

ANSWERS TO END-OF-CHAPTER PROBLEMS
Fundamentals of Heat and Mass Transfer (Global Edition)
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CHAPTER 1

- 1.1 14.5 W/m², 58 W
1.2 1700 W/m², 1020 W
1.4 2667 W
1.5 4312 W, \$4.14/d
1.6 0.11 W/m · K
1.7 8400 W
1.8 0.10 W/m · K
1.9 (a) 18.5 × 10⁻⁶
1.11 375 mm
1.12 110.40°C, 110.24°C
1.13 1.1°C
1.14 1400 W/m², 18,000 W/m²
1.15 (a) 22.0 W/m² · K; (b) 22.12, 0.6
1.16 20 W/m², 0 W/m², -20 W/m²
1.17 6.3 W/m² · K
1.18 4570 W/m² · K, 65 W/m² · K
1.19 102.5°C, 0.00926 K/W
1.20 51.8°C, 3203°C
1.21 6.3 m/s
1.22 0.44 W, 5.25 W
1.23 15 mW
1.24 (a) 25,650 W; (b) \$17,980
1.25 -80 W/m², 80 W/m²
1.26 2.83, 2.65
1.27 236.5 K
1.28 4.3 W
1.29 0.42, 264 W
1.30 (a) 8.1 W; (b) 0.23 kg/h
1.32 (a) 0, 144 W, 144 W, 0; 0, 144 W, 144 W, 0; (b) 2.04 × 10⁵ W/m³; (c) 39.0 W/m² · K
1.33 (a) 4.86 MW; (b) 9.22 kW; (c) 4.87 MW; (d) 4.87 MW
1.34 (a) 300°C; (b) 3.89 MW; (c) 3.19 kW; (d) 3.89 MW
1.37 (a) 0.223 W; (b) 3.44 W
1.38 100°C, 0.00926 K/W, 0.262 K/W
1.39 (a) 643 W; (b) 175 h
1.40 512°C, 518°C
1.42 (a) 0.063°C/s; (b) 37.80°C

- 1.43 375 W, 1.8×10^{-4} W, 0.097 W
 1.44 180 J, 1080 J, 5400 J
 1.46 840 kW
 1.47 (a) 32.5 kW/m^2 , 126 kW/m^2 , 17.6 K/s, 68.6 K/s
 1.48 (a) 104 K/s; (b) 1251 K
 1.50 $144 \text{ J/kg} \cdot \text{K}$
 1.51 \$0.0087/day
 1.52 (a) -0.084 K/s ; (b) 439 K
 1.53 3.2 h
 1.54 (a) $60.6 \times 10^{-3} \text{ kg/s} \cdot \text{m}^2$, 121 g/m^2 ; (b) $32.3 \times 10^{-3} \text{ kg/s} \cdot \text{m}^2$
 1.55 (a) $7.13 \times 10^{-3} \text{ m}^3/\text{s}$; (b) 70°C
 1.56 (a) -0.044 K/s ; (b) 230 W, 230 W
 1.57 (a) 26°C ; (b) $4.0 \times 10^{-5} \text{ l/s}$
 1.58 $12.2 \text{ W/m}^2 \cdot \text{K}$, $12.2 \text{ W/m}^2 \cdot ^\circ\text{C}$
 1.59 (a) 86.7°C ; (b) 47°C
 1.60 $375 \text{ W/m}^2 \cdot \text{K}$
 1.61 (a) 5268 W; (b) 41°C
 1.62 (a) 153°C ; (b) $16 \text{ W/m}^2 \cdot \text{K}$
 1.63 (a) 476 W/m^2 ; (b) 45.6°C ; (c) 60%

CHAPTER 2

- 2.5 $8.4 \times 10^3 \text{ K/m}$, $6.4 \times 10^6 \text{ K/m}$, $1.6 \times 10^9 \text{ K/m}$
 2.6 $33.3 \text{ W/m} \cdot \text{K}$, $4 \text{ W/m}^2 \cdot \text{K}$
 2.7 (a) 2000 K/m , -200 kW/m^2 ; (b) -2000 K/m , 200 kW/m^2 ; (c) 2000 K/m , -200 kW/m^2
 2.8 0, 80 K/m
 2.10 (a) $15.0 \text{ W/m} \cdot \text{K}$, 400 K; (b) $70.0 \text{ W/m} \cdot \text{K}$, 380 K
 2.11 (b) $5.9 \times 10^{-3} \text{ W/m} \cdot \text{K}$, (c) $0.74 \times 10^{-3} ^\circ\text{C}$, (d) 25.02°C
 2.12 1010 W, \$1050; 151 W, \$157; 10.1 W, \$10
 2.15 288 K
 2.16 $765 \text{ J/kg} \cdot \text{K}$, $36.0 \text{ W/m} \cdot \text{K}$
 2.17 1490 W/m^2
 2.21 (a) 0, $0.98 \times 10^5 \text{ W/m}$; (b) 56.82 K/s
 2.22 (a) 200 W/m^2 , 182 W/m^2 , 18 W/m^2 ; (b) $4.3 \text{ W/m}^2 \cdot \text{K}$
 2.23 (b) $2 \times 10^5 \text{ W/m}^3$; (c) -2950 W/m^2 , 5050 W/m^2 ; (d) $51 \text{ W/m}^2 \cdot \text{K}$, $101 \text{ W/m}^2 \cdot \text{K}$; (f) $-2 \times 10^5 \text{ W/m}^3$; (g) 20°C , $4.94 \times 10^6 \text{ J/m}^2$
 2.26 (a) $1.25 \times 10^6 \text{ W/m}^3$; (b) 130°C , 10^4 K/m , $-1.25 \times 10^5 \text{ K/m}^2$; (c) 230°C , 10^4 K/m , $-1.25 \times 10^5 \text{ K/m}^2$; (d) 230°C , $2 \times 10^4 \text{ K/m}$, $-2.5 \times 10^5 \text{ K/m}^2$
 2.39 (a) 0.20 m; (b) 0; (c) -4608 W/m^2 , $-144,765 \text{ W}$; (d) $24,000 \text{ W/m}^2$, $-24,000 \text{ W/m}^2$, $72,382 \text{ W}$, $-72,382 \text{ W}$
 2.40 (d) 133°C , 122°C , 133.1°C
 2.43 (c) 18.0 kW/m^2 , -360 K/m ; (d) $8.73 \times 10^6 \text{ J/m}^2$; (e) $8.73 \times 10^6 \text{ J/m}^2$
 2.49 (a) $1.8 \times 10^6 \text{ W/m}^3$; (c) $1.8 \times 10^5 \text{ W/m}^2$; (d) $7.77 \times 10^7 \text{ J/m}^2$
 2.52 (b) $3.18 \times 10^8 \text{ W/m}^3$, $1.59 \times 10^5 \text{ W/m}^2$

