RAJASTHAN PUBLIC SERVICE COMMISSION, AJMER

SYLLABUS FOR SCREENING TEST FOR THE POST OF

ASSISTANT DIRECTOR, INDUSTRIAL SAFETY MUESEUM & TRAINING CENTRE, (FACTORIES & BOILERS DEPARTMENT)

CHEMICAL ENGINEERING

Process Calculations and Thermodynamics: Laws of conservation of mass and energy, use of tie components, recycle, bypass and purge calculations; degree of freedom analysis. First law of thermodynamics and its application to close and open systems, Second law of thermodynamics, Entropy, thermodynamic properties of pure substances: equation of state and departure function, properties of mixtures, partial molar properties, fugacity, excess properties and activity coefficients, phase equilibria: predicting VLE of systems, chemical reaction equilibria.

Fluid Flow Operation: Fluid statics, Newtonian and non-Newtonian fluids, Bernoulli equation and its applications, Orifice and Venturi meter, impulse momentum equation and its application, friction factors, energy balance, dimensional analysis, shell balances, flow through pipeline systems, flow meters, pumps and compressors, packed and fluidized beds, elementary boundary layer theory.

Heat Transfer: Conduction, convection and radiation, heat transfer coefficients, steady and unsteady heat conduction, boiling, condensation and evaporation, types of heat exchangers, evaporators and their design.

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

Chemical Reaction Engineering: Theories of reaction rates; kinetics of homogeneous reactions, interpretation of kinetic data, single and multiple reactions in ideal reactors, Constant volume and Varying volume Batch Reactor, Batch Reactor Design Equations, Design Equations for Flow Reactors, Applications of the Design Equations for Continuous-Flow Reactors, Reactors in Series.

Safety in Chemical Process Plant: Safety, hazard and Risk, accident- nature and loss statistic. Hazards: Detection, Management, Recent trends in safety & hazard analysis, hazardous waste treatment, laws, Industrial Hygiene: Identification and evaluation, Source Models: Introduction, spills of toxic, flammable and explosive materials, various source models. Fires and Explosions: Distinction, definitions, characteristics and explosion hazard rating of process plant, Preventions of fire and explosions.

Mechanical Operation: Particle size and shape, Measurement and analysis, Screening and screen analysis- Screen effectiveness, working principle of industrial screening equipments, Shape factor, Selectivity index, Size reduction, Principal of comminution, Crushing, Grinding, Pulverization, Ultra fine grinding, Grindability, Crushing laws.

Plant Design and Economics: Design code, Design pressure, Design temperature of cylindrical and spherical shells under internal and external pressures, Process design and sizing of chemical engineering equipment such as compressors, heat exchangers and Boilers; principles of process economics and cost estimation including total annualized cost, cost indexes, rate of return, payback period, discounted cash flow, optimization in design,.

Chemical Technology: Inorganic chemical industries; sulfuric acid, NaOH, fertilizers (Ammonia, Urea, SSP and TSP); natural products industries (Pulp and Paper, Sugar, Oil, and Fats); polymerization industries; polyethylene, polypropylene, PVC and polyester synthetic fibers, Formation and Evaluation of Crude Oil, Testing of Petroleum Products.

Environmental Technology: Classification of air pollutants, Primary and Secondary pollutants, Source of air pollulation, Atmospheric Dispersion: Meteorology, Adiabatic lapse rate, Atmospheric stability, Inversion – types of inversion, maximum mixing height, Atmospheric classes, Plumes and types of plumes under different atmospheric condition, plume rise, Particulate Pollutant: Particulate pollution and control equipment, centrifugal collector, Electronic precipators, Bag filter and Scrubber, Characteristic of water and waste water, Oxygen Demand, BOD, NBOD, CBOD, Primary Treatment by Sedimentation, Flocculation, Coagulation, Filtration, Disinfections, Waste water treatment, Biological (secondary) waste water treatment, Advance treatment methods.

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Pattern of Question Papers:

1.   Objective Type Paper
2.   Maximum Marks : 100
3.   Number of Questions : 100
4.   Duration of Paper : Two Hours
5.   All Questions carry equal marks
6.   There will be Negative Marking
7.   The candidate has to choose either Chemical Engineering or Electrical Engineering or Mechanical Engineering.

