DETAILED SYLLABUS FOR THE POST OF CHEMICAL INSPECTOR/ TECHNICAL ASSISTANT (CHEMICAL) (Factories and Boilers)

TOTAL MARKS : 100

MODULE 1

PROCESS CALCULATIONS AND THERMODYNAMICS (10 marks)

Basic concepts: mole, weight percent, mole percent, normality, molarity, molality, vapour pressure, absolute pressure, gauge pressure. Conversion of units, Ideal gas, Dalton's Law, Amagat's law, Steady and unsteady state mass and energy balances including multiphase, multi-component, reacting and non-reacting systems, recycle, bypass and purge calculations.

Laws of thermodynamics, applications of first law to closed and open systems. Equations of state for real gases – van der Waals equation, Redlich-Kwong equation and Virial equations. Compressibility charts. Second law and Entropy. Thermodynamic properties of pure substances: Work function, Gibbs free energy, fugacity, activity, residual properties, properties of solutions: partial molar properties, fugacity in solutions, activity coefficients, excess properties; phase equilibria: predicting VLE of systems; chemical reaction equilibria.

MODULE 2

FLUID MECHANICS (10 marks)

Properties of fluids: Density, Specific gravity, Viscosity, Compressibility; Newton's law of viscosity, Newtonian and Non-Newtonian fluids, U Tube, Differential & Inclined tube Manometers.

Laminar flow, Turbulent Flow, Critical Velocity, Reynolds Number, Boundary layer-formation, separation and wake formation. Flow through pipes: Continuity, Navier Stokes and Bernoulli's equations. Velocity distribution in pipes, effect of roughness, friction factor. Fluid Friction in straight pipes and fittings, Hagen-Poiseuille equation, Empirical equation for friction factor, friction loss in pipes and fittings. Flow past immersed bodies: drag, stream lining, friction in flow through beds of solids; Fluidization.

Selection of pipe sizes, pipe fittings, types and selection of valves, Flow Measurement: Venturi meter, orifice meter, pitot tube, rotameter.

Pump classifications, NPSH, Priming of centrifugal pumps and self-priming, fans, blowers, compressors and, vacuum systems - vacuum pumps and ejectors.

MODULE 3

PARTICLE TECHNOLOGY (8 marks)

Particle size and shape, types of screens, screen analysis, particle size distribution; size reduction and classification of solid particles: Types of crushing equipments, coarse crushers, Intermediate crushers, fine grinders; Laws of crushing.

Agitation and mixing: Purpose of agitation, agitation equipment: propellers, paddles and turbines, Flow pattern in agitated vessels, prevention of swirling, draft tubes and baffles, power consumption in agitated vessels. Mixers for solids and pastes.
Crystallization: crystal geometry, principles of crystallization, nucleation, crystal growth, equipments for crystallization.

Filtration: applications, classification of filters, Filter operation, constant pressure and constant volume filtration. Centrifugation, classification of centrifuges. Sedimentation, free and hindered settling, Clarifiers and thickeners, Separation of solids from gases: cyclone separator, bag filter, Electrostatic precipitator.

Storage and transportation of solids: Hoppers, bins, devices for discharge of solids: different types of conveyors; storage of liquids: storage tanks, Storage of volatile liquids – floating roof tanks, Storage of gases: Horton sphere, pressure cylinders, gas holders.

MODULE 4

HEAT TRANSFER (10 marks)

Heat transfer by conduction: Fourier's law, thermal conductivity, steady state and unsteady state heat transfer, Steady state conduction through composite plane, cylindrical and spherical walls, overall heat transfer coefficient from individual heat transfer coefficients. Critical thickness of insulation.

Forced and free convections: Heat Transfer to fluid without phase change, thermal boundary layer and hydro dynamic boundary layers. Newton's law, Dimensionless numbers in heat transfer, Correlations for forced and free convection heat transfer. Reynolds, Prandtl and Colburn analogies.

Boiling and condensation: Boiling phenomena, regimes of pool boiling. Dropwise and film type condensation, Effect of non-condensable gases on rate of condensation, heat transfer coefficients for boiling and condensation.

Heat transfer by radiation: Blackbody, emissivity, Laws of radiation, view factor, radiation shield.

Heat transfer equipments: Types of heat exchangers, parts of shell and tube and

double pipe heat exchangers. LMTD and LMTD correction factor, fouling factor, Calculation of heat transfer area, types of reboilers and condensers.

Evaporation: Types of evaporators, Single and multiple effect evaporators, Area, capacity, steam economy, boiling point elevation, method of feeding in multiple effect operation.

MODULE 5

MASS TRANSFER OPERATIONS (10 Marks)

Molecular diffusion: Fluxes J_A and N_A, Fick's law, steady state and Equimolal counter diffusion, mass transfer coefficients: film, penetration and surface renewal theories.

Absorption: Mechanism of Absorption, choice of solvent, conditions of equilibrium between gas and liquid, multistage and continuous operation of absorbers and strippers.

Adsorption: Types of adsorption, adsorbents, adsorption isotherms.

Humidification: Absolute and relative humidity, Percentage saturation, dew point. Adiabatic saturation temperature, wet bulb temperature, types and operation of cooling towers.

Distillation: Boiling point diagram and equilibrium curves, application of Raoult's law, relative volatility, Types of distillations: Simple distillation, steam distillation Azeotropic distillation, extractive distillation and fractional distillation. Use of open steam.