CHAPTER 3

- 3.2 40 mm, \$3132/yr
3.3 (a) 1270 W/m^2
3.4 85.7 W/m^2 , 31 W/m^2
3.5 (b) 2833 W/m^2
3.6 14.1 W/m^2
3.7 0.0248 m, 0.295 m, 0.592 m, 0.624 m
3.8 1.58 mm from bottom
3.9 (a) $996 \text{ W/m}^2 \cdot \text{K}$, 0.40%; (b) $14.5 \text{ W/m}^2 \cdot \text{K}$, 37.9%
3.10 (a) 0.533; (b) 24.97°C , 12.88°C ; (c) -59°C
3.11 (a) 29.4 W
3.12 (b) 4.21 kW; (c) 0.6%
3.13 $1.302 \times 10^8 \text{ J}$
3.14 (b) 86 mm
3.15 0.185 K/W
3.16 85.6 W/m^2 , 102 W/m^2
3.17 $1.53 \text{ W/m} \cdot \text{K}$
3.18 2.13
3.20 (b) 526°C
3.21 $0.00778 \text{ m}^2 \cdot \text{K/W}$
3.22 $34,600 \text{ W/m}^2$
3.23 $4.54 \times 10^4 \text{ W/m}^2$, 68°C
3.24 (a) 762 W
3.25 (b) 49°C ; (c) $67,160 \text{ W/m}^2$
3.26 1123 W
3.27 (a) $1.97 \times 10^6 \text{ K/W}$
3.28 (a) 0.268 W
3.29 0.022
3.30 $0.0265 \text{ W/m} \cdot \text{K}$, $0.0414 \text{ W/m} \cdot \text{K}$
3.31 $0.789 \text{ W/m} \cdot \text{K}$, 1495 kg/m^3 , $880 \text{ J/kg} \cdot \text{K}$
3.32 $0.79 \text{ W/m} \cdot \text{K}$
3.34 (b) 3.61 kW
3.35 1280 W
3.36 (b) 189 W
3.40 (a) $48.3 \times 10^6 \text{ K/W}$; (b) 62.3°C
3.41 (a) 603 W/m
3.42 0.784 m, 68mm
3.43 2377 W/m
3.45 (a) 214 mm, 420 W/m
3.46 (a) 188 W/m ; (b) 21.6°C
3.47 4.5 W/m , 13 mm
3.48 (b) 253°C
3.49 (a) 47.1 W/m ; (c) 3.25 h

- 3.51 (b) 1577 W/m, 457 K, 350 K
3.52 (a) 0.01 m; (b) 770 W/m, 909 W/m; (c) 55 mm
3.53 5 mm
3.54 (a) 63.3°C
3.56 0.062 W/m · K
3.58 8668 W
3.59 13.5 mm, 91%
3.60 601 K
3.61 (a) 489 W, (b) 120°C
3.63 (a) 1.69 m
3.64 77.9°C
3.65 0.33 m, 2620 W/m³
3.66 9610 A, 1356 K; 7450 A, 931 K; 3020 A, 503 K
3.67 (b) 60°C, 65°C; (c) 200 W/m²; (d) 55°C
3.68 212°C
3.69 6.27°C, 62.7°C, 627°C
3.70 (a) 38.7 W/m
3.71 (a) 50.2°C
3.72 29 A, 3.0 m, 3.2 kW
3.76 (a) 130°C; (c) 50°C; (d) 180°C
3.83 (a) 6406 A; (b) -15,240 W; (c) -10,990 W/m, -11,350 W/m, 4250 W/m, 3890 W/m
3.84 (b) 1458 K
3.85 (a) 938 K, 931 K; (b) 3×10^8 W/m³
3.86 (a) 71.8°C, 51.0°C; (b) 192°C
3.88 (a) 36.6°C; (b) 129.4°C; (c) 337.7°C
3.89 (a) 5.26°C, 5.14°C
3.92 63.6°C, -140 W/m
3.93 510 nm
3.94 20.1 mm/min
3.96 (c) -17.2 W, 23.6 W
3.97 (b) 164.3°C, 145.1°C
3.99 1.35×10^6 K/W, 2.65×10^6 K/W
3.102 (b) 508 W
3.103 (c) 0.333, 607°C
3.105 (a) 180%; (b) 29%
3.106 156.5°C, 128.9°C, 107.0°C
3.107 (a) Case A: 151 W/m, 0.96, 20.2, 0.50 m · K/W, 95.6°C
Case B: 144 W/m, 0.92, 19.3, 0.52 m · K/W, 96.0°C
Case D: 450 W/m, 0, 60.0, 0.167 m · K/W, 25°C
3.108 29.6 mm, 26.3
3.109 (a) Case A: 151 W/m, 0.96, 20.1, 0.50 m · K/W, 95.6°C
Case B: 144 W/m, 0.92, 19.2, 0.52 m · K/W, 96.0°C
Case D: 450 W/m, 0, 60.0, 0.167 m · K/W, 25°C

- 3.110 121 W
3.111 5.2 nm, 0.2 nm
3.112 17.5 W/m · K
3.113 56.6 W/m · K
3.114 1.50 W, 7.84 W, 8.44 W, 3.12 W
3.115 (b) 5995 W, -4278 W
3.116 (a) 2.44×10^{-3} K/W
3.117 454 W
3.118 (1) -0.4 W; (2) 22
3.119 (b) 50.9 W
3.122 37.0 W
3.124 1315%
3.125 (a) 1.40 W
3.126 (a) 0.99, 6.0; (b) 110.8 W/m
3.127 (a) 0.97, 11.05; (b) 6.82 kW/m
3.128 394 K, 383 K, 381 K
403 K, 392 K, 382 K, 381 K
3.129 39,300 W/m, 405 K, 393 K, 384 K, 382 K
3.130 3.3×10^{-5} l/s
3.131 2341 W/m³
3.132 (b) 34.2°C; (c) 36.7°C
3.133 (a) 0.022; (b) 1.91, 0.024; (c) 0.087; (d) 0.21, 0.54; (e) 0.54
3.134 (a) 0.59 W; (b) 16.7 W
3.135 0.22 W
3.136 2.63 W, 114 W, 3990 W; 534 K, 947 K, 1671 K
3.137 3.0 W, 429 W
3.138 0.0263 W, 21.09 W, 102.3 W
3.139 24.7 μm, 7.1 mm
3.140 (a) 7.9×10^5 W/m², 7.9×10^8 W/m²; (b) 87.7 W/m², 87.7×10^3 W/m²; (c) 101 W/m²,
 68.6×10^3 W/m²; (d) 187 W/m², 26.2×10^3 W/m²
3.142 (a) 0.123 W/m · K; (b) 0.129 W/m · K
3.143 1.37×10^{-3} m · K/W

CHAPTER 4

- 4.2 94.5°C
4.3 5.6 kW/m
4.6 0.45 W/m · K
4.7 (c) 2.70, 3.70, 0.19°C, 0.14°C
4.8 92.7°C
4.10 2.6 μW
4.11 (a) 1.097; (b) 0.480; (c) 1.097, 0.493; (d) 658 W, 288 W
4.12 141°C
4.13 110 W/m

