISD RP-110, 124, 147, 148, 149 ;Knowledge on OISD GDN-180 ; Knowledge of CEA Regulation & Approval process ;Electrical Safety ; Isolation & Release procedure for breaker / Starter ;Electrical Shock treatment plan ;Failure Analysis & Reporting

PROJECT ENGINEER : INSTRUMENTATION

- Basic Analog and Digital Electronics
- Electrical Circuits
- Power Electronics & Drives
- Measurement & Instruments
- Control systems –
- PID controlling & tuning,
- Open/Closed/Cascade loop control,
- Control system Networking/computer networks
- Field instrumentation systems –
- principle of working
- Diagnostics and troubleshooting
- Sensors, transducers and transmitters
- Industrial instrumentation for process variables like temperature, flow, pressure etc
- Continuous Emission Monitoring Systems and online process analyzers,
- Communication protocols – HART, Foundation Fieldbus, Wireless protocols and Serial communication etc.,
- Control valves and on/off valves
- Safety systems, PLC/DCS/SCADA - diagnostics and troubleshooting
- Pneumatic control systems

- Basic Data Acquisition Systems
- Loop wiring, Cabling
- Process safety and Safety systems

Further, Engineer should have knowledge of the following:
- Instrumentation Equipment specifications & Design
- Engineering for Procurement & Construction of Instrumentation projects
- Analyze and improvement of Tender specifications
- Standardization of Specifications
- Technical evaluation of bids.
- Review of vendor drawings & data
- Understanding P&IDs. PFDs
- OISD and IS standards on industrial Lighting
- Basic Knowledge on Area Classification Basis Gas group, Zone, Temperature etc
- Basic knowledge on OISD standards
- Failure Analysis & Reporting
- Knowledge of Indian and International Instrumentation Codes and Standards

REFINERY ENGINEER : CHEMICAL

Section 1: Process Calculations and Thermodynamics

Steady and unsteady state mass and energy balances including multiphase, multi- component, reacting and non -reacting systems. Use of tie components; recycle, bypass and purge calculations; Gibb's phase rule and degree of freedom analysis. First and Second laws of thermodynamics. Applications of first law to close and open systems. Second law and Entropy. Thermodynamic properties of pure substances: Equation of State and residual properties, properties of mixtures: partial molar properties, fugacity, excess properties and activity coefficients; phase equilibria: predicting VLE of systems; chemical reaction equilibrium.

Section 2: Fluid Mechanics and Mechanical Operations

Fluid statics, Newtonian and non- Newtonian fluids, shell -balances including differential form of Bernoulli equation and energy balance, Macroscopic friction factors, dimensional analysis and similitude, flow through pipeline systems, flow meters, pumps and compressors, elementary boundary layer theory, flow past immersed bodies including packed and fluidized beds, Turbulent flow: fluctuating velocity, universal velocity profile and pressure drop. Particle size and shape, particle size distribution, size reduction and classification of solid particles; free and hindered settling; centrifuge and cyclones; thickening and classification, filtration, agitation and mixing; conveying of solids.

Section 3: Heat Transfer

Steady and unsteady heat conduction, convection and radiation, thermal boundary layer and heat transfercoefficients, boiling, condensation and evaporation; types of heat exchangers and evaporators and their process calculations. Design of double pipe, shell and tube heat exchangers, and single and multiple effect evaporators.

Section 4: Mass Transfer

Fick's laws, molecular diffusion in fluids, mass transfer coefficients, film, penetration and surface renewal theories; momentum, heat and mass transfer analogies; stage -wise and continuous contacting and stage efficiencies; HTU & NTU concepts; design and operation of equipment for distillation, absorption, leaching, liquid-liquid extraction, drying, humidification, dehumidification and adsorption.

Section 5: Chemical Reaction Engineering

Theories of reaction rates; kinetics of homogeneous reactions, interpretation of kinetic data, single and multiple reactions in ideal reactors, non- ideal reactors; residence time distribution, single parameter

model; non- isothermal reactors; kinetics of heterogeneous catalytic reactions; diffusion effects in catalysis.

Section 6: Instrumentation and Process Control
Measurement of process variables; sensors, transducers and their dynamics, process modelling and linearization, transfer functions and dynamic responses of various systems, systems with inverse response, process reaction curve, controller modes (P, PI, and PID); control valves; analysis of closed loop systems including stability, frequency response, controller tuning, cascade and feed forward control.

Section 7: Plant Design and Economics
Principles of process economics and cost estimation including depreciation and total annualized cost, cost indices, rate of return, payback period, discounted cash flow, optimization in process design and sizing of chemical engineering equipment's such as compressors, heat exchangers, multistage contactors.

