Introduction

ORGANIZATION OF THIS BOOK

Although NCEES does not release old PE exams or reveal specific exam problems, it has identified the exam subject areas and their approximate weighting as a percentage of the exam questions. *Chemical Engineering Solved Problems* is organized into seven sections that correspond to the sections of the Chemical Engineering PE exam.

Subject Area and Knowledge Clusters	Approximate Percentage of Examination

I. MASS/ENERGY BALANCES AND THERMODYNAMICS 24%

A. *Mass Balances* (11%):
material balances and stoichiometry; phase behavior; process variants: bypass, recycle, and purge; combustion processes (e.g., water-free analysis, excess air, staged combustion)

B. *Energy Balances and Thermodynamics* (13%):
sensible heat (heat capacity); latent heat (e.g., fusion, vaporization, sublimation); heat of reaction (exothermic, endothermic); heat of solution; estimation and correlation of physical properties; applications requiring combinations of sensible heat calculations, latent heat considerations, heats of reaction, etc.

II. FLUIDS 17%

A. *Fluid Transport* (3%):
physical properties (e.g., viscosity, density, surface tension); pipe and tubing data (e.g., schedule number, surface roughness)

B. *Mechanical-Energy Balance* (11%):
potential (e.g., elevation change) and kinetic energy (e.g., velocity); friction: Reynolds number, pressure drop (e.g., friction factor, pipes, valves, fittings, expansion and contraction); flow applications: single conduit, parallel and branched systems, pumps, turbines, and compressors (e.g., work/energy requirements, efficiency and performance curves), two-phase flow (e.g., slug flow), filtration

C. *Flow Measurement Techniques* (3%):
pitot tube, orifice, and venturi, etc.; pressure differential measurement (e.g., manometers); mass flow (e.g., Coreolis, vortex shedding, thermal); permanent pressure drop (e.g., orifice valve)

III. HEAT TRANSFER 16%

A. *Mechanisms* (6%):
physical properties (viscosity, density, heat capacity, etc.); conduction (e.g., Fourier's law in differential and integral form, parallel and series arrangements, mean area); convection: free (natural) convective heat-transfer coefficient, forced convective heat-transfer coefficient (metallic and nonmetallic); phase change (e.g., vaporization, condensation, sublimation, crystallization); combinations of mechanisms: (conduction, convection, and radiation in series)

B. *Applications* (10%):
insulation (e.g., type, sizing, and placement); measurement instruments (thermocouples, thermometers, RTD, IR, etc.); heat exchangers: overall heat-transfer coefficient, fouling factors, Reynolds number, mean temperature difference (LMTD, f-factor), types (e.g., double pipe, shell-and-tube, extended surface, plate), design (e.g., area, configuration, pressure drop), evaluation of existing and new exchanger systems (NTU method/pinch technology); service use of heat transfer equipment (e.g., condensers, reboilers, heat pumps); radiant and convective transfer

IV. MASS TRANSFER 13%

A. *Phase Equilibria* (5%):
equilibrium data (e.g., VLE, LLE): equations of state, Henry's law and Raoult's law, non-ideal solutions (e.g., activity coefficient), azeotrope systems; phase equilibrium calculations: bubble and dew points, flash calculation; diffusion (e.g., purification, water treatment, chip manufacturing, chemical vapor deposition)

B. *Mass Transfer Contactors (Absorption, Stripping, Distillation, Extraction)* (7%):
continuous contacting (packed): minimum rate of flow of liquid (absorption), vapor (stripping), solvent (extraction), and reflux (distillation),

minimum number of transfer units or stages, height and number of transfer units or stages, types of packing, flooding—calculation of minimum vessel diameter, feed location for distillation column/tower; trayed contactors: minimum rate of flow of liquid (absorption), vapor (stripping), solvent (extraction), and reflux (distillation), minimum number of stages, theoretical stages—graphical methods, flooding—calculation of minimum vessel diameter, stage efficiency, feed location for distillation column/tower

C. *Miscellaneous Separation Processes* (1%):
drying; adsorption (e.g., PSA, water treatment)

V. KINETICS 11%

A. *Reaction Parameters* (2%):
rate constant; chemical equilibria; activation energy

B. *Reaction Rate* (2%):
rate equation; order of reaction; analysis of experimental data from reaction systems

C. *Reactor Design and Evaluation* (5%):
batch reactor; continuous stirred-tank reactor to include recycle to the reactor; plug-flow reactor (e.g., gas phase reactor); multiple reactors in series; yield and selectivity