- 4.14 6.72L, 612 W/m
4.15 1122 W/m
4.16 72.1°C, 78.1°C, 70.0°C
4.17 12.5 W/m, 11.3 W/m
4.18 11.7 kW
4.19 5.28 mW
4.20 84 W/m
4.21 9.9 W/m
4.22 45.2°C
4.23 (c) 1.55×10^{-4} m
4.24 (a) 1.62 kW/m; (b) 93°C
4.25 156.3 W, 81.3°C
4.26 (a) 745 W/m; (b) 3.54 kg/s
4.27 (a) 0.16°C
4.28 16.4 kW, 230.5°C, 195.6°C
4.29 (a) 1.2°C
4.30 (a) 4.46 W, 98.2°C; 3.26 W, 78.4°C; (b) 4.09 W, 92.1°C; 3.05 W, 75.1°C
4.31 304 W/m, 0.022 m
4.32 (a) 74.6 kW/m; (b) 2.38×10^8 W/m³, 315°C
4.33 0.70 W
4.45 6711 W/m
4.47 70.99°C, 69.01°C, 2.78 kW/m
4.48 (a) 348.6 K, 368.9 K, 374.6 K, 362.4 K, 390.2 K, 398.0 K; (b) 1.53×10^8 W/m³
4.49 3.00 kW/m
4.50 (a) 362.4 K, 390.2 K, 369.0 K; (b) 7500 W/m
4.51 (a) 28 W/m · K, 1400 W/m; (b) 1339 W/m; (c) 1401 W/m
4.52 (a) 122.0°C, 94.5°C, 95.8°C, 79.7°C; (b) 1117 W/m; (c) -1383 W/m
4.53 (a) 46.6°C, 45.7°C, 45.4°C, 49.2°C, 48.5°C, 48.0°C, 47.9°C, 10,340 W/m
4.54 114.5 W/m
4.55 1220 W/m
4.56 (a) 160.7°C, 95.6°C, 48.7°C; (b) 743 W/m
4.57 (a) 118.8°C, 156.3°C, 168.8°C, 206.3°C, 162.5°C; (b) 117.4°C, 156.1°C, 168.9°C, 207.6°C, 162.5°C
4.58 (a) 272.2°C, 952 W/m; (b) 271.0°C, 834 W/m
4.59 0.71
4.60 456 W/m
4.62 10.6 kW/m, 9.33 kW/m
4.64 1487 W/m
4.65 (a) 7.72 kW/m; (b) 7.61 kW/m
4.66 94.0°C
4.67 (a) 100 W/m, 1
4.70 (a) 131 W/m; (b) 129 W/m
4.71 (a) 1683 W/m

- 4.72 1477 W/m
4.73 (c) 25.0 W/m
- 4S.1 2.83, 7.34 kW/m
4S.2 4.26ℓ, 245 W/m
4S.3 (a) 50°C; (b) 0.53ℓ, 3975 W/m; (d) 1.70ℓ, 12,750 W/m
4S.4 2.34ℓ
4S.5 2.58ℓ, 11,600 W/m; 1.55ℓ, 6975 W/m
4S.6 (a) 7.8 kW/m; (b) 0.24 m
4S.7 4ℓ, 45.6 kW/m; 3.5ℓ, 39.9 kW/m
4S.8 3500 W/m, 4500 W/m

CHAPTER 5

- 5.5 (a) 0.75 mm, 1.49 mm, 0.016, 0.032; (b) 1.43 mm, 0.00095; (c) 2.29 mm, 5.18×10^{-4} ;
(d) 3.18 mm, 6.5 mm, 0.0036, 0.0073; (e) 2 mm, 6 mm, 1.0×10^{-4} , 3.1×10^{-4} ;
(f) 5 mm, 10 mm, 0.023, 0.045; (g) 50 mm, 100 mm, 2.3, 4.5
- 5.6 1122 s
5.8 $35.3 \text{ W/m}^2 \cdot \text{K}$
5.9 7.04 h
5.10 0.11 m/s, 0.16 m/s
5.11 138 s
5.12 $0.0041 \text{ m}^2 \cdot \text{K/W}$
5.13 0.43 s
5.14 550 s
5.15 $407 \times 10^{-6} \text{ s}$
5.16 (b) 63.8°C
5.17 968 s, 456°C
5.18 (a) 84.1°C, 83.0°C
5.19 $4.6 \times 10^{-9} \text{ m}^2 \cdot \text{K/W}$
5.20 1.08 h, 1220 K
5.21 (a) 1 ms
5.22 80°C, 38.3 s
5.23 (a) 1190 s, 199 s; (b) 24.1 s; (c) 21.0 s
5.24 64.8°C, 18.4 s
5.25 (b) 825 s, 122°C
5.26 (a) 11.3 min; (b) 5.9 min
5.27 (d) 1.04 h, 0.826 h
5.28 2.26 m, 0.017 J
5.29 $1.56 \times 10^{-4} \text{ s}$, $2.28 \times 10^{-5} \text{ s}$
5.30 1092 K, 1100 K, 1111 K
5.31 $2.8 \text{ W/m}^2 \cdot \text{K}^{1.25}$, 0.25
5.32 (a) 98.1°C; (b) 1.67 h

- 5.33 86 ms, 147 ms
5.34 0.9991, 0.9652, 0.9931, 0.7235, 0.9684, 0.1705; 0.9223, 0.8780, 0.5339, 0.3482, 0.1638, 0.0232
5.35 $0.613 \text{ W/m} \cdot \text{K}$, $2.73 \times 10^6 \text{ J/m}^3 \cdot \text{K}$
5.36 (a) 45.3 min; (b) $2.21 \times 10^7 \text{ J/m}^2$
5.37 1080 s
5.38 48 s
5.39 644 s
5.40 0.11 m
5.41 (a) 10.9 s
5.42 (a) 164 s, 367 s
5.43 (a) 0.5, 0.5, 0.5
5.44 (a) 3.6 s; (b) $-3.53 \times 10^4 \text{ }^\circ\text{C/m}$
5.45 (a) 1100 s
5.46 63.8 s, 51.8°C
5.47 (a) 486 K
5.48 (a) 145 s
5.49 (a) 139°C ; (b) 155°C
5.50 500 K
5.51 254°C
5.52 27 min, 149 kW
5.53 579 s
5.54 (a) $0.30 \text{ W/m} \cdot \text{K}$
5.55 3.4 s
5.56 (a) 66 s, 114°C ; (b) 77.4 kW
5.57 1760 s, 22,600 J
5.58 140 s, 36 mm/s
5.59 (b) 72 s; (c) 7125 W/m^2 ; (d) 3364 J; (e) 428 K
5.60 (a) 98.6 s, (b) 100°C
5.61 3.5 s
5.62 (a) 100 s
5.63 (a) 94.2 s, 0.0025; (b) 3.0 s
5.65 $-4.99 \times 10^5 \text{ J/m}^2$
5.66 1729 s
5.67 (a) 2.81 min; (b) 56 kJ
5.68 (a) 0.34 mm, 2.36 mm
5.69 1.585
5.70 (a) 276°C , 315°C
5.71 9.3°C
5.72 (a) 257 s
5.75 376.2 K
5.76 (b) 0.43 s
5.78 21.8 ns
5.79 6.6 m

