Questions for Final Exam (Chemical Engineering BSc)

I. Physical Chemistry

1. Gases: Description of ideal and real gases.Characteristic physical properties, equations of states, van der Waals equation, virial equation. Critical state. Kinetic-molecular theory of gases.

2. Thermodynamics: Basic concepts of thermodynamics: the classification of systems and their walls. Laws of thermodynamics. Heat, work, entropy, enthalpy, free energy. State functions and path functions. Different specific heats, their significance and determination. Heat engines, refrigerators and heat pumps. Thermochemistry.

3. Phase equilibria: Phase rule and its concepts. Characterization of phase transitions, phase diagrams and phase equilibria. Phase transitions in one-component and multicomponent systems.

4. Chemical equilibrium: The free energy profile of chemical reactions. Chemical potential.Characterization of chemical equilibria, various types of reaction quotients and equilibrium constants.External influences on equilibria.Equilibria in chemical systems.

5. Transport processes: Diffusion, thermal conduction, viscosity. Fick's laws. The Einstein equation, Nernst–Einstein and Stokes–Einstein equation for calculating diffusion coefficients.

6. Fundamental of reaction kinetics: The concepts of reaction rate and rate law. Thermal activation and the temperature dependence of the rate coefficient.The information content of the activation energy and the pre-exponential factor.

7. Reaction mechanisms: Elementary steps. Simplifying methods: steady-state and pre-equilibrium approximations. The Lindemann–Hinshelwood mechanism of unimolecular processes.Catalysis and its significance.The kinetics of heterogeneous reactions, adsorption isotherms (BET, Langmuir). The kinetics of enzyme-catalyzed processes. Non-thermal activation.

8. Fundamentals of radiochemistry: The structure and stability of the atomic nucleus. Radioactivity, nuclear reactions.Current forms of nuclear power, its economic and environmental impact.

9. Physical chemistry of colloids: The definition of colloid systems, their classification and stability. Types of interfaces and adsorption. Fundamentals of nanotechnology.

10. Electrochemistry: Chemical reaction caused by current, electrolysis. Electrode potential and electromotive force. Different types of electrodes. Electric current production with chemical reactions: the thermodynamics of Galvanic cellsand kinetic aspects of electricity generation.

II. Unit Operations

1. Physical quantities, balance equations and the similitude theory: The SI unit system. Definition of dimension and unit. Differential and integral form of balance equations valid for one and two phase unit operations. Stationary and unstationary state. Dimensionless numbers. Similitude and scale-up. Extensive and intensive physical quantities.

2. Flow in unpacked pipes and in pipelines: Fluids in rest, Pascal's law. Bernoulli equation. Cavitation. Newtonian and non-Newtonian fluids. Newton's law of viscosity. Basic types of fluid flow. Reynolds' experiment. Hagen-Poisseuille equation. Modified Bernoulli equation. Fanning equation. Moody diagram. Energy requirement of fluid transport. Types of pumps.

3. Flow near solids, in packed columns: Flow around immersed objects. Interpretation of Reynolds number. Types of flow around spherical particles. Stokes' law for the frictional force. Drag coefficient for laminar, transitional and turbulent regions. Ergun equation. Packed columns, characteristics and types of packings. Methods of flow measurement.

4. Types of heat transport, heat transmission by spatially varying temperature difference: Types and calculation of heat transport. Stationary heat transmission with constant temperature difference through flat and cylindrical wall. Determination of heat flow and thermal resistances. Direct and indirect heat exchange. Determination of the power requirement for a stationary recuperative heat exchanger. Temperature-space function of co-current and counter current heat exchangers. Logarithmic mean temperature difference. Chilton-Colburn analogy. Types and apparatus of heat exchangers.

5. Physical separation operations: sedimentation, filtration, centrifugation, membrane separation: Terminal velocity of sedimentation. Stokes' law. Drag coefficient as a function of Reynolds number. Apparatus for settling, dust removers, cyclones. Basics of filtration. Darcy's law of filtration. Batch filtration using constant pressure, continuous filtration using constant flow rate. Filtration units. Filtration using centrifugal force. Types of centrifuges. Basics of membrane filtration. Concentration polarization.