D. *Heterogeneous Reaction Systems* (2%):
multi-phase reactors: fluidized beds, packed beds; stability/runaway reactions; mixing

VI. PLANT DESIGN AND OPERATION 19%

A. *Economic Consideration* (2%):
equipment-cost correlations (e.g., cost indices)/ economic calculations; operating costs; time value of money

B. *Design and Operation* (6%):
process equipment design; process flow sheet development; design optimization; operating manuals (e.g., startup, shutdown, maintenance); equipment testing, troubleshooting, and analysis

C. *Safety* (5%):
emergency venting devices (e.g., safety valves, blowout walls); performance of scheduled audits (e.g., testing safety valves, checking rupture, disks); flares and vents; plant layout considerations (e.g., equipment arrangement, pipe racks, and layouts); fire protection; emergency ingress and egress; process hazard analysis

D. *Environmental* (2%):
evaluation and permitting of gas discharges and liquid discharges; solid waste management (non-hazardous and hazardous); industrial hygiene (e.g., MSDS, TLV, noise control, ventilation, personal protective equipment); pollution prevention

E. *Materials* (2%):
materials properties and selection; structural design considerations (e.g., temperature limits, pressure limits, thermal expansion, pressure vessels per ASME Section VIII); corrosion considerations

F. *Process Control* (2%):
sensors (e.g., choice, location); controller actions; feed-back/feed-forward actions; data interpretation

TOTAL 100%

HOW TO USE THIS BOOK

Chemical Engineering Solved Problems should be used to practice solving problems in each of the subject areas covered on the PE exam.

To optimize your study time and obtain the maximum benefit from the practice problems, use the following four-step process.

step 1: Review the problems in each subject area and identify those with which you are least familiar. Work a few of these problems to assess your general understanding of the subject and to identify strengths and weaknesses. When working problems, always make your best attempt to solve the problem before looking at the solutions provided in the book. Then use the solutions to check your work for those problems you are able to solve or to provide guidance in finding solutions to the more difficult problems.

step 2: Focus first on solving problems in those topic areas where the least mastery and greatest weaknesses exist. Begin by locating relevant resource materials, and then work the problems in one subject area at a time. As you work problems, some of these resources will emerge as being more important to you than others. These are the ones you will want to prepare for use when taking the PE exam.

step 3: Use the solved problems as a guide to understanding the general approach to solving problems in each subject area. Although the problems encountered on the PE exam may not be exactly the same as those presented in this book, the approach to solving problems will be the same. It may be useful to make

notes in the margins to explain concepts or to reference sources that can help you solve a particular problem. These notes can be consulted while you are taking the exam.

step 4: After you have identified and addressed weaknesses by working problems in those subject areas with which you are least familiar, follow the same procedures outlined above, organizing resource materials and making notations, to work the problems in the remaining subject areas.

Remember that the solution presented for each example problem may represent only one of several methods for obtaining a correct answer. It may also be possible that an alternative method of solving a problem will produce a different, but nonetheless appropriate, answer.

EXAM ORGANIZATION

The PE exam consists of two parts: a morning session and an afternoon session, each lasting four hours. In completing the exam you will need to provide answers to 80 multiple-choice problems, 40 in the morning and 40 in the afternoon. Four possible answers are provided for each problem, but only one of the options is correct. The problems presented in *Chemical Engineering Solved Problems* follow a similar format. On the PE exam, one point is awarded for each correct answer, but no penalty is assessed for incorrect answers. Therefore, after you have answered problems you are able to solve, you should guess at those you are unable to solve. Don't leave any questions unanswered.

Both the morning and afternoon sessions of the exam are open book. In general, any bound reference material is allowed, including personal notes and sample calculations. Textbooks, handbooks, and other professional reference books are allowed. However, no writing tablets, scratch paper, or other unbound notes or materials are permitted. Battery-operated, silent, nonprinting calculators are allowed. However, each local jurisdiction defines specifically what materials you are permitted to bring with you to the exam. To find out what materials are allowed in the exam in your area, call your state board of registration.

The exam is meant to assess your personal competence without consultation, discussion, or sharing of information with others during the exam period. Do not expect to share any references or to communicate with others while taking the exam.

Information about the state boards can be found at **www.ppi2pass.com/stateboards.html**. More information about the chemical engineering PE exam can be found at **www.ppi2pass.com/chfaqs.html**.