- 5.80 10.6 s
5.83 3.1 μm
5.84 203 $^{\circ}\text{C/s}$, 57.6 $^{\circ}\text{C/s}$, 0.227 $^{\circ}\text{C/s}$
5.85 3.33 m, 18.8 W/m^2
5.89 (b) 230 $^{\circ}\text{C}$
5.93 (c) 115 $^{\circ}\text{C}$, 70.0 $^{\circ}\text{C}$, 44.2 $^{\circ}\text{C}$, 30.9 $^{\circ}\text{C}$, 24.7 $^{\circ}\text{C}$, 21.9 $^{\circ}\text{C}$, 20.7 $^{\circ}\text{C}$, 20.3 $^{\circ}\text{C}$, 20.1 $^{\circ}\text{C}$, 20.0 $^{\circ}\text{C}$
5.94 (a) 60.0 $^{\circ}\text{C}$, 60.7 $^{\circ}\text{C}$, 61.4 $^{\circ}\text{C}$, 61.9 $^{\circ}\text{C}$, 62.4 $^{\circ}\text{C}$, 62.8 $^{\circ}\text{C}$, 63.2 $^{\circ}\text{C}$, 63.4 $^{\circ}\text{C}$, 63.6 $^{\circ}\text{C}$, 63.7 $^{\circ}\text{C}$, 63.8 $^{\circ}\text{C}$; (b) 63.8 $^{\circ}\text{C}$, 63.3 $^{\circ}\text{C}$, 60.7 $^{\circ}\text{C}$; (c) 27 s
5.95 24.1 $^{\circ}\text{C}$, 71.5 $^{\circ}\text{C}$
5.96 (a) 64 s; (b) 94 s
5.98 87 s
5.100 161 s, 1364 $^{\circ}\text{C}$, 2.42m
5.101 275 $^{\circ}\text{C}$, 312 $^{\circ}\text{C}$
5.103 (c) 502.3 K, 300.1 K
5.104 (a) 119.3 $^{\circ}\text{C}$, 45.1 $^{\circ}\text{C}$
5.105 (d) 0.79, 0.37
5.106 (a) 882 $^{\circ}\text{C}$, 594 $^{\circ}\text{C}$; (b) 889 $^{\circ}\text{C}$, 231 $^{\circ}\text{C}$; (c) 11,100 s, 617.5 $^{\circ}\text{C}$, 16,000 s, 305.7 $^{\circ}\text{C}$
5.107 (a) $\sim 100^{\circ}\text{C}$
5.108 (a) 136 s; (b) 73 s
5.109 (a) ~ 14.3 s
5.112 (b) 806 K, 1.17 s
5.113 961.5 W/m , 1376 W/m , 1530 W/m , 1530 W/m
5.114 ~ 248 s
- 5S.1 1170 s, 410 $^{\circ}\text{C}$, 537 $^{\circ}\text{C}$
5S.2 96 $\text{W/m}^2 \cdot \text{K}$
5S.3 0.0073 m/s
5S.4 7.6 min
5S.5 (a) 3507 s; (b) 51 $^{\circ}\text{C}$
5S.6 199 $^{\circ}\text{C}$
5S.7 (a) 12 s; (b) -1.0°C ; (c) -3.4 J
5S.8 (a) 5.1 s, 68.3 $^{\circ}\text{C}$
5S.9 1.83 h
5S.10 434 K, 320 K
5S.11 (a) 260 $^{\circ}\text{C}$
5S.12 ~ 2.75 h
5S.13 561 K, 604 K
5S.14 (a) 402.7 K, 370.5 K, 362.4 K

CHAPTER 6

- 6.3 -9205 W/m^2
6.4 705 $\text{W/m}^2 \cdot \text{K}$, -171.4°C/m , $-17,056^{\circ}\text{C/m}$

- 6.5 1.33
6.6 $10.9 \text{ W/m}^2 \cdot \text{K}$, 1.0
6.8 $11.0 \text{ W/m}^2 \cdot \text{K}$, $3.48 \text{ W/m}^2 \cdot \text{K}$, $7.88 \text{ W/m}^2 \cdot \text{K}$, $4.98 \text{ W/m}^2 \cdot \text{K}$
6.9 $67.35 \text{ W/m}^2 \cdot \text{K}$
6.10 (a) $\sim 20 \text{ W/m}^2 \cdot \text{K}$, $\sim 10 \text{ W/m}^2 \cdot \text{K}$, $\sim 30 \text{ W/m}^2 \cdot \text{K}$
6.11 $155 \text{ W/m}^2 \cdot \text{K}$
6.14 600 W/m^2 , 18.9 W
6.15 229, $924 \text{ W/m}^2 \cdot \text{K}$, 29 W
6.16 (a) 20.9 m/s
6.17 (a) 31.4 m; (b) 0.157 m
6.18 12.8 mm
6.19 0.43 m, 0.003 m
6.20 (b) $29.9 \times 10^{-6} \text{ m}^2/\text{s}$, $5.98 \times 10^{-6} \text{ m}^2/\text{s}$, $2.99 \times 10^{-6} \text{ m}^2/\text{s}$; (c) 5.23 m, 1.05 m, 0.523 m
6.22 1.32, 309 K, 272 K
6.23 2066 W
6.24 $40 \text{ W/m}^2 \cdot \text{K}$
6.25 30 mm
6.26 (a) $34.3 \text{ W/m}^2 \cdot \text{K}$; (b) $59.0 \text{ W/m}^2 \cdot \text{K}$
6.27 167, 64,400, 11,700
6.28 1.11
6.29 3802, 6.29×10^4 , 0.71, 0.068
6.30 2
6.31 6.69
6.32 (a) 4.0 m, 4.2 m
6.33 42.5°C
6.34 (a) 47.2°C ; (b) 13.2 m/s
6.36 88.6
6.37 16.6 mm, 250 K
6.38 240 W
6.39 2.66 kW
6.40 26.0 N/m^2
6.41 0.785 N
6.42 4260 W/m^2
6.43 14.3 W
6.44 $1.55 \times 10^{-3} \text{ m/s}$
6.45 (a) 0.0179 m/s; (b) $0.75 \times 10^{-5} \text{ kg/s}$; (c) $5.31 \times 10^{-5} \text{ kg/s}$
6.46 1.32 m/s
6.47 $10^{-6} \text{ kg/s} \cdot \text{m}^2$
6.49 385, 6.29×10^4 , 0.62, 0.0073; 1613, 6.29×10^4 , 2.56, 0.0187; 1.06×10^7 , 1577, 6.74×10^5 , 76.9
6.50 (a) $0.975 \times 10^{-3} \text{ kmol/m}^3$, 0.0258 atm; (b) $9.28 \times 10^{-4} \text{ kg/s} \cdot \text{m}^2$
6.51 (a) $4.64 \times 10^{-4} \text{ kg/s}$; (b) 1247 W
6.52 0.605, 457, 1.26×10^5 ; 2.56, 581, 9.44×10^4 ; 1.25, 631, 1.57×10^5 ; 0.829, 0.549, 0.275 ; $6.8 \times 10^{-3} \text{ m/s}$

- 6.53 (a) 1.63×10^{-4} kg/s; (b) 282.2 K
 6.54 1.50×10^{-3} kg
 6.55 $359 \text{ W/m}^2 \cdot \text{K}$
 6.56 (a) 0.031, 0.80; (b) $198 \text{ W/m}^2 \cdot \text{K}$; (c) 74%
 6.57 0.00395 m/s
 6.58 7.78 km
 6.59 (a) $+795 \text{ W/m}^2$, $+131 \text{ W/m}^2$, -563.1 W/m^2 ; (c) 1227 W/m^2
 6.60 784 W
 6.61 (a) 0.70 kg/h; (b) 86°C
 6.62 2950 W
 6.63 (a) 4.7°C ; (b) 0.0238 m/s; (c) 16.2°C
 6.64 $357 \times 10^{-6} \text{ W}$, $88.1 \times 10^{-6} \text{ W}$, $-912 \times 10^{-6} \text{ W}$, 122 K/s, 578 K/s; (b) 289 K, 304 K
 6.65 (a) 0.0142 bar, 0.214; (b) 0.225; (c) 0.242
 6.66 (a) 0.172 m/s, 65.3 s; (b) $173 \text{ W/m}^2 \cdot \text{K}$, $77,464 \text{ W/m}^2$; (c) 429°C
 6.67 (a) 0.0113 m/s; (b) 90 J
 6.68 (b) -0.32 K/s
- 6S.2 40.83°C
 6S.3 (b) 1510 W/m, $453 \text{ kg/s}^2 \cdot \text{m}$
 6S.4 (a) 34.2 N/m^2 , 0.738 N/m^2 ; 6840 W/m^2 , 148 W/m^2 ; (b) $1.37 \times 10^6 \text{ W/m}^3$, $2.95 \times 10^4 \text{ W/m}^3$; (c) 34.0°C , 30.5°C
 6S.5 (a) 0.0028, 0.0056, 13.4; (b) 3.38
 6S.7 (b) 117°C
 6S.8 (a) $6.66 \times 10^7 \text{ W/m}^3$; (b) 1462 W; (c) 81.2°C , 303°C
 6S.14 (e) $6.71 \times 10^{-4} \text{ kg/s}$