6. Thermal separation operations: distillation, evaporation and crystallization: Batch and continuous distillation, rectification. Operating point. Types and parts of a continuous rectification apparatus. Operating lines of a rectifier. The q-line. Equilibrium stage, its determination using McCabe-Thiele diagram. The aim of evaporation, Robert-type evaporator. Multistage evaporators and their connections. Crystallization and its phase diagram. Apparatus for crystallization.

7. Absorption-desorption, extraction: Two film theory of component transfer. Concentration-space diagram of a continuous counter current absorption unit operation. Equation of operating line. Transfer unit and its graphical determination. Chemisorption. Types of absorption-desorption apparatus. Liquid-liquid extraction. Ternary phase diagram. Distributional diagram of the key component. Batch and continuous extraction. Continuous one-stage mixer-settler extractor. Liquid-solid extraction and its apparatus.

8. Drying, adsorption, ion exchange: Physical adsorption, chemisorption, ion exchange. Types of moisture binding. Rate of drying. Enthalpy of moist air. Types, material- and energy balance of drying apparatus. Types of equilibrium adsorption isotherms for one key component. Selectivity coefficient of adsorption in equilibrium for a two-component system. Theories of the adsorption mechanism. Requirements for adsorbents, examples for industrial adsorbents. Breakthrough curves of an adsorber column. Pressure-alternating gas adsorption. Fluidizational adsorption apparatus. Ion-exchange columns.

9. Methods of feed preparation and surface increase: size reduction, sieving, vaporization, homogenization: Crushers and grinders. Energy requirement of size reduction. Screening and classification. Sieve analysis. Mixing of solids, apparatus. Mixing of fluids. Momentum balance for the agitator. Power requirement of agitation. Fluid mixers. Vaporization of fluids, aim, apparatus. Mixing of gases. Measurement of gas flow.

10. Chemical reactors: Classification of reactors based on flow, operation mode, component stream and heat. Operation time, residence time. Concentration-time and concentration-space functions of batch and continuous reactors. Heat balance of a reactor. Stability of reactors.

III. Chemical Technology

1. Water technology. Occurrence and uses of water, water purification. Water softening. Hardness, Water softening methods involving and without precipitates.

2. Sulfur industry. The use of sulfur, sulfur sources, Claus process, production of sulfur dioxide and sulfur trioxide, contact sulfuric acid process. Superphosphate production and byproduct utilization.

3. Nitrogen industry. Structure of the nitrogen industry. Production and purification of synthesis gas. Ammonia synthesis. Combustion of ammonia, nitric acid production. Nitrogen-containing fertilizers.

4. Rock salt based industry. Brine electrolysis, membrane cell and mercury cell processes.

5. Aluminum and iron production. Alumina production according to Bayer, the electrolysis of alumina. Occurrence of iron, ores, ore substitutes. The types of iron, the blast furnace operation.

6. Processing and refining crude oil. Modern oil refinery: the goal of quality improvement and conversion technologies, feedstock (including atmospheric and vacuum distillation, hydrodesulfurization, catalytic cracking, reforming, alkylation, delayed coking), the main products. Requirements of the motor fuels.

7. Production of olefins by steam cracking. Classification of feedstocks ethylene yield point of view. Most important cracking parameters and their typical values. Main steps of the pyrolysis and the fractionation of the products. Industrial uses of ethylene and propylene.

8. Polyolefins. Properties of different polyethylene (PE) and polypropylene (PP) polymers (including MWD, melt index, mechanical properties, ESCR). Interpretation of the relationship between the chemical structure and the properties using the bimodal polyolefin as an example. Typical industrial reactors for the production of LDPE, HDPE (LLDPE) and PP. Description of an optionally selected technology from the LDPE, HDPE or PP technologies. Uses of polyolefins.

9. Biotechnology: definition, types of procedures. The comparison of the synthetic and fermentation processes. Phases and types of the industrial fermentation. Requirements of the mixed tank reactors in the biotechnology. The functions of the mixing, aeration, fermentation parameters. Extraction of the pharmaceutically important components from the fermentation broth.

10. Industrial production and types of solid dosage forms. Properties and advantages of granules. Excipients of the granulation and tableting. Requirements and types of granulation processes. Types and advantages of tablets. The aim of coating of tablets, requirements and methods. Advantage, disadvantage and types of capsule dosage forms. Typical examination methods of the solid dosage forms.