THE NATIONAL COUNCIL OF EXAMINERS FOR ENGINEERING AND SURVEYING
PRINCIPLES AND PRACTICE OF ENGINEERING EXAMINATION

CHEMICAL

EFFECTIVE APRIL 2003

		Approximate Percentage of Examination
I.	**Mass/Energy Balances and Thermodynamics**	**24%**
	A. Mass Balances	11%
	1. Material balances and stoichiometry	
	2. Phase behavior	
	3. Process variants: bypass, recycle, and purge	
	4. Combustion processes (e.g., water-free analysis, excess air, staged combustion)	
	B. Energy Balances and Thermodynamics	13%
	1. Sensible heat (heat capacity)	
	2. Latent heat (e.g., fusion, vaporization, sublimation)	
	3. Heat of reaction (exothermic, endothermic)	
	4. Heat of solution	
	5. Estimation and correlation of physical properties	
	6. Applications requiring combinations of sensible heat calculations, latent heat considerations, heats of reaction, etc.	
II.	**Fluids**	**17%**
	A. Fluid Transport	3%
	1. Physical properties (e.g., viscosity, density, surface tension)	
	2. Pipe and tubing data (e.g., schedule number, surface roughness)	
	B. Mechanical-Energy Balance	11%
	1. Potential (e.g., elevation change) and kinetic energy (e.g., velocity)	
	2. Friction: Reynolds number	
	3. Friction: pressure drop (e.g., friction factor, pipes, valves, fittings, expansion and contraction)	
	4. Flow applications: single conduit, parallel and branched systems	
	5. Flow applications: pumps, turbines, and compressors (e.g., work/energy requirements, efficiency and performance curves)	
	6. Flow applications: two-phase flow (e.g., slug flow)	
	7. Flow applications: filtration	
	C. Flow Measurement Techniques	3%
	1. Pitot tube, orifice, and venturi, etc.	
	2. Pressure differential measurement (e.g., manometers)	
	3. Mass flow (e.g., Coreolis, vortex shedding, thermal)	
	4. Permanent pressure drop (e.g., orifice, valve)	

Approximate Percentage of Examination

III. Heat Transfer **16%**

A. Mechanisms 6%

1. Physical properties (viscosity, density, heat capacity, etc.)
2. Conduction (e.g., Fourier's Law in differential and integral form, parallel and series arrangements, mean area)
3. Convection: free (natural) convective heat-transfer coefficient
4. Convection: forced convective heat-transfer coefficient (metallic and nonmetallic)
5. Phase change (e.g., vaporization, condensation, sublimation, crystallization)
6. Combinations of mechanisms: (conduction, convection, and radiation in series)

B. Applications 10%

1. Insulation (e.g., type, sizing, and placement)
2. Measurement instruments (thermocouples, thermometers, RTD, IR, etc.)
3. Heat exchangers: overall heat-transfer coefficient, fouling factors, Reynolds numbers
4. Heat exchangers: mean temperature difference (LMTD, f-factor)
5. Heat exchangers: types (e.g., double pipe, shell-and-tube, extended surface, plate)
6. Heat exchangers: design (e.g., area, configuration, pressure drop)
7. Heat exchangers: evaluation of existing and new exchanger systems (NTU method/pinch technology)
8. Service use of heat transfer equipment (e.g., condensers, reboilers, heat pumps)
9. Radiant and convective transfer

IV. Mass Transfer **13%**

A. Phase Equilibria 5%

1. Equilibrium data (e.g., VLE, LLE): equations of state
2. Equilibrium data (e.g., VLE, LLE): Henry's Law and Raoult's Law
3. Equilibrium data (e.g., VLE, LLE): non-ideal solutions (e.g., activity coefficient)
4. Equilibrium data (e.g., VLE, LLE): azeotrope systems
5. Phase equilibrium calculations: bubble and dew points
6. Phase equilibrium calculations: flash calculation
7. Diffusion (e.g., purification, water treatment, chip manufacturing, chemical vapor deposition)

B. Mass Transfer Contactors (Absorption, Stripping, Distillation, Extraction) 7%

1. Continuous contacting (packed): minimum rate of flow of liquid (absorption), vapor (stripping), solvent (extraction) and reflux (distillation)
2. Continuous contacting (packed): minimum number of transfer units or stages
3. Continuous contacting (packed): height and number of transfer units or stages
4. Continuous contacting (packed): types of packing
5. Continuous contacting (packed): flooding—calculation of minimum vessel diameter
6. Continuous contacting (packed): feed location for distillation column/tower

Approximate Percentage of Examination

7. Trayed contactors: minimum rate of flow of liquid (absorption), vapor (stripping), solvent (extraction), and reflux (distillation)
8. Trayed contactors: minimum number of stages
9. Trayed contactors: theoretical stages—graphical methods
10. Trayed contactors: flooding—calculation of minimum vessel diameter
11. Trayed contactors: stage efficiency
12. Trayed contactors: feed location for distillation column/tower

C. Miscellaneous Separation Processes 1%
1. Drying
2. Adsorption (e.g., PSA, water treatment)

V. Kinetics 11%

A. Reaction Parameters 2%
1. Rate constant
2. Chemical equilibria
3. Activation energy

B. Reaction Rate 2%
1. Rate equation
2. Order of reaction
3. Analysis of experimental data from reaction systems

C. Reactor Design & Evaluation 5%
1. Batch reactor
2. Continuous stirred-tank reactor to include recycle to the reactor
3. Plug-flow reactor (e.g., gas phase reactor)
4. Multiple reactors in series
5. Yield and selectivity

D. Heterogeneous Reaction Systems 2%
1. Multi-phase reactors: fluidized beds
2. Multi-phase reactors: packed beds
3. Stability/runaway reactions
4. Mixing

VI. Plant Design and Operation 19%

A. Economic Consideration 2%
1. Equipment-cost correlations (e.g., cost indices)/economic calculations
2. Operating costs
3. Time value of money

	Approximate Percentage of Examination
B. Design and Operation	6%
1. Process equipment design	
2. Process flow sheet development	
3. Design optimization	
4. Operating manuals (e.g., startup, shutdown, maintenance)	
5. Equipment testing, troubleshooting, and analysis	
C. Safety	5%
1. Emergency venting devices (e.g., safety valves, blowout walls)	
2. Performance of scheduled audits (e.g., testing safety valves, checking rupture, disks)	
3. Flares and vents	
4. Plant layout considerations (e.g., equipment arrangement, pipe racks, and layouts)	
5. Fire protection	
6. Emergency ingress and egress	
7. Process hazard analysis	
D. Environmental	2%
1. Evaluation and permitting of gas discharges and liquid discharges	
2. Solid waste management (non-hazardous and hazardous)	
3. Industrial hygiene (e.g., MSDS, TLV, noise control, ventilation, personal protective equipment)	
4. Pollution prevention	
E. Materials	2%
1. Materials properties and selection	
2. Structural design considerations (e.g., temperature limits, pressure limits, thermal expansion, pressure vessels per ASME Section VIII)	
3. Corrosion considerations	
F. Process Control	2%
1. Sensors (e.g., choice, location)	
2. Controller actions	
3. Feed-back/feed-forward actions	
4. Data interpretation	
TOTAL	**100%**

Notes

1. The knowledge areas specified under A., B., C., … etc., are examples of kinds of knowledge, but they are not exclusive or exhaustive categories.
2. This examination contains 80 multiple-choice questions. Examinee works all questions.