

# MPT1: Technical Assistant Gr. III (1): Diploma in Chemical Engineering

## Syllabus for Paper III (Core)

*Taken from curriculum of diploma course in chemical engineering (State board of Kerala Technical education)*

### CHEMICAL PROCESS PRINCIPLES

Units and dimensions, conversion of units, dimensionless group, chemical formulae, mass relation, chemical reactions, gm atom, gm mole, kg atom, kg mole, Relation between mass and volume of gaseous substances. Method of expressing compositions of mixture of solids, liquids and gases, Density, specific gravity and specific gravity scales.

**Material Balances:** Types of processes - Material balances equations – key component - material balances problem involving mixing, leaching, crystallization, evaporation, distillation, absorption – simple problem involving bypass and recycle. Chemical reactions, complete and incomplete reactions, stoichiometric proportions of reactants and product limiting reactant and excess reactants, percentage conversion and yield. Material balance calculation involving chemical reactions including combustion problems

### CHEMICAL ENERGETICS

Reversible & Irreversible reaction, Exothermic & endothermic reactions; Systems & surroundings – Types of Systems-Open, closed, Isolated; pressure, volume temperature, work, energy, internal energy, total heat, concept of perfect gas, Fundamentals of thermodynamics, Thermodynamic Processes-Isothermal, Adiabatic, Isobaric, Isochoric; First Law of Thermodynamics; Internal energy (E) and Internal energy change (E) Concept of Work & Heat; Mathematical expression for the 1st Law of thermodynamics. Enthalpy (H) and Enthalpy Change (H), Entropy (S) and Entropy Change (S) Second Law of Thermo dynamics -Gibbs Free energy (G) and Gibbs free energy change; Third Law of Thermodynamics. Law of conservation of energy and applications.

### PROPERTIES OF FLUID, FLUID STATISTICS AND FLUID DYNAMICS

**Properties of fluids:** compressible and incompressible fluids – viscosity – definition, units and determination of viscosity. Viscosity of gases and liquids and their variation with temperature and pressure. Viscosity index – Newtonian and Non-Newtonian fluids. Laws of fluid statics and its application – fluid pressure – units and its measurements – concept of fluid heads and its calculations, gauge pressure – manometers, construction, working and calculation of pressure difference based on reading of the different types of manometers, industrial type manometers.

**Fluid dynamics:** Types of fluid flow in pipes, viscous and turbulent flow, Reynold's experiment, critical velocity, problems, types of fluid heads – static head, kinetic head, impact head, potential head, definitions and expressions.

**Fluid flow:** Stream line and turbulent flow – Pressure energy, Potential energy and kinetic energy of a liquid – Equation of continuity – Bernoulli's theorem – Applications

**Pipes and pipe fittings:** Pipe and tube standards, fittings for screwed, welded and flanged joints. Gaskets and packing: - Rubber, plastic, cork, rubber cork, asbestos, compressed asbestos fiber, metallic gaskets. Sealing of rotating shafts – stuffing boxes and mechanical seals. Fundamentals of flow control mechanism and valve classifications-valve materials -Gate valve and its variations like sluice valve and slide valve- Plug valve (cocks) – 2 way and 3 way and non-lubricating plug valves- Constructional details of Ball valves – Globe valve- Butterfly valve Diaphragm valve.

**Flow measurement:** Variable head meters – orifice, venturi and pitot tube, annular tube – variable area meters – rotameter – positive displacement meters, current or propeller type flow meters, weirs, notches, hot wire anemometers Level measurement: Sight glasses, float type, displacement type (torque tube), diaphragm box, bubbler system, electrical methods, radiation methods Specific gravity, Off line and on line measurement, Humidity, Dew point method, wet bulb method, hygrometry, electrical type. Moisture content in different products

**Fluid Handling Equipment:** Pumps-Pump classifications – Positive displacement and Centrifugal. Positive displacement pumps – reciprocating and rotary – reciprocating type – piston plunger pumps –simplex and duplex – single acting and double acting. Diaphragm pumps – Rotary – gear pump, screw pumps, lobe pumps. Fluid displacement pumps – Airlift, Acid egg, Jet pumps, Electromagnetic pumps. Centrifugal pumps: - Basic working principles, types of impellers for different fluids, single suction and double suction type. Split case and multistage pumps. Priming of centrifugal pumps and self-priming pumps. Turbine pumps, NPSH, cavitation, selection of pumps based on liquid characteristic, head, capacity etc: - Fans, Blowers, compressors – Positive displacement blowers, turbo blowers, turbo compressors, positive displacement compressors, vacuum pumps and ejectors. Nash Hytor. Installation, start up and shut down procedures of above machineries.

## HEAT TRANSFER

**Heat transfer by conduction:** Heat transfer by conduction in solids – steady state and unsteady state flow – definition – units of heat flow. Fourier's law of conduction – Rate equation for heat flow – steady state heat flow conduction through single wall; Thermal conductivity. Steady state conduction through composite wall in series; Steady state conduction through cylindrical wall and spherical wall.