Extraction: Applications, effect of temperature and pressure, choice of solvent, equipment for stagewise and continuous contact.

Leaching: applications, cross current and counter current leaching.

Drying: Purpose and industrial applications, Mechanism of drying, rate of drying, batch and continuous driers.

MODULE 6

CHEMICAL REACTION ENGINEERING (10 marks)

Theories of reaction rates, Arrhenius law, Collision theory, transition state theory, kinetics of homogeneous reactions, interpretation of kinetic data – constant volume and variable volume batch reactors, Steady state flow reactors, single and multiple reactions in ideal reactors, series and/or parallel combination of ideal reactors.

Kinetics of enzyme reactions (Michaelis-Menten and Monod models).
Non-ideal reactors; residence time distribution, E, C and F curves, Conversion from tracer information, single parameter models, multi parameter models and zero parameter models.

MODULE 7

INSTRUMENTATION AND PROCESS CONTROL (10 marks)

Principles of measurement: Static and dynamic characteristics of measuring instruments. Instruments for indication, recording and remote control of Temperature – filled system thermometers, thermocouples, resistance thermometers, radiation pyrometer. Pressure and vacuum diaphragm gauges, bellow gauges, strain gauges. Level measuring instruments, Specific gravity and Humidity measurement, Instrumental methods of composition analysis: Chromatographic analysis – flame photometry, spectrophotometry. Process Control: First order and second order system response and characteristics, Open loop and closed loop transfer functions, poles, zeros, Control room – panels and control room functions, P, PI and PID Controllers, offset, effects of integral and derivative actions, Control valves – types and characteristics.

Stability analysis: Routh test, Bode stability criteria. Gain and phase margins, Zeigler Nichols tuning criteria. Time integral performance criteria.

Advanced control systems: Cascade control, feedforward and ratio controls, dead time compensation.

MODULE 8

ENERGY, ENVIRONMENT AND SAFETY ENGINEERING (12 marks)

Conventional, un-conventional and non-conventional energy sources, thermal, hydel and nuclear power plants, efficiency, merits and demerits of the above power plants, fluidized bed combustion, combined cycle power plants.

Solar energy, flat plate collectors, focusing collectors, solar pond, solar thermal power generation, solar energy application in India. Ocean wave energy conversion, ocean thermal energy conversion, tidal energy conversion, wind energy. Energy from biomass, Energy audit and Energy conservation in chemical process plants.

Sources and classification of wastewater- Types of water pollutants and their effects- Wastewater sampling, preservation and analysis- Physical, chemical and biological characteristics of wastewater-determination of solids and organic matter-dissolved oxygen (Oxygen Sag Curve) - biochemical oxygen demand-chemical oxygen demand - wastewater microbiology. Wastewater treatment methods - pretreatment - primary treatment - secondary treatment - tertiary treatment-advanced treatment methods. Air

pollution: sources, classification. Sampling and analysis of air pollutants, Solid waste management, Noise pollution - effects of noise on people.

Safety in the site selection and lay out, Classification of Fire- Pool fire, Jet fire, Flash fire, Explosion-UVCE, BLEVE, Dust explosion, Deflagration, Detonation. Toxic release, Runaway Reaction. Fire pyramid. Types of fire extinguishers and its handling. Fixed fire protection systems. Relief system and Detectors. Hazard rating of chemical plants- Dow index and Toxicity index. Emergency planning-onsite and offsite emergency planning, Mock drill. Safety Inspections, safety Audits, safety Analysis, Hazard Survey and analysis, HAZOP, Bow tie diagram, Fault tree analysis, failure mode and effect analysis, Event tree analysis, The concept of inherent safety. Occupational Health and Safety Administration, Safety provisions in Factories Act.

MODULE 9

CHEMICAL TECHNOLOGY (10 marks)

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), Rubber – tyre industry, vulcanization.

Petroleum refining: Origin and formation of Petroleum, Drilling operations, Evaluation and Characterization of crude. Transportation & Storage of Petroleum, pre-treatment of Crude, Atmospheric distillation &Vacuum distillation of crude, Cracking, Reforming, Isomerization, Alkylation, Polymerization. Bharath stage norms of Diesel and Gasoline.
Petrochemicals: Types of plastics, Polymerization processes, polymerization industries (polyethylene, polypropylene, PVC and polyester, synthetic fibers - nylon and viscous rayon).

MODULE 10

ECONOMICS AND MANAGEMENT OF CHEMICAL INDUSTRIES (10 marks)

Time value of money and equivalence, equations used in economic analysis, methods of calculating depreciation and total annualized cost, cost indices, rate of return, payback period, discounted cash flow, cost estimation techniques, profitability analysis, break-even analysis, inflation, principles of accounting, profit and loss account, balance sheet account.

Project Management, Network construction, Arrow diagram, Redundancy. CPM and PERT

Networks, Scheduling computations, PERT time estimates, Probability of completion of project, crashing. Operations management, Human resources management, Marketing management, Financial management, Entrepreneurship, Business plans, Corporate social responsibility, Patents and Intellectual property rights.

NOTE: - It may be noted that apart from the topics detailed above, questions from other topics prescribed for the educational qualification of the post may also appear in the question paper. There is no undertaking that all the topics above may be covered in the question paper.

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