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ELECTRICAL ENGINEERING

1. Basics of Electrical circuits, Network theorems, Resonance in series and parallel circuits, Analysis of magnetically coupled circuits, Analysis of three-phase circuits. Time response of RL, LC, RC and RLC circuits. Network graph, Duality. Trigonometric and exponential forms of Fourier series. Parameters of two port network, analysis of generalized two port networks, Complex frequency, network functions. Constant–k and m-derived filters.

2. Measurement of current, voltage, power factor, energy and frequency. Measurement of low, medium and high resistances, magnetic measurements, Q-meter, cathode ray oscilloscope, generalized treatment of A.C. bridges, instrument transformers, ratio and phase angle errors, transducers, measurement of non-electrical quantities.

3. Electric field due to various charge configurations. Electric potential and displacement vector, Gauss's law. Poisson's and Laplace's equation and their solutions. Boundary conditions. Biot-Savart's law, Ampere's law, magnetic vector potential. Energy stored in magnetic field. Interaction of moving charge and current with magnetic field. Boundary conditions. Analogy between electric and magnetic fields.

4. Basic principles of electromagnetic energy conversion, Construction, operation, characteristics, performance of dc generators and motors. Construction, working principle, equivalent circuit, voltage regulation, efficiency, parallel operation of transformers, Auto-transformers, Construction, working principle, equivalent circuit, torque-slip curves, performance calculation, starting and speed control of three-phase induction motors. Induction generator, Construction, basic principles and theory of cylindrical and salient-pole synchronous machines. Equivalent circuit, voltage regulation, operational characteristics, parallel operation,

5. DC and AC motor drives, Plugging, Regenerative and dynamic braking. Multi-quadrant characteristic: Characteristics of load. Review of starting and running characteristics of ac and dc industrial motors. Drives for machine tools, lifts, cranes, paper mills, printing machinery, rolling mills etc. Systems of electric traction.

6. Generation of electrical energy using thermal, hydro, nuclear and diesel based power plants, concept of cogeneration, non-conventional sources of energy, load factors and load curves, load forecasting, electricity tariffs, power factor

improvement, Renewable Energy Sources & their Prospects, power generation scenario in India.

7. Transmission line parameters , modelling and performance analysis of short, medium and long transmission line, ABCD line constants, Insulators, method of improving string efficiency, Mechanical characteristics of transmission lines, Overhead lines & Underground Cables: parameters calculations.

8. Protective relays, operation, characteristics and applications of overcurrent relay, differential relay and distance relay. Protection of Transmission Line, Transformers, Synchronous generator, induction machine and busbar. Carrier Current Protection of Transmission Lines, current interruption theories, different types of Circuit Breakers.Bus admittance matrix. Bus classification. Gauss Siedel, Newton Raphson and fast decoupled Load flow methods, Economic dispatch andunit commitment of thermal and hydrothermal plants. Control of voltage, Excitation systems. Load Frequency Control and Automatic generation control. Steady state and transient stability, swing equations, equal area criterion. Solution of Swing Equation, Transient stability analysis of multi-machine systems. Basic theory of line compensation, Flexible AC Transmission Systems,. FACTS devices HVDC Transmission System.

9. Open loop and closed loop control systems. Servomechanism. Modelling of mechanical, electrical and electro-mechanical systems. Analogy between electrical and mechanical systems. Determination of transfer function, block diagram reduction and signal flow graph method. Time response analysis of first order and second order system, Steady state error and error constants. Absolute stability and relative stability. Conditions for stability. Routh's stability criterion. Relative stability analysis. The Root locus concepts. Stability analysis by use of root locus method. Correlation between time and frequency response. Polar plot and Bode plot. Determine the Gain and Phase margin. Nyquist stability criterion. Determine the relative stability using Nyquist criterion.

10. BJT and FETconfigurations and characteristics, Transistor at low frequencies, Analysis of a transistor amplifier circuit using h-parameters,Biasing circuits. Introduction Op-Amp, differential amplifier, adder, subtractor, integrator, differentiator circuit using OP-Amp, voltage to current and current to voltage converter, Instrumentation amplifier, log and anti-log amplifier, the peaking amplifier, sample and hold circuit. Introduction to Basic comparator, Schmitt trigger, Clippers and Clampers, Voltage to frequency and frequency to voltage

converters.SCR, MOSFET, IGBT, GTO, Classification of SCR triggering methods, Commutation methods, Series and parallel operation of SCRs, Single phase and Three-phase uncontrolled and controlled converters. Voltage and current source inverters, Pulse width modulated inverters with IGBTs/MOSFETs. Choppers, Different schemes and circuit configurations, Single-phase A.C. Regulators-different circuit configuration and their operation. Cycloconverter. Boolean Algebra and Logic Gates, Simplification of Boolean Functions, Karnaugh Map, Code Conversion, NAND and NOR Circuits, Binary Parallel Adder & Subtractor, BCD Adder & Subtractor, Flip-flops. Registers and Counters. Architecture of 8085 microprocessor, instruction set. Programming using assembly language (8085) for looping, decision making, counting, indexing, searching. Interrupts and subroutine.