CHAPTER 7

- 7.1 (a) 3.99 mm, 4.48 mm; 0.93 mm, 0.52 mm; 23.5 mm, 1.27 mm; 0.34 mm, 1.17 mm
 7.2 (a) 0.163 mm, 0.515 mm, 1.63 mm, 151 mm; (b) 2.82 N/m^2 , 0.893 N/m^2 , 0.28 N/m^2 ,
 0.409 m/s , 0.129 m/s , 0.0409 m/s
 7.7 $13,560 \text{ W/m}$, 9780 W/m , 5530 W/m
 7.8 (a) $8.71 \times 10^5 \text{ W/m}^3$; (b) 158.4°C
 7.9 (a) 51.1 W, 12.2 W, 8.3 W, 255.3 W
 7.10 (a) 0.257 N, $8.13 \text{ W/m}^2 \cdot \text{K}$, 1950 W; 0.227 N, $7.16 \text{ W/m}^2 \cdot \text{K}$, 3440 W; (b) 0.620 N,
 $9050 \text{ W/m}^2 \cdot \text{K}$, 5430 W; 0.700 N, $12,600 \text{ W/m}^2 \cdot \text{K}$, 15,100 W
 7.11 3.2×10^5 , 1.5×10^6
 7.12 56.5 W
 7.13 (c) $4110 \text{ W/m}^2 \cdot \text{K}$, $4490 \text{ W/m}^2 \cdot \text{K}$, $5072 \text{ W/m}^2 \cdot \text{K}$
 7.14 (a) 17.6 W; (b) 143.6 W
 7.15 (a) 14.3 W, 125.9°C
 7.16 (a) 33.8°C , 797 W; (b) 675 W; (c) 90.6 kW

- 7.17 1515 W
7.18 $47.45 \text{ W/m}^2 \cdot \text{K}$
7.19 $6944 \text{ W}, -0.27^\circ\text{C/s}$
7.20 (a) $8.73 \text{ W/m}^2 \cdot \text{K}, 14.5 \text{ W/m}^2 \cdot \text{K}, 11.1 \text{ W/m}^2 \cdot \text{K}$
7.21 29°C
7.22 (b) 188°C
7.23 46.2°C
7.24 (a) $23.4 \text{ W}, 28.2^\circ\text{C}$; (b) $271 \text{ W}, 72.6^\circ\text{C}$; $105 \text{ W}, 200^\circ\text{C}$
7.25 (b) 256°C ; (c) 210°C
7.26 $-4.66 \text{ K/s}, -2.33 \text{ K/s}, 1.91 \text{ m}$
7.27 (a) $1253 \text{ W/m}^2 \cdot \text{K}, 2.51 \text{ kW}, 0.097 \text{ N}$; (b) $1372 \text{ W/m}^2 \cdot \text{K}, 2.74 \text{ kW}, 0.110 \text{ N}$; (c) $3562 \text{ W/m}^2 \cdot \text{K}, 7.12 \text{ kW}, 1.379 \text{ N}$; (d) $4024 \text{ W/m}^2 \cdot \text{K}, 8050 \text{ W}, 1.615 \text{ N}$
7.28 (a) 27.7°C ; (b) 108°C
7.29 3158
7.30 (a) 64°C ; (c) 6.6 m/s
7.31 47.1°C
7.32 3.84 m/s
7.33 (a) 55 W ; (b) 39 W
7.34 $0.28 \text{ W}, 0.69 \text{ W}$
7.35 $0.59 \text{ W}, 0.53 \text{ W}$
7.36 (a) $71.1 \text{ W/m}, 20.4 \text{ kW/m}, 1640 \text{ W/m}$
7.37 $3.24 \text{ N/m}, 520 \text{ W/m}$
7.38 (a) 603 K ; (b) 200 s
7.39 (a) 562 K ; (b) 155 s
7.40 $19.8 \text{ W/m}^2 \cdot \text{K}, 0.0802 \text{ K/W}, 623 \text{ W}$
7.41 117 W
7.42 $5980 \text{ W}, 7670 \text{ W}$
7.44 (a) 2.33 W ; (b) 37.4 mm ; (c) 64.0 ; (d) 328%
7.45 (a) $\$0.415/\text{m} \cdot \text{d}$; (b) $\$0.363/\text{m} \cdot \text{d}$
7.46 (a) $235 \text{ W/m}^2 \cdot \text{K}$; (b) 0.87 W ; (c) 1.02 W
7.47 (b) 73.8 m/s
7.48 (b) 195 mA
7.50 (a) 27.6°C ; (b) 27.6°C
7.52 (a) 45.8°C ; (b) 68.3°C
7.54 (a) 3644 W/m
7.55 452.2 K
7.56 (b) 18.7 mm
7.57 (a) $3.24 \text{ K/W}, 3.06 \text{ K/W}, 2.88 \text{ K/W}, 2.41 \text{ K/W}, 2.07 \text{ K/W}$; (b) $3.24 \text{ K/W}, 2.95 \text{ K/W}, 2.70 \text{ K/W}, 2.16 \text{ K/W}, 1.80 \text{ K/W}$; (c) $1.86 \text{ K/W}, 1.74 \text{ K/W}, 1.63 \text{ K/W}, 1.48 \text{ K/W}, 1.19 \text{ K/W}$;
7.58 (a) 0.011 N ; (b) 3.14 W
7.59 (a) $0.489 \text{ N}, 638 \text{ W}$; (b) $0.452 \times 10^{-3} \text{ N}, 1.99 \text{ W}$
7.60 (a) 18.8°C ; (b) 672°C
7.61 $0.0184 \text{ W}, 0.0125 \text{ W}$