**Theory of convection** – film concept of heat transfer temperature gradient in forced convection – derivation of overall heat transfer coefficient from individual heat transfer coefficient.

**Forced convection and Radiation:** Heat transfer by forced convection inside tubes for laminar and turbulent flow –heat transfer to fluid without phase change – mechanism of natural convection – heat transfer in boiling liquids – flash boiling sub cooled boiling – saturated boiling – regimes of boiling – maximum and minimum radiation – elementary idea of black body – gray body- emissivity – emissive power – radiation laws; radiation between surfaces; combined heat losses by convection and radiation.

**Heat Exchangers:** Parallel flow – counter current flow – cross flow heat exchangers – Fouling effect calculation – LMTD – calculation in heat exchangers – Heat transfer equipment – Heaters and heat

exchangers – single pass shell and tube heaters; Multi-pass heaters – economic number of passes, allowances for expansion in heaters and heat exchange, floating head heaters – use of baffles on shell side of heat exchangers, double pipe heat exchangers – plate type heat exchangers – air fin cooler – calculation of heat transfer area and length of tubes.

**Evaporation** – Examples of industries where evaporation is used as a unit operation. Types of evaporators – basis of classification – horizontal tube – vertical tube – climbing film – falling film – forced circulation evaporators – examples of application of each in industries - continuous operation and control of evaporators – evaporator accessories – entrainment separator – condensers, vacuum pump – steam trap – salt catchers – continuous salt removal, evaporation under vacuum – operational difficulties.

Multiple effect evaporation – principle of multiple effect evaporation – operation of multiple system – method of feeding – advantages of multiple effect evaporation – steam economy and capacity. Temperature distribution in multiple effect and effect of boiling point

## MASS TRANSFER

**Diffusion:** Molecular diffusion-molar flux

**Absorption:** conditions of equilibrium between gas and liquid – Henry's law – factors controlling rate of absorption – equipment for absorption operations – packed tower – packing materials – characteristics of packing – liquid distributors – channeling

**Absorption:** Physical and chemical adsorption – various types of adsorbents – applications – manufacture of adsorbents; ion exchange – principle — molecular sieves

**Humidity:** General mechanism of diffusion processes – Definitions and mathematical expressions for molal humidity – Absolute humidity – Relative humidity – percentage humidity – Humid volume – Humid

heat – Enthalpy and dew, Humidity chart – its importance and applications, Adiabatic saturation temperature – wet bulb temp cooling towers – atmospheric – natural and forced draft, cross flow type – humidification and dehumidification – air conditioning

**Drying:** Purpose and industrial applications – drying equipment – classifications – tray dryer – tunnel dryer – rotary dryer – turbo dryer – spray dryer – drum dryer – cylinder dryer – fluid bed dryer – dry basis and wet basis of expression of moisture content – equilibrium moisture content – free moisture content – bound and unbound water – mechanism of batch drying of solids – constant rate and falling rate period. Derivations of equations for time of drying in constant rate and falling rate

**Distillation:** Distillation as an interphase mass transfer, industrial applications, definition of terms – less volatile, more volatile, low boiling, high boiling – vapor – liquid equilibrium diagrams and their importance. Ideal and non-ideal solutions, Azeotropes – maximum and minimum boiling – volatility and relative volatility – calculation of relative volatility of a binary mixture. Types of distillation. – equilibrium – simple distillation- steam distillation.

## INSTRUMENTATION AND PROCESS CONTROL

**Measurement of Temperature, Pressure, Flow & Level :** Principles of measurement –Instruments for indication, Process variables to be measured in chemical industries- static and dynamic characteristics - elementary principles and description of the instruments used for the measurement of the following; Temperature – filled system thermometers –thermocouples, resistance thermometers, total radiation and optical pyrometers. Pressure and vacuum – manometers – diaphragm gauges, bellow gauges, Bourden gauges, absolute pressure gauges, Mc load gauges pirani gauge, piezo resistance and ezo electric transducers. Different flow meters and level measuring instruments- Level measurement: float type, displacement type , diaphragm box, bubbler system, electrical methods, radiation method

**Measurement of viscosity, specific gravity, humidity:** Viscosity—Ostwald-continuous viscometer Sp. Gravity- Displacement meter, hydrometer; Humidity- Absolute humidity, specific humidity, relative humidity, wet bulb and dry bulb temperature, dewpoint temperature; Dew point method, wet bulb method, hygrometry, electrical type. pH- significance- scale-liquids, Electrodes- glass, calomel, pH meter- principle-sensing elements-immersed type

**Process control & Computer Aided Process Modeling Simulation:** Process -control variables-terms types of control action-proportional integral, PI-PD-PID process control system open and closed loop systems – block diagrams of back ward feed, forward feed controls – types of control modes – on-off, proportional, integral, derivative, and their combinations. Comparison of different types of controls- temperature control of air oven instrumentation diagrams- various controlling methods-- feedback control- feed forward control, controllers-working of flapper nozzle Pneumatic Control- Various control valve plugs-. Final control elements – control valves, actuators, fluid flow control valve.