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MECHANICAL ENGINEERING

1. THERMODYNAMICS: Thermodynamics systems and processes and their heat & work analysis, Laws of thermodynamics, flow and non-flow processes, Ideal and real gases, Entropy, Reversible and irreversible processes, availability, Otto, Diesel, Dual and Brayton cycles.

2. STEAM POWER ENGINEERING: Carnot, Rankine, Modified Rankine, Reheat and Regenerative cycles. Classification and working of various low pressure and high pressure boilers. Boiler accessories and mountings. Safety standards as per IBR code. Steam Turbines: impulse and reaction turbines, velocity diagrams and thermodynamic analysis. Compounding and governing of turbines.

3. INTERNAL COMBUSTION ENGINES: Classification of I.C. Engines, Two and Four stroke engines, Combustion in S.I. and C.I. Engines, Fuel supply systems, Ignition systems, Lubrication systems, Cooling system, Performance parameters and their analysis, Air pollution: causes and control.

4. HEAT TRANSFER, REFRIGERATION & AIRCONDITIONING: Modes and mechanisms of heat transfer, Conduction through plane and composite walls, cylinders and spheres. Critical thickness of insulation, extended surfaces, Natural and forced convection heat transfer, Heat exchangers, Radiation. Vapour compression refrigeration cycle, refrigerants and their properties. Psychrometry and psychrometric processes, Air conditioning and load calculation, Effective temperature and human comfort.

5. STRENGTH OF MATERIALS: Stress and strain, Thermal stresses, Elastic constants, Shear force and bending moment diagrams, Principal planes and stresses, Mohr's circle, Theories of failures, Shear and bending stresses, Deflection of beams, Torsion of shafts, Columns and struts, Strain Energy.

6. DESIGN OF MACHINE ELEMENTS: Engineering materials and their properties, Heat treatment, Factor of safety, Stress concentration, Fatigue failure.Design of machine elements such as Cotter and Knuckle joints, Bolts, Riveted joints, welded joints, shafts, keys, couplings and gears. Design of journal bearings, selection of antifriction bearings. Design of thick and thin cylinders. Springs and levers.

7. THEORY OF MACHINES: Kinematics Links, pairs, chains and mechanisms. Inversions of four bar, single and double slider crank chains. Straight line and steering gear mechanisms, Gear and gear trains. Belt, rope and chain drive. Clutches and

brakes. Cams and followers. Flywheel and Governors. Gyroscope. Balancing of rotating and reciprocating masses. Free and forced vibrations of single degree of freedom systems. Critical speed of shafts.

8. FLUID MECHANICS AND MACHINES: Fluid properties, fluid statics, manometry, buoyancy, control-volume analysis of mass, momentum and energy; differential equations of continuity and momentum; Bernoulli's equation. Flow measurement: orifice & mouthpieces, pitot tube andventurimeter. Viscous flow of incompressible fluids. Flow through pipes, head losses in pipes and bends. Hydraulic turbines, velocity triangles, power and efficiency. Reciprocating and centrifugal pumps. Performance characteristics of hydraulic machines. Unit and specific quantities.

9. PRODUCTION ENGINEERING: Principle of working and equipments for welding processes. Foundry and casting processes. Hot & cold rolling, forging, drawing and extrusion. Metal forming. Theory of metal cutting. Unconventional machining methods. Jigs and fixtures, NC, CNC and DNC machines. Limits, fits and tolerances. Statistical quality control: Control charts and sampling plans.

10. INDUSTRIAL ENGINEERING: Types of organizations, Principles and function of management,Scientific management. Production planning and control. Work study. Break even analysis and inventory control. CPM and PERT.Job evaluation and merit rating. Wage payment systems and incentive schemes. Industrial occupational health &safety and related acts. Factory and boiler act. Labour acts.

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