

Appendices

APPENDIX A: GRAPHICAL SYMBOLS FOR PIPING SYSTEMS AND PLANT

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APPENDIX B: CORROSION CHARTS

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APPENDIX C: PHYSICAL PROPERTY DATA BANK

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APPENDIX D: CONVERSION FACTORS

<i>An asterisk (*) denotes an exact relationship</i>			
Length	*1 in.	:	25.4 mm
	*1 ft	:	0.3048 m
	*1 yd	:	0.9144 m
	1 mile	:	1.6093 km
	*1 Å (angstrom)	:	10^{-10} m
Time	*1 min	:	60 s
	*1 h	:	3.6 ks
	*1 day	:	86.4 ks
	1 year	:	31.5 Ms
Area	*1 in. ²	:	645.16 mm ²
	1 ft ²	:	0.092903 m ²
	1 yd ²	:	0.83613 m ²
	1 acre	:	4046.9 m ²
	1 mile ²	:	2.590 km ²
Volume	1 in. ³	:	16.387 cm ³
	1 ft ³	:	0.02832 m ³
	1 yd ³	:	0.76453 m ³
	1 UK gal	:	4546.1 cm ³
	1 US gal	:	3785.4 cm ³
Mass	1 short (US) ton	:	907.18 kg
	1 oz	:	28.352 g
	*1 lb	:	0.45359237 kg
	1 cwt	:	50.8023 kg

(Continued)

An asterisk () denotes an exact relationship—Cont'd*

	1 long (UK) ton	:	1016.06 kg
	1 short (US) ton	:	907.18 kg
Force	1 pdl	:	0.13826 N
	1 lbf	:	4.4482 N
	1 kgf	:	9.8067 N
	1 tonf	:	9.9640 kN
	*1 dyn	:	10^{-5} N
Temperature difference	*1 deg F (deg R)	:	$\frac{5}{9}$ deg C (deg K)
Energy (work, heat)	1 ft lbf	:	1.3558 J
	1 ft pdl	:	0.04214 J
	*1 cal (internat. table)	:	4.1868 J
	1 erg	:	10^{-7} J
	1 Btu	:	1.05506 kJ
	1 hp h	:	2.6845 MJ
	*1 kW h	:	3.6 MJ
	1 therm	:	105.51 MJ
	1 thermie	:	4.1855 MJ
Calorific value (volumetric)	1 Btu/ft ³	:	37.259 kJ/m ³
Velocity	1 ft/s	:	0.3048 m/s
	1 mile/h	:	0.44704 m/s
Volumetric flow	1 ft ³ /s	:	0.028316 m ³ /s
	1 ft ³ /h	:	7.8658 cm ³ /s
	1 UK gal/h	:	1.2628 cm ³ /s
	1 US gal/h	:	1.0515 cm ³ /s
Mass flow	1 lb/h	:	0.12600 g/s
	1 ton/h	:	0.28224 kg/s
Mass per unit area	1 lb/in. ²	:	703.07 kg/m ²
	1 lb/ft ²	:	4.8824 kg/m ²
	1 ton/sq mile	:	392.30 kg/km ²
Density	1 lb/in. ³	:	27.680 g/cm ³
	1 lb/ft ³	:	16.019 kg/m ³
	1 lb/UK gal	:	99.776 kg/m ³
	1 lb/US gal	:	119.83 kg/m ³
Pressure	1 lbf/in. ² (1 psi)	:	6.8948 kN/m ²
	1 ksi (1000 psi)	:	6.8948 MN/m ²
	1 tonf/in. ²	:	15.444 MN/m ²
	1 lbf/ft ²	:	47.880 N/m ²
	*1 standard atm	:	101.325 kN/m ²
	*1 atm (1 kgf/cm ²)	:	98.0665 kN/m ²
	*1 bar	:	10^5 N/m ²
	1 ft water	:	2.9891 kN/m ²

(Continued)