Basics, Measurement of Temperature, Pressure, Vacuum, Head and Level, Process recording equipment, control systems

Introduction to process modelling and simulation, tools of simulation, approaches of simulation, planning of calculation in a plant simulation.

## PARTICLE TECHNOLOGY

**Filtration:** Filtration as a solid, liquid separation and its application in industry. Classification of filters atmospheric, pressure and vacuum filters – field of application and constructional details, working and application of 1) 1. Sand filter – open – closed 2) Filter presses – plate and frame filter press, non-washing, open delivery, washing, closed delivery 3) Leaf filters – pressure and vacuum types – Moore filter. 4) Continuous filter – rotary drum – working cycle, methods of cake discharge, installation – horizontal pan filters – tilting pan filters – selection of filters – filter aids, their function and applications – pre-coating, filter media – types of filter mediums and its specific applications – properties of filter medium and selection.

**Centrifugation:** Centrifugal force developed in centrifuges – classification of centrifuges, batch semi continuous, continuous, top driven, bottom driven, perforated solid bowl, super centrifuges, operation and field of application.

**Size Reduction:** Nature of the materials to be crushed – hardness, structure, moisture content, crushing strength, stickyness, soapyness, explosiveness; Types of crushing equipment, coarse crushers –Intermediate crushers –fine grinder, open circuit grinding – closed circuit grinding, Jaw crusher, gyratory crusher, crushing rolls, angle of nip; hammer mill, knife mill, ball mill.

Average particle size – specific surface of mixture, volume surface mean diameter – arithmetic mean diameter – mass mean diameter – shape factor.

**Size Separation:** Screens- Tyler and US standard screens, Screen analysis- efficiency and capacity of screens; Types of screening equipment – grizzlies – trammels, shaking screens, vibrating screens, separation of solids in liquids. Theory of settling, free and hindered settling.

**Agitation/ Mixing:** Purpose of agitation, agitation equipment, Types of Impellers- propellers, paddles and turbines. Flow pattern in agitated vessels – prevention of swirling – draft tubes and baffles - their functions and effects. Power consumption in agitated vessels Mixing of solids to solids. Ribbon blender – double cone, 'V' type mixers – pug mill.

**Storage and Transportation of Solids, Gases and Liquids:** Storage of solids – Hoppers, bins, angle of repose. Devices of for discharge of solids –Open storage of solids. Conveyor types – Belt conveyor, Chain conveyor, Scraper conveyor, Apron conveyor, Bucket conveyors, Bucket elevators, Screw conveyors, Pneumatic conveyors, Pneumatic conveying system Auxiliary equipment – Field of application of the above conveyors.

Storage of liquid-storage tanks, Storage of volatile liquids – floating roof,

Storage of gases- Horton sphere, Wet and Dry specifications and codes for gas storage, Safety precautions.

## BIOCHEMICAL ENGINEERING

Fermentation and Fermentation Equipment: Schematic representations-fermenter –construction details-controlling parameters-pH, temperature, dissolved oxygen, foaming; aerobic and anaerobic process, -solid state fermentation (SSF) and submerged fermentation (SmF)-reactors for SSF and SmF bioreactors; Manufacture of ethyl alcohol

## PLANT UTILITIES AND MAINTENANCE

**Air and Water:** Cooling Water - Production of Cooling Water, Distribution of Cooling, Chilled Water-Preparation of Chilled Water; Boiler Feed Water – Water treatment methods - Lime soda process, Hot and cold water, Advantages and Disadvantages, Ion exchange Process; Air handling Equipments- Instrument Air, Preparation methods, Heating and Cooling of air, compressed Air - Plant air.

**Steam and Boilers:** Properties of steam – Explanation of properties of steam such as total heat of water - latent heat total heat of steam, super heat, dryness fraction. Function of boilers –

classification – working principle; fire tube and water tube boilers, Simple vertical boiler, Cochran boiler- Babcock and Wilcox boiler High pressure boilers, Benson boiler, Lamont boiler, Boiler mountings, accessories.

**Operational Maintenance of Plant Equipment:** Principle of management – types of maintenance - Breakdown maintenance, scheduled maintenance, Preventive maintenance- Advantages, Objective of Preventive maintenance -

**Industrial Safety and Environmental Engineering:** Safety practices in a chemical industry – Explosive limit - Flammable limit – Inflammable limit – Safety precautions. characteristics of hazardous material – TLV, STEL, TLV-C, LD 50, LC 50, flammable liquids, lighting and ventilation, chemistry of fire, fire, personal protective equipment

Sources of water pollution, effects of water pollution, control standards of KSPCB – BOD, COD determination, primary, secondary, Tertiary waste water treatment, aerobic and anaerobic digestion, activated sludge process, activated carbon process.

Definition of air pollution – sources, effects of air pollution on man, material and animals control of dust emissions, ESP, Bog filters, absorbers, scrubbers, etc., sources of gaseous pollutants, measurement of air, control limits of gaseous pollutants