- 7.62 (a) 2 m/s, 0.163 m; (b) 1.11 mm, $1.25 \times 10^{-3} \text{ m}^3$
7.63 (a) 67 s; (b) 48 s
7.64 2.1 m/s, 1.6 m
7.65 1.1 m/s, 10.3 m
7.66 (a) 0.0011 s, 166.7 m/s; (b) $35,400 \text{ W/m}^2 \cdot \text{K}$, $7.8 \times 10^{-4} \text{ s}$
7.67 36 mm
7.68 (a) 0.3 m/s; (b) 1.86 mm
7.69 (a) 20.4; (b) 45.8°C
7.70 (b) 337°C
7.71 (a) 726 K; (b) 735 K
7.72 $234 \text{ W/m}^2 \cdot \text{K}$, 0.0149 bar, 28.4 kW/m
7.73 58.5 kW, $5.9 \times 10^{-3} \text{ bar}$
7.74 16, 684 N/m^2
7.75 -532 kW/m
7.76 (a) 7671 W, 47.6°C ; (b) 195 N/m^2 , 56 W
7.77 (a) 37°C ; (b) 359 N/m^2 ; 2.26 kW
7.78 (a) $435 \text{ W/m}^2 \cdot \text{K}$; (b) 321 K, 2453 W
7.79 (a) 363 K; (b) 355 kW, 0.190 kg/s
7.80 (a) 0.27 mm; (b) 0.98 mm
7.81 1.68 W
7.82 -1.20 K/s
7.83 118 K
7.84 1.3%, 70%
7.85 (c) 0.179 kg/s
7.86 (a) $470.5 \text{ W/m}^2 \cdot \text{K}$; (b) 40.1 s
7.87 1189 s
7.88 65.7 kW
7.89 (a) 941°C , 333 W; (b) 1314°C
7.90 (a) 10.5°C , 0.0134 kg/s
7.91 (a) 7.0°C , 0.0168 kg/s; (b) 6.2°C , 0.0173 kg/s
7.92 (a) 41.2°C , 0.0154 kg/s
7.93 (a) 1043 W; (b) 1560 W, 3.0 m, $34.7 \text{ W/m} \cdot \text{K}$
7.94 (a) 0.0728 m/s; (b) 0.0028 kg/s
7.95 (a) $9.29 \times 10^{-4} \text{ kg/s} \cdot \text{m}$, 2265 W/m
7.96 5.93 kW
7.97 (a) $0.0135 \text{ kg/s} \cdot \text{m}$
7.98 3.57 W
7.99 (a) 0.123 kg/h, 44.9 W; (b) 52.3°C
7.100 (b) $2.12 \times 10^{-4} \text{ kg/s} \cdot \text{m}^2$
7.101 337 W/m, 483 W/m, 589 W/m
7.102 31°C , 139 MW, 672 MW
7.103 54.8°C , 25.2°C
7.104 $2.73 \times 10^6 \text{ kg/day}$

- 7.105 $0.0016 \text{ kg/s} \cdot \text{m}^2$
7.106 (a) $4.81 \times 10^{-4} \text{ kg/s} \cdot \text{m}^2$, 1268 W/m^2
7.107 (a) 20.3 kg/h ; (b) 102 days
7.108 290.9 K , $1.08 \times 10^{-5} \text{ kg/s}$
7.109 (a) $0.362 \text{ kg/h} \cdot \text{m}$, 152 W/m ; (b) 58.9°C
7.110 (a) 485 W ; (b) 3135 W
7.111 (a) 9424 W/m
7.112 45.6°C , 0.21
7.113 (b) $1.82 \times 10^{-7} \text{ kg/s}$, -8.9 K/s
7.114 160 s
7.115 $3.60 \times 10^{-8} \text{ kg/s}$
7.116 $9.06 \times 10^{-8} \text{ kg/s}$
7.117 35 body diameters/s
7.118 (a) $1.12 \times 10^{-8} \text{ kg/s}$; (b) 2.3 K
7.119 (a) 1.83; (b) 28.0°C , 0.00129

CHAPTER 8

- 8.1 0.041 m/s , $-0.86 \times 10^{-5} \text{ bar/m}$
8.2 $1.19 \times 10^4 \text{ N/m}^2$, 2.99 W ; $3.31 \times 10^4 \text{ N/m}^2$, 8.32 W
8.3 0.0215 bar
8.4 (a) 0.289 bar , 1.42 kW ; (b) 0.402 bar , 1.97 kW
8.5 (c) 96; (d) 2.12 m/s , 1332
8.6 (a) 0.033 m/s , 0.038 m/s , 0.037 m/s , 2.1 m , 0.03 m , 1.3 m , 3.97 m , 10.1 m , 0.025 m ;
(b) 0.0063 kg/s , 0.464 m , 2.72 m , 0.0059 kg/s , 1.72 m , 2.3 m , 0.0056 kg/s , 0.73 mm ,
 4.65 m , 0.0052 kg/s , 38 mm , 5.74 m
8.7 0.50 m/s , 20.0°C
8.8 0.84 MPa , 0.46 MW , 0.46°C
8.9 (c) 0.46°C
8.11 (a) 2.31 m , 34.4°C , 40.9 W , 0.446 W ; (b) 2.31 m , 34.4°C , 40.9 W , $5.37 \times 10^{-5} \text{ W}$
8.12 (a) 471 W , 113.5°C , 60°C , 153.5°C ; (b) 353 W , 90.2°C , 20°C , 150.2°C
8.14 (b) 60.8°C
8.15 (b) 44.2°C
8.16 8
8.19 (a) 35°C , 15980 W
8.20 $12,682 \text{ W/m}^2$, 121°C , 52.7°C
8.22 (a) 376 W , (b) 369 W
8.23 90 kg/h , 1360 W
8.24 26.8 m
8.25 (a) 7.16 W
8.26 13.7 m , 0.077 W
8.27 (b) 1266 s
8.28 (a) 10.6 m

- 8.29 (a) 40.8°C , 714 W, 0.059 W; (b) 2.09 m, 0.145 W
8.30 $\$0.411/\text{m} \cdot \text{d}$
8.31 (a) 63°C ; (b) 65.9°C
8.33 (a) 29.9°C , -1212 W , 4.03 N/m^2
8.34 1 m, $30,700 \text{ W/m}^2$
8.35 (a) 81.7°C ; (b) $9.1 \times 10^{-4} \text{ bars}$, 0.19 W
8.36 0.39 m
8.37 7840 W/m^2 , 7040 W/m^2
8.38 (a) 42.2°C , 7500 W, 1.29 h; (b) 0.324 h
8.39 1920 W/m^2 , 192 W/m^2 , 19.2 W/m^2 ; 201°C , 79.8°C , 53.3°C
8.40 (a) 323 K; (b) 325 K
8.41 (a) 198°C , 71 N/m^2 , 221 W; (b) 195°C , 119 N/m^2 , 415 W
8.42 (a) 85.6°C , 661 W
8.44 (a) 100 kW; (b) 2.67 kW
8.45 343 W/m
8.46 80.3 W/m
8.47 (a) 543°C , 232°C
8.48 (b) 111°C , $9.1 \times 10^6 \text{ W}$
8.49 (a) 37.1°C ; (b) 47.4°C
8.50 (a) 98.5 m; (b) 10.6 m
8.51 43.61°C , 44.55°C
8.52 (a) 10 kW; (b) 3.4 m
8.54 (a) $409 \text{ W/m}^2 \cdot \text{K}$; (b) $93.4 \text{ W/m}^2 \cdot \text{K}$; (c) $76.1 \text{ W/m}^2 \cdot \text{K}$, 15°C
8.55 15.7°C , 438 W
8.56 (b) 244 W/m, 187°C
8.57 0.90, 308.3 K
8.58 (b) 53°C
8.59 9.3 m
8.60 85°C , 53 mm
8.61 379 K, 406 K
8.62 (a) 0.485 W; (b) 0.753 W; (c) 0.205 Pa, 1.02 Pa
8.63 (b) 305.3 K, 15.7 kW
8.64 2724 W, 312 K
8.66 (a) $53,700 \text{ W/m}^2$; (b) $123,400 \text{ W/m}^2$
8.67 (a) 1.9 m
8.68 30.1°C , 224 N/m^2
8.69 131 W/m, 426 W/m, 59.3 Pa/m, 177 Pa/m
8.70 (a) 3.346 kW; (b) 69 s
8.71 (a) 19.7 m; (b) 1575 W/m^2 ; (c) 58.4 m
8.73 2.51 m, 388°C
8.74 (a) 704.5 K; (b) 683 K, 1087 K, 300 K
8.75 (a) 20.6°C , 0.084 W; (b) 18.9°C , 0.126 W; (c) 21.5°C
8.76 (a) 9.77 m; (b) 159 mm; (c) 775 N/m^2 , 379 N/m^2 ; (d) $2.25 \times 10^{-3} \text{ kg/s}$

