Questions for Final Exam (Chemical Engineering MSc)

Transport Processes

1. Transport processes in chemical engineering. Definition of balance equation, driving force. Integral and differential balance equations and their interpretation. Solving balance equations based on simplified hydrodynamic models.
2. Similarity theory and model. Introduction of dimensionless numbers based on balance equations and dimension analysis. Scale-up.
3. Characteristics of momentum transport. Flow in pipes, flow around solid bodies and grains, flow through packed pipe. Integrated interpretation of different flows.
4. Determination of terminal velocity of sedimentation in gravitational field. Design of continuous sedimentation equipment. Filtration by gravitation and centrifuge. Operation of fluidization equipment and their application.
5. Characteristics of heat transport. Equipment of passive and active heat transport. Determination of heat transfer coefficient. Design of recuperative heat exchangers. Instrumentation and control of heat exchangers. Entropy loss during heat transfer.
6. Characteristics of component transport. Determination of component transfer coefficient. Definition of equilibrium state and transfer unit. Component transfer in batch, continuous cascade, and continuous equipment. Interpretation of operating point, operating line, driving force and balance.
7. Absorbers. Design of packed absorber required for the purification of gases with given concentration and flow rate. Simplifying requirements. Determination of the sizes and operating parameters of absorbers. Sensitivity test. Instrumentation and control of absorbers. Chemisorption.
8. Batch and continuous distillation. Design of simple batch distillation equipment.
9. Rectification. Design of plate rectification column for binary systems.
10. Extraction. Design of cross-current extraction equipment, determination of solvent demand.
11. Chemical reactors. Industrial problem. Reaction rate. Basic reactor types. Determination of conversion and reactor volume. Basic equations for the operations of batch and continuous reactors.
12. Series and parallel connections of different reactors. Application of Levenspiel method to determine the reactor volume. Definitions of residence time and operating time. Reaction rate and stoichiometry.
13. Design of isothermic reactors. Design of reactors for complex chemical reactions. Design of membrane reactors and semi-batch reactors. Catalytic reactors and their design. Pressure drop on packed catalyst layer in the case of gas reactions.
14. Real reactors. Residence time density and distribution functions. Mathematical models of real reactors, complex models from simple models (dead zone, bypass, recirculation).
15. Thermal examination of reactors. Design of non-isotherm reactors. Design of isotherm, adiabatic and polytrop reactors and their thermal stability.

Pharmaceutical technologies

1. Requirements for protective groups. Introduction of cleavage classification of protecting groups. Protective groups for hydroxyl, carbonyl, carboxyl and primary amino groups. Adding and removing protective groups, orthogonality.
2. Types of retrosynthetic transformations. Disconnection, synthon, reagent. Classification of synthons based on polarity and place of disconnection, transpolarization of reacting centers , equivalence of functional groups, retrosynthetic principles of aromatic compounds.
3. Types and structures of the main carbohydrates in plant-based biomass. Biorefinery, technologies of first and second generation biofuels. Main components of lignocellulose and crab shell, and their biorefinery.
4. Benzene as a raw material. Comparison of industrial methods for phenol production. Application of phenol: bisphenol-A production, comparison of methods to produce polycarbonate resins. Additional applications for bisphenol A and phenol. Production and application of cyclohexane: synthetic procedures for adipic acid and caprolactam production.
5. Comparison of procedures for aniline production. Application of aniline. Toluene as raw material: Production of isocyanates and their application in chemical industry: MDI and TDI. Production and application of other aromatic derivatives: alkylated benzene derivatives, xylenes, chlorinated benzene derivatives, hydroquinone, resorcinol, catechol, anthraquinone.
6. Opportunities of forming carbon-carbon bonds in acid- and base catalyzed reactions. Transition metal catalyzed cross-coupling reactions to form carbon-carbon bonds.
7. Possible synthetic routes for forming carbon-halogen, carbon-oxygen and carbon nitrogen bonds.
8. Oxo compounds, opportunities of producing of carboxylic acids and their derivatives.
9. Classification and name of heterocyclic compounds. Production and reactions of three- and four-membered saturated heterocyclic compounds. Characterization of five-membered heterocyclic compounds with one heteroatom.
10. Characterization of five-membered heterocyclic compounds with two heteroatoms. Production and reactions of six-membered heterocyclic compounds with one or more heteroatoms.
11. Classification of isomers, importance of chirality, topicity of groups and surfaces. Substrate controlled asymmetric syntheses, AdN reaction of chiral non-racemic ketones. Chiral excipient, reagent and catalyst controlled asymmetric syntheses. Enantioselective epoxidation.
12. Biocatalytic processes, enzymes. Dynamic kinetic resolution. Kinetic resolution of alcohols and amines. Fermentation processes, possibilities for improving technologies, phase of industrial fermentation.
13. Possibilities of increasing efficiency of organic syntheses. Microwave activation: basic of activation, rules for selecting solvent, open and closed system. Solid phase syntheses: principle, advantages of the method, types of applied resins. Introduction of Merrifield peptide synthesis. Fundamentals of combinatorial and parallel syntheses, advantages of using microreactors and flow chemistry systems.
14. Carbohydrate based pharmaceutical ingredients. Opportunities of development of carbohydrate based drugs. Characterisation of cyclodextrins and their use in pharmaceutical industry.

