Subject Areas for MSc. Admission Exams

Data Engineering in Chemistry

Master programme, Faculty of Chemical Engineering

An applicant for MSc study must have a bachelor-level knowledge of chemistry, mathematics and physics. The student is expected to master the basic use of a Computer Algebra System or/and scripting programming language. Discussion during the examination may require the general knowledge of other disciplines at the most rudimentary bachelor level.

Mathematics

1. First derivative. Geometrical and physical meaning of derivatives.
2. Indefinite and definite integrals. Its meaning.
3. Differential equations and applications
4. Systems of linear algebraic equations
5. Characteristics of random variables (expectation value, variance, standard deviation, quantiles and critical values)
6. Normal (Gaussian) distribution, density and distribution function of the normal distribution. Its meaning.
7. Linear regression, the estimates of the parameters of the model.
8. Partial derivatives and the gradient of functions of two variables. Geometrical meaning of the gradient
9. Inner (dot) product of vectors, the norm of the vector. Cross product and its properties.

Physics

1. Physical quantities and units – scalar and vector quantities, vector algebra, International System of Units SI
2. Particle motion: Force, the Newton's laws, work, power, kinetic and potential energy. Conservation of mechanical energy and linear momentum, elastic and inelastic collisions.
3. Object motion: Vector quantities of rotational motion, moment of inertia, torque, angular momentum. Work, power and energy in rotational motion. Rolling motion of rigid bodies. Static equilibrium conditions, centre of gravity.
4. Fluid mechanics: Hydrostatic pressure, Archimedes' law, Bernoulli's equation, real liquid flow.
5. Direct current circuits: Current, voltage, resistance, Ohm's law, Joule law, Kirchhoff's rules.

Physical chemistry

1. State behaviour of gases; the ideal gas equation, the Pressure–Volume dependence for real fluids, critical properties of pure substances.
2. The first law of thermodynamics; internal energy, enthalpy, work, heat, adiabatic processes.
3. The second and third laws of thermodynamics; entropy, the Gibbs and Helmholtz energies.
4. Thermochemistry; heat capacity, reaction heat, the Hess' law, the Kirchhoff's law.
5. Thermodynamic description of mixtures. Partial molar quantities, excess functions, chemical potentials, activities, standard states.
6. The phase rule, phase equilibrium of one-component systems; Clapeyron equation, Clausius-Clapeyron equation, phase diagrams.
7. Phase equilibrium of two-component systems (vapour-liquid, liquid-liquid and solid-liquid equilibria), the Raoult´s law, the Henry´s law, phase diagrams, the lever rule.
8. Chemical equilibrium of simple reactions, equilibrium constant, mass balance, the response of equilibrium to the conditions.
9. Electrochemical processes; electrolytic cells – the Faraday´s law, galvanic cells – the Nernst equation, standard potentials.
10. Chemical kinetics of simple reactions, rate laws, reaction order, rate constant and its temperature dependence, half-life of a reaction, integrated rate laws for reactions of the first and second order.

Chemical Engineering and Bioengineering
Chemical Engineering and Bioengineering - DD

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Chemical Engineering

1. Material balances: intensive and extensive quantities, system and its boundaries, time (period) of balancing, stream, accumulation, source/sink (generation/consumption), fictitious streams, formulation of material balances, input matrix.
2. Fluid flow: laminar and turbulent flow, Reynolds number, continuity equation, Bernoulli equation, transport of fluids in pipes without/with a pump.
3. Cake filtration: mass balance of filtration, filtration rate, filtration equation, washing of the cake, type of filters.
4. Mixing: design rules for a mixing vessel, Power number for mixing, Reynolds number of mixing, Power correlations.
5. Mechanisms of heat transfer: convection, conduction, heat transfer in heat exchangers, calculation of heat transfer area.
6. Drying: mass and enthalpy balance of continuous dryers and a preheater (calorifer), mass balance of a batch dryer, calculation of drying time in a batch dryer.
7. Extraction - mutually immiscible solvents: graphical solution of repeated (cross-flow) and counter-current extraction, equilibrium (theoretical) stage.
8. Distillation: principle of batch and flash distillation, schematics of counter-current distillation with reflux (rectification), material and enthalpy balances.
9. Chemical reactors: material balances of a batch reactor with ideal mixing, continuously stirred tank reactor with ideal mixing, and tubular reactor with plug flow.