<i>An asterisk (*) denotes an exact relationship—Cont'd</i>			
	1 in. water	:	249.09 N/m ²
	1 in. Hg	:	3.3864 kN/m ²
	1 mmHg (1 torr)	:	133.32 N/m ²
Power (heat flow)	1 hp (British)	:	745.70 W
	1 hp (metric)	:	735.50 W
	1 erg/s	:	10 ⁻⁷ W
	1 ft lbf/s	:	1.3558 W
	1 Btu/h	:	0.29307 W
	1 ton of refrigeration	:	3516.9 W
	Moment of inertia	1 lb ft ²	:
Momentum	1 lb ft/s	:	0.13826 kg m/s
Angular momentum	1 lb ft ² /s	:	0.042140 kg m ² /s
Viscosity, dynamic	*1 P (Poise)	:	0.1 N s/m ²
	1 lb/ft h	:	0.41338 mN s/m ²
	1 lb/ft s	:	1.4882 N s/m ²
Viscosity, kinematic	*1 S (Stokes)	:	10 ⁻⁴ m ² /s
	1 ft ² /h	:	0.25806 cm ² /s
Surface energy (surface tension)	1 erg/cm ²	:	10 ⁻³ J/m ²
	(1 dyn/cm)	:	(10 ⁻³ N/m)
Mass flux density	1 lb/h ft ²	:	1.3562 g/s m ²
Heat flux density	1 Btu/h ft ²	:	3.1546 W/m ²
	*1 kcal/h m ²	:	1.163 W/m ²
Heat transfer coefficient	1 Btu/h ft ² F	:	5.6783 W/m ² K
Specific enthalpy (latent heat, etc.)	*1 Btu/lb	:	2.326 kJ/kg
Specific heat capacity	*1 Btu/lb °F	:	4.1868 kJ/kg K
Thermal conductivity	1 Btu/h ft °F	:	1.7307 W/m K
	1 kcal/h m °C	:	1.163 W/m K

Note: Where temperature difference is involved K = °C.
 Taken from MULLIN, J. W.: The Chemical Engineer No. 211 (Sept. 1967), 176. SI units in chemical engineering.

APPENDIX E: DESIGN PROJECTS (SHORTER PROBLEM STATEMENTS)

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Projects include: acetaminophen, acetic acid, acetophenone, acrolein, acrylic acid, alendronate, amlodipine besylate (NorvascTM), ammonia, argon recovery, aspartame, aspirin, benzene reduction, biopulping, black liquor recovery, bromine, carbon nanotubes, cellulose acetate, chemi-mechanical pulping, chlor-alkali, chlorine-free pulp bleaching, chloroform, ciprofloxacin, citalopram hydrobromide (CelexaTM), 3-R citronellol, Cleve's acid, clopidogrel (PlavixTM), cocoa processing, crude oil distillation, cyclohexanone with phenol, cyclosporin A, dextrans, dicalcium phosphate, dicyclopentadiene,

2,6-dimethyl naphthalene, doxycycline, erythorbic acid, ethanol by fermentation, ethylene by oxidative dehydrogenation, ethylene by steam cracking, ethylene from ethanol, fexofenadine (AllegraTM), Fischer-Tropsch catalyst, fluconazole, fluoxetine hydrochloride, fluticasone propionate (FloventTM), folic acid, fuel processor, gas to liquids by Fischer-Tropsch synthesis, granulocyte colony stimulating factor, guaifenesin (ActifedTM, RobitussinTM), hydrocracking, hydrogen by steam reforming of methane, hydrogen for fuel cells, ibuprofen (AdvilTM, MotrinTM), insect repellent, isomerization of naphtha, Kraft pulping, krypton recovery, lactic acid by fermentation, lansoprazole (PrevacidTM), linear alkylbenzenes, lisinopril, loratidine, low-fat snacks, d-malic acid, mannitol, margarine, methanol to olefins, methylene chloride, moisturizing lotion, monosodium glutamate, 2,6-naphthalene dicarboxylic acid, natural gas liquefaction, natural gas liquids recovery, niacinamide, nitric acid, nitrobenzene, s-ofloxacin, omeprazole (PrilosecTM), oxygen (small scale portable/medical), paroxetine (PaxilTM), phenol, phosgene, phosphoric acid, polylactic acid, potassium permanganate, propylene by catalytic dehydrogenation, propylene by steam cracking, propylene glycol by fermentation, propylene oxide, pseudoephedrine, pyridine, riboflavin, risperidone (RisperdalTM), salicylic acid USP, setraline hydrochloride (ZolofTM), simvastatin (ZocorTM), sulfur dioxide treatment, sulfur recovery, sumatriptan (ImigranTM), tocopherol, toxic waste disposal, urea DSM process, venlafaxine (EffexorTM), xenon recovery & zeolite synthesis.

APPENDIX F: DESIGN PROJECTS (LONGER PROBLEM STATEMENTS)

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Projects include: 2-ethylhexanol, acrylonitrile, aniline, chlorine (from hydrogen chloride), chlorobenzenes, hydrogen from fuel oil, methyl ethyl ketone & urea.

APPENDIX G: EQUIPMENT SPECIFICATION (DATA) SHEETS

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APPENDIX H: TYPICAL SHELL AND TUBE HEAT EXCHANGER TUBE-SHEET LAYOUTS

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APPENDIX I: MATERIAL SAFETY DATA SHEET

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