- 8.77 1, 1.25, 1.54, 2.42
 8.78 6.90×10^{-2} kg/s, 5.79 m, 67.8 mm
 8.79 (a) 35.1°C; (b) 33.2°C
 8.80 (a) 3190 W, -2039 W; (b) 9197 W, -8065 W
 8.81 (a) 81.3°C
 8.82 310 K, 418 W
 8.83 350 K, 3.0 W
 8.84 0.100 kg/m^3 , 0.783 kg/m^3 , 0.764 kg/m^3
 8.85 (a) 307.8 K, 373 W; (b) 704 W
 8.86 0.346 mm, 0.237 mm, 0.920 mm
 8.87 (a) 298.6 K, 45 W; (b) 349.9 K, 3.0 W
 8.88 (a) 0.48°C; (b) 43.6°C, 27.6°C
 8.89 (a) 52 mm; (b) 316 K; (c) 15.9×10^6 Pa; (d) 1.63 km, 1650 s
 8.90 2.94 μm , 1.99 μm
 8.91 (a) 1.88×10^{-5} kg/s, 2.55×10^{-5} kg/s, 3.36×10^{-5} kg/s, 308.7 K, 307.9 K, 307.1 K; (b) 2.60×10^{-5} kg/s, 307.7K
 8.92 0.0032 m/s
 8.93 2.42×10^{-2} m/s
 8.94 0.026 m/s
 8.95 3.6×10^{-4} kg/s · m², 3.0×10^{-4} kg/s · m², 2.4×10^{-4} kg/s · m², 0.0108 m, 0.0107 m, 0.0106 m
 8.96 (a) 50.6 W; (b) 34.2°C
 8.98 0.0177 kg/m^3 , 4.54×10^{-6} kg/s
 8.99 (a) 3.78 m; (b) 46.7 W
 8.100 (a) 8.7 mm Hg, 0.0326 kg/m^3 ; (b) 3.20×10^{-5} kg/s
 8.101 (a) 0.0050 m/s; (b) 0.134 liter/day
 8.102 (d) 0.0181 kg/m^3

CHAPTER 9

- 9.2 $300.9 \times 10^{-6} \text{ K}^{-1}$
 9.4 727, 12.5, 512, 1.01×10^6
 9.5 5.8, 663, 209
 9.6 5.20, 23.78, 108.7
 9.7 (a) 17.5 mm; (b) 0.47 m/s, 3.5 mm; (c) $4.3 \text{ W/m}^2 \cdot \text{K}$; (d) 0.60 m
 9.8 0.881
 9.9 (a) 34 mm; (b) 16.8 W
 9.10 12.6 mm
 9.12 $4.42 \text{ W/m}^2 \cdot \text{K}$, $4.51 \text{ W/m}^2 \cdot \text{K}$
 9.13 $6.5 \text{ W/m}^2 \cdot \text{K}$
 9.14 (a) $3.03 \text{ W/m}^2 \cdot \text{K}$; (b) $2.94 \text{ W/m}^2 \cdot \text{K}$
 9.15 0.174 m, 10.4 W
 9.16 45.7 W
 9.17 (b) 223 W, \$1.120/day

- 9.18 273.8 K, 174.8 W
9.19 274.4 K, 273.2 K, 140 W
9.21 11.7 W
9.22 153 W
9.23 (a) $347 \text{ W/m}^2 \cdot \text{K}$
9.24 (a) 364.2 W; (b) 46.5°C , 16.4%
9.25 (a) 118 kW/m^3
9.26 (a) 35.8°C ; (b) 28.8°C ; (c) 68.8°C , 49.5°C
9.27 (a) 94.3 W
9.28 (a) 74.9°C , 1225 W; (b) 71.4°C , 1262 W
9.29 24.8 W/m^2
9.30 85.5 W/m
9.31 (a) 72.7 W; (b) 483 W
9.32 468 W
9.33 (a) 120 W/m
9.34 181 s
9.35 $0.560 \text{ W/m} \cdot \text{K}$, 0.815
9.36 56.7°C , 4.30 K/W, 3.56 K/W, 0.30 K/W, $4.2 \times 10^{-3} \text{ K/W}$
9.37 90.2 W
9.38 45.3°C , 1007 W
9.39 (a) $2.91 \times 10^5 \text{ W}$; (b) $8.53 \times 10^4 \text{ W}$, 1463 K; (c) 0.13 m
9.40 (a) 42.9 min; (b) 11.0 min
9.41 (a) $4.0 \text{ W/m}^2 \cdot \text{K}$; (b) $3.2 \text{ W/m}^2 \cdot \text{K}$; (d) 45.7°C , 34.0°C
9.42 21.6 kW
9.43 66°C
9.44 698 W/m
9.46 (a) 642 W/m ; (b) 1760 W/m ; (c) 146 W/m
9.47 103 W/m
9.48 (a) 50.8 W/m , 0.953; (b) 56.9 W/m , 0.948
9.49 64.8°C
9.50 (b) $8 \text{ W/m}^2 \cdot \text{K}$, 30.2 W/m
9.51 (a) 2.04 W; (b) 1.97 W
9.52 6.72 W/m
9.53 79°C
9.54 (a) 163 W/m , 41.7°C ; (b) 60.8°C , 12.5°C , 52.8 W/m
9.56 (a) $207 \text{ W/m}^2 \cdot \text{K}$; (b) $387 \text{ W/m}^2 \cdot \text{K}$
9.57 (a) $9.84 \text{ W/m}^2 \cdot \text{K}$; (b) $32.1 \text{ W/m}^2 \cdot \text{K}$; (c) 221 s; (d) 245 s
9.58 (a) 33.3 kW; (b) $\sim 855 \text{ s}$, 9.07 kg
9.59 4
9.60 (c) 0.17 m/s, 0.00185 m/s
9.61 (a) 1.55 W; (b) 187 W; (c) 57.0 W
9.63 7.12 mm, 63.1 W
9.64 92.16 W
9.65 (a) 7.2 W, \$0.25

- 9.66 (a) 28.6 W
9.67 8.30 mm, 19, 378 W
9.68 (a) 18.0 W; (b) 19.6 mm
9.69 26.3 kW/m
9.70 7 mm
9.71 68 W
9.72 74.9 W/m
9.73 (a) 124 W/m²; (b) 146 W/m²; (c) 26 W/m²
9.74 (a) 429 kg; (b) 105 × 10⁶ J, 0.102; (c) 33.4 kg
9.75 (a) 1.57; (b) 1.23
9.77 (a) 74%, 35.4°C
9.78 (a) 466 W
9.79 (a) 44.9 W/m; (b) 47.3 W/m
9.80 100, 7.39; 51.6, 3.82; 45.0, 3.33
9.81 43.4 W/m
9.82 0.1 m, 45.2 W/m
9.83 57.8 mm
9.84 463 W/m
9.85 0.022 kg/s
9.86 1.33
9.88 2.02 m/s
9.89 (a) 54.6 W/m; (b) 72.3 W/m; (c) 70.7 W/m; (d) 235 W/m
9.90 8.74 W
9.91 (a) 55.1°C
9.92 43.9 W, 47.9 W
9.94 6.21 × 10⁻⁵ kg/s · m
9.95 1.55 × 10⁻⁶ kg/s
9.96 (a) 9.18 W; (b) 1.64 × 10⁶; (c) 6.14 W/m² · K; (d) 0.00592 m/s, 2.12 kg/day, 59.4 W;
(e) 81.6 W
9.97 77 A, 102 A