Section 8: Chemical Technology
Inorganic chemical industries (sulfuric acid, phosphoric acid, chlor-alkali industry), fertilizers (Ammonia, Urea, SSP and TSP); natural products industries (Pulp and Paper, Sugar, Oil, and Fats); petroleum refining and petrochemicals; polymerization industries (polyethylene, polypropylene, PVC and polyester synthetic fibers).

LAW OFFICER

- The Indian Contract Act
- The Indian Partnership Act
- The Arbitration & Conciliation Act, 1996 including 2015 Amendment
- The Constitution of India
- The Transfer of Property Act
- The Indian Easements Act
- The Sale of Goods Act
- The Indian Penal Code
- The Civil Procedure Code
- The Criminal Procedure Code
- The Indian Evidence Act
- The Consumer Protection Act
- The Essential Commodities Act
- The Competition Act
- Information Technology Act
- The Companies Act
- Negotiable Instruments Act
- Intellectual Property laws
- Legal Metrology Act

QUALITY CONTROL OFFICER

SECTION 1: PHYSICAL CHEMISTRY

STRUCTURE: Postulates of quantum mechanics: Time dependent and time independent Schrödinger equations. Born interpretation. Particle in a box. Harmonic oscillator. Rigid rotor. Hydrogen atom: atomic orbitals. Multi-electron atoms: orbital approximation. Variation and first order perturbation techniques. Chemical bonding: Valence bond theory and LCAO-MO theory. Hybrid orbitals. Applications of LCAO-MOT to H2+, H2 and other homonuclear diatomic molecules, heteronuclear diatomic molecules like HF,

CO, NO, and to simple delocalized – electron systems. Hückel approximn and its application to annular –electron systems. Symmetry elements and operations. Point groups and character tables. Origin of selection rules for rotational, vibrational, electronic and Raman spectroscopy of diatomic and polyatomic molecules. Einstein coefficients. Relationship of transition moment integral with molar extinction coefficient and oscillator strength. Basic principles of nuclear magnetic resonance: nuclear g factor, chemical shift, nuclear coupling.

EQUILIBRIUM: Laws of thermodynamics. Standard states. Thermochemistry. Thermodynamic functions and their relationships: Gibbs-Helmholtz and Maxwell relations, spontaneity and equilibrium. Absolute entropy. Partial molar quantities. Thermodynamics of mixing. Chemical potential. Fugacity, activity and activity coefficients. Chemical equilibria. Dependence of equilibrium constant on temperature and pressure.
Non-ideal solutions. Ionic mobility and conductivity. Debye-Hückel limiting law. Debye-Hückel-Onsager equation. Standard electrode potentials and electrochemical cells. Potentiometric and conductometric titrations.

Phase rule. Clausius- Clapeyron equation. Phase diagram of one component systems: CO_2, H_2O, S;
two component systems: liquid- vapour, liquid-liquid and solid-liquid systems. Fractional distillation. Azeotropes and eutectics. Statistical thermodynamics: microcanonical and canonical ensembles, Boltzmann distribution, partition functions and thermodynamic properties.

KINETICS: Transition state theory: Eyring equation, thermodynamic aspects. Potential energy surfaces and classical trajectories. Elementary, parallel, opposing and consecutive reactions. Steady state approximation. Mechanisms of complex reactions. Unimolecular reactions. Kinetics of polymerization and enzyme catalysis. Fast reaction kinetics: relaxation and flow methods. Kinetics of photochemical and photophysical processes.

SURFACES AND INTERFACES: Physisorption and chemisorption. Langmuir, Freundlich and BET isotherms. Surface catalysis: Langmuir-Hinshelwood mechanism. Surface tension, viscosity. Self-assembly. Physical chemistry of colloids, micelles and macromolecules. Heterogeneous catalysis.

DATA ANALYSIS: Mean and standard deviation; absolute and relative errors; linear regression; covariance and correlation coefficient.

SECTION 2: INORGANIC CHEMISTRY

MAIN GROUP ELEMENTS: Hydrides, halides, oxides, oxoacids, nitrides, sulfides –shapes and reactivity. Structure and bonding of boranes, carboranes, silicones, silicates, boron nitride, borazines and phosphazenes. Allotropes of carbon. Chemistry of noble gases, pseudohalogens, and interhalogen compounds. Acid-base concepts.

TRANSITION ELEMENTS: Coordination chemistry –structure and isomerism, theories of bonding (VBT, CFT, and MOT). Energy level diagrams in various crystal fields, CFSE, applications of CFT, Jahn-Teller distortion. Electronic spectra of transition metal complexes: spectroscopic term symbols, selection rules, Orgel diagrams, charge-transfer spectra. Magnetic properties of transition metal complexes. Reaction mechanisms: kinetic and thermodynamic stability, substitution and redox reactions.

LANTHANIDES AND ACTINIDES: Recovery. Periodic properties, spectra and magnetic properties.