15. Process and method of drug development. Structure-activity relationships. Drug targets and interactions with small molecules.

Plastic processing and technologies

1. Extrusion. Basics of extrusion, parts of extruder, its operation. Screw types, one and twin screw extruders.
2. Principle, operation of film blowing, typical raw materials. Providing steady wall thickness. Extrusion blow molding. Injection blow molding- production technology of PET bottles.
3. Injection molding. Parts and operation of reciprocating-screw injection molding machine. Steps: clamping, injection dwelling,cooling, mold opening, ejection. Clamping-injection pressure relationship. Reactive injection molding.
4. Rotational molding. Raw materials, characteristics of products made by rotational molding. Steps of rotational molding.
5. Calendering. Aim of calendering, preparing mixtures, products. Opportunities to make films with steady wall thickness by means of calenders.
6. Hot working processes. Vacuum forming, overpressure thermal forming, deep drawing. The technology of vacuum forming, technological steps. The aim of pre-stretching.
7. Plastic composites. Definition, structure of composites. Applied matrices, natural and synthetic reinforcing agents. Opportunities to produce plastic composites (lamination, pultrusion, winding, production of sandwich like structures), injection molding in the presence of reinforcing agents.
8. Production of polymer foams (principles of physical and chemical methods). Production of polystyrene foam (technological and ecological considerations), polyurethane foams (chemical and technological implementation).
9. Production of polymer fibers (from melt, solution, coagulation bath, film). Comparison of production processes: advantages, disadvantages. Carbon fibers.
10. Environmental concerns, recycling and application of plastics and plastic composites. Comparison of linear and crosslinked polimer matrices based on environmental protection.
11. Study of polymers. Hardness measurements (Rockwell, Shore A, D, Brinell). Principle of tensile testing, parameters determined by tensile testing: ultimate strength, tensile strength, elongation at break, E-modulus, yield point. Impact tests: Izod impact strength, impact resistance-tensile strength, principle and operation of falling dart impact tester. Measurement of stress corrosion. Melt Flow Index.
12. Upstream processes, different sources of crude oil. (onshore, offshore, shale oil). Thermal processes in the refinery, delayed coking fluid coking, viscosity breaking and flexicoking.
13. Catalytic processes in the refinery, fluid catalytic cracking (FCC), hydrocracking, catalytic reforming, isomerization, alkylation, LPG to aromatics, and hydrotreatment. Criteria for the quality assessment of engine fuels.
14. Production of ethylene and propylene, and their production process parameters. Polymerization technologies for ethylene and propylene. Production of ethylene-oxide and propylene-oxide.
15. Polyurethane technologies. Introduction of raw material technologies (synthesis of isocyanates: MDI and TDI), effect of isocyanate/polyol ratio on the properties of the final product.