CHAPTER 10

- 10.2 5413 W/m², 229 kW/m²
10.3 (c) 0.032 mm
10.4 1300 W/m² · K, 10,000 W/m² · K, 47,000 W/m² · K, 210 W/m² · K, 1200 W/m² · K, 0.15 mm
10.5 (a) 38,600 W/m² · K; (b) 0.017
10.6 13,690 W/m² · K
10.7 66.4, 38.0, 26.8, 29.7
10.8 73 kW/m², 232 kW/m²; 105 kW/m², 439 kW/m²
10.9 (b) 89°C
10.10 110.1°C, 119.1°C
10.11 12.30 kW, 19 kg/h, 0.384, 30°C

- 10.12 (a) 110°C , $1.043 \times 10^6 \text{ W/m}^2$; (b) 109°C
10.13 131.6°C , 133.8°C
10.14 (a) 3.5 W , -19°C
10.15 ~ 10 , 118°C
10.16 4.70 MW/m^2 , 23.8 MW/m^2
10.17 55.4°C
10.19 0.81 MW/m^2
10.21 (a) 0.0131 ; (b) 144.6°C , 182.1°C
10.23 378 K , 500 K
10.25 835 W
10.26 (a) 858 kW/m
10.27 1.34 MW/m^2 , 2048 K
10.28 (a) 146 kW/m^2
10.29 $4.16 \times 10^4 \text{ W/m}^2$
10.30 0.475 MW/m
10.32 68.0 kW/m
10.33 (a) 197°C , 0.672 ; (b) 691°C
10.34 (a) 35.6°C ; (b) 54.0°C
10.35 $1.11 \times 10^{-3} \text{ kg/s}$
10.36 6.69 mm , $1.29 \times 10^{-3} \text{ kg}$, $9.7 \times 10^{-2} \text{ kg}$
10.37 40.3 kW , 0.0177 kg/s
10.38 0.00171 kg/s , 0.00176 kg/s
10.40 (a) 1.04 MW , 0.435 kg/s ; (b) 0.96 MW , 0.402 kg/s
10.41 (a) 78°C
10.42 0.141 , 0.560 mm
10.43 (a) 48.6°C , 4270 W/m , $0.0018 \text{ kg/s} \cdot \text{m}$
10.45 8.82 MW/m , $3.59 \text{ kg/s} \cdot \text{m}$
10.46 (a) 28.3 kW/m , $1.16 \times 10^{-2} \text{ kg/s} \cdot \text{m}$; (b) $1.27 \times 10^{-2} \text{ kg/s} \cdot \text{m}$, 30.9 kW/m , 9%
10.47 (a) 144 mm
10.48 (a) 0.0118 kg/s , $7.98 \times 10^{-3} \text{ kg/s}$; (b) 50.6°C , 55.4°C ; (c) 6.23 m
10.49 $2.78 \times 10^{-3} \text{ kg/s}$
10.50 0.0080 kg/s , 0.0020 kg/s ; 0.0086 kg/s , 0.0014 kg/s
10.51 $7127 \text{ W/m}^2 \cdot \text{K}$, $9.0 \times 10^{-3} \text{ kg/s} \cdot \text{m}$
10.52 (a) $43,300 \text{ W/m}^2 \cdot \text{K}$, $0.0546 \text{ kg/s} \cdot \text{m}$
10.53 (a) $2570 \text{ W/m}^2 \cdot \text{K}$, 283 W/m , $1.19 \times 10^{-3} \text{ kg/s} \cdot \text{m}$
10.54 $144,900 \text{ W/m}^2 \cdot \text{K}$, $7.56 \times 10^{-4} \text{ kg/s}$
10.55 (a) 89.4°C , (b) -79°C
10.56 2.11 W , 0.033 m^2
10.57 (a) 79.4°C , 55.7 W ; (b) 16.4 mm
10.58 (a) 0.286 kg/s , 0.089 kg/s ; (b) 379.7 K , 1.27 bars
10.60 (a) 114.2°C ; (b) 80.9°C , $2.6 \times 10^{-4} \text{ kg/s}$
10.61 (a) 1870 W , 325 K , 300 K

CHAPTER 11

- 11.2 1.01 years
11.3 (a) $92.1 \text{ W/m}^2 \cdot \text{K}$; (b) $691 \text{ W/m}^2 \cdot \text{K}$
11.4 $249 \text{ W/m}^2 \cdot \text{K}$, $1138 \text{ W/m}^2 \cdot \text{K}$
11.5 11,600 W
11.6 924 W/m
11.7 (a) $98.0 \text{ W/m}^2 \cdot \text{K}$; (b) $512 \text{ W/m}^2 \cdot \text{K}$
11.8 $168 \text{ W/m}^2 \cdot \text{K}$
11.9 $29.22 \text{ W/m}^2 \cdot \text{K}$
11.10 $12.6 \text{ W/m}^2 \cdot \text{K}$
11.12 3.09 m^2 , 2.64 m^2 , 2.83 m^2 , 2.84 m^2
11.13 4.44 m^2
11.14 $52.6 \times 10^{-4} \text{ m}^2 \cdot \text{K/W}$
11.15 19.4 kW, $132 \text{ W/m}^2 \cdot \text{K}$
11.16 0.90, 2.8
11.17 (a) 0.97 m; (b) 2250 W, 145°C , $338 \text{ W/m}^2 \cdot \text{K}$, $9.59 \times 10^{-4} \text{ m}^2 \cdot \text{K/W}$
11.18 (a) 48°C ; (c) $132 \text{ W/m}^2 \cdot \text{K}$; (d) 0.8; (e) 1
11.20 5.19 kg/s, 37.5 m
11.21 (a) 7600 W, 48.1°C ; (b) 40 m
11.22 $0.0029 \text{ m}^2 \cdot \text{K/W}$
11.23 (a) 357 K, 515 K; (b) $30.7 \text{ W/m}^2 \cdot \text{K}$
11.24 (a) 12 m^2 , 627 kW, 37.5°C ; (b) \$440,000/yr
11.25 (a) 9.0 mm, 3.5 m
11.26 79.8°C , $8.70 \times 10^{-4} \text{ kg/s}$
11.27 (a) 399 K, 70
11.28 (a) 74%; (b) 24°C
11.29 (a) 469.8 K, 327.9 K, 517 kW
11.30 60.8°C
11.31 0.185 kg/s
11.32 (a) $3550 \text{ W/m}^2 \cdot \text{K}$, 41.1°C , 0.85 kg/s
11.33 (a) 344.4 K
11.34 (a) 1.89 kg/s
11.35 (a) 720, 0.858 m; (b) 0.513 m
11.36 (b) 0.50
11.37 (b) 0.60
11.38 36.8°C , 37.5°C
11.39 (a) 3.07 m^2 , 33.4°C
11.40 (a) 9.6 m
11.41 (a) $508 \text{ W/m}^2 \cdot \text{K}$; (b) 1.95 m