ORGANOMETALLICS: 18-Electron rule; metal-alkyl, metal-carbonyl, metal-olefin and metal- carbene complexes and metallocenes. Fluxionality in organometallic complexes. Types of organometallic reactions. Homogeneous catalysis - Hydrogenation, hydroformylation, acetic acid synthesis, metathesis

and olefin oxidation. Heterogeneous catalysis - Fischer- Tropsch reaction, Ziegler-Natta polymerization.Cages and metal clusters.

NUCLEAR CHEMISTRY: Decay processes, half-life of radioactive elements, fission and fusion processes. Nuclear reactions, radio-analytical techniques and activation analysis.

BIOINORGANIC CHEMISTRY: Ion (Na+ and K+) transport, oxygen binding, transport and utilization, electron transfer reactions, nitrogen fixation, metalloenzymes containing magnesium, molybdenum, iron, cobalt, copper and zinc.

CHEMICAL PERIODICITY : Ionisation Energy, Atomic Radius, Electronegativity, Electron Affinity

SOLIDS: Crystal systems and lattices, Millerlaw,ionic plane crystals, structures of AX, AX2, ABX3 type compounds, spinels, band theory, metals and semiconductors.

INSTRUMENTAL METHODS OF ANALYSIS: UV-visible spectrophotometry, NMR and ESR spectroscopy, mass spectrometry. Chromatography including GC and HPLC. Electroanalytical methods- polarography, cyclic voltammetry, ion-selective electrodes. Thermoanalytical methods.

SECTION 3: ORGANIC CHEMISTRY

STEREOCHEMISTRY: Chirality of organic molecules with or without chiral centres and determination of their absolute configurations. Relative stereochemistry in compounds having more than one stereogenic centre. Homotopic, enantiotopic and diastereotopic atoms, groups and faces. Stereoselective and stereospecific synthesis. Conformational analysis of acyclic and cyclic compounds. Geometrical isomerism. Configurational and conformational effects, and neighbouring group participation on reactivity and selectivity/specificity.

REACTION MECHANISMS: Basic mechanistic concepts –kinetic versus thermodynamic contro postulate and Curtin-Hammett principle. Methods of determining reaction mechanisms through identification of products, intermediates and isotopic labelling. Nucleophilic and electrophilic substitution reactions (both aromatic and aliphatic). Addition reactions to carbon-carbon and carbon-heteroatom (N,O) multiple bonds. Elimination reactions. Reactive intermediates – carbocation, carbanions, carbenes, nitrenes, arynes and free radicals. Molecular rearrangements involving electron deficient atoms.

ORGANIC SYNTHESIS: Synthesis, reactions, mechanisms and selectivity involving the following classes of compounds –alkenes, alkynes, arenes, alcohols, phenols, aldehydes, ketones, carboxylic acids, esters, nitriles, halides, nitro compounds, amines and amides. Uses of Mg, Li, Cu, B, Zn and Si based reagents in organic synthesis. Carbon-carbon bond formation through coupling reactions - Heck, Suzuki, Stille and Sonogoshira. Concepts of multistep synthesis - retrosynthetic analysis, strategic disconnections, synthons and synthetic equivalents. Umpolung reactivity –formyl and acyl anion equivalents. Selectivity in organic synthesis –chemo-, regio- and stereoselectivity. Protection and deprotection of functional groups. Concepts of asymmetric synthesis –resolution (including enzymatic), desymmetrization and use of chiral auxilliaries. Carbon-carbon bond forming reactions through enolates (including boron enolates), enamines and silyl enol ethers. Michael addition reaction. Stereoselective addition to C=O groups (Cram and Felkin-Anh models).

COMMON NAMED REACTIONS AND REARRANGEMENTS: Applications in organic synthesis.

PERICYCLIC REACTIONS AND PHOTOCHEMISTRY: Electrocyclic, cycloaddition and sigmatropic reactions. Orbital correlations - FMO and PMO treatments. Photochemistry of alkenes, arenes and carbonyl compounds. Photooxidation and photoreduction. Di-π-methane rearrangement, Barton reaction.

HETEROCYCLIC COMPOUNDS: Structure, preparation, properties and reactions of furan, pyrrole, thiophene, pyridine, indole, quinoline and isoquinoline.

BIOMOLECULES: Structure, properties and reactions of mono- and di-saccharides, physicochemical properties of amino acids, chemical synthesis of peptides, structural features of proteins, nucleic acids, steroids, terpenoids, carotenoids, and alkaloids.

SPECTROSCOPY: Applications of UV-visible, IR, NMR and Mass spectrometry in the structural determination of organic molecules.

AROMATICITY: Benzenoid and non-benzenoid compounds –generation and reactions.

PETROLEUM CHEMISTRY: Origin & synthesis of petroleum products, Distillation of Crude Oil, Hydrogenation, dehydrogenation, Thermal, hydro and catalytic cracking, Isomerisation, Visbreaking

HUMAN RESOURCE OFFICER

Manpower/workforce Planning

Job Analysis, forecasting techniques, job design, Manpower Planning process, Forecasting techniques, Demand and Supply, Outsourcing, Current Trends.

Recruitment and Selection

Interviewing techniques, methods of selection, psychometric tools, Employee Value Proposition, Recruitment metrics, use of technology in recruitment, Employee onboarding, Employer branding , Government guidelines on Recruitment.

Performance Management

Balanced scorecard, force ranking method, performance appraisal system, Performance Appraisals Methods, feedback, Rating biases, career planning, job rotation, job enrichment, succession planning, Reward and Recognition schemes, 360 degree feedback, Assessment centers.

Capability Building

Training design and implementation models, Leadership theories, Training need analysis, Training evaluation models, leadership development programs, sensitivity trainings, knowledge management system, different approaches to learning – e-learning, micro-learning, Development Centers

Compensation Management

Job Evaluation, Internal and External equity, concept of cafeteria payments, Theories of compensation, concept of wages, job satisfaction, Government guidelines.

Industrial Relations

Conflict Resolution Techniques, Grievance Handling mechanisms, Negotiation styles, negotiation process, Collective Bargaining, history of industrial relations in India, Approaches to IR, Trade Union movement, Whistle Blower policy, Disciplinary action approach and process.

Labour Laws

Introduction; Trade Union Act 1926, Industrial Dispute Act 1947, Industrial Employment Act (standing order act) 1946, Factories Act, 1948, EPF Act, 1952, ESI act, 1948, Workmen's Compensation Act 1923,

Maternity Benefit Act, 1961, Payment of Gratuity Act, 1972, Contract Labor act 1970, Child Labor Act, 1970, Prevention Of Sexual Harassment (POSH) Act , Code on Wages 2019.

Organizational Development

HRM Models, Change management theories, Motivation theories, Measures of employee engagement, Exit Interview analysis, Attrition Analysis, Employee engagement survey, basics of statistics, validity, reliability, measures of central tendency, frequency distribution, correlation and regression, Research design, sampling techniques, data collection techniques, culture dimension models, Employee Assistance program, personality theories, group dynamics, group formation process, group norms, organization structure – types, HR Audit, HR Scorecard, Emotional Intelligence, Values, communication modes, barriers to communication, Strategic HRM, Diversity and Inclusion, Organizational Citizenship Behaviour

Corporate Social Responsibility

Corporate Social Responsibility, Corporate Social Value, Employee Volunteerism,

Human Resource Information System

Human Resource Management-Systems Approach, strategic Role of Information in HRM, Information Technology-Concepts & Issues, HRIS Philosophy ,HRIS Implementation and Control, HR Analytics

FIRE & SAFETY OFFICER

Fire Engineering Fundamentals: Chemistry of Fire, Combustion process, Limits of Flammability, Flame Spread, Effects of Heat, Fire Resistance, Fire Load,

Fire Fighting Chemicals: Water, Foam, DCP, Clean agents

Fire Detection & Control: Fire Detection principles, classification of detectors, Fire Extinction methods, water based, chemical based, clean agent systems, operation and maintenance of detection / alarm systems

Fire Protection – I (Special hazards: Industrial Fires): Fire Suppression Systems, Fire Water systems, sprinkler systems, Fire resistant construction, Emergency exists

Fire Protection – II (Special hazards: Flammable Liquid Storages): Plant siting considerations, Ignition source control, Hazards of Bulk storages, Fire Protection for Flammable storages, Passive barriers

Fire Services Hydraulics: Sprinkler system demand, hydraulics of sprinkler systems,

Fire Safety Laws: Doctrine of Sovereign immunity; Factories Act, Explosives act, Petroleum act

Fire Codes and Standards: Standards for Fire Equipment, Personal Safety equipment

Paramedics / First Aid: Management of Burns, Fractures, wounds, trauma handling

Inspection & Testing of Fire Fighting Systems: Fire Sprinkler testing, OISD/NFPA standards for testing & Inspection, Fire Pumps testing

Safety Management: Goals & Need of Safety, Accident Prevention, Accident Investigation, Personal Protection equipment

Safety in Construction: Safety in welding & gas cutting, excavations, work at height, electrical, material handling, lifting/hoisting.

Safety Engineering: Accident trends in Industry, Safety Indices, Frequency & Severity Rates, Job Safety Analysis, work permit administration.

NOTE: The syllabus/topics mentioned are indicative in nature. Candidates are also expected to possess significant knowledge/proficiency pertaining to their qualifying degree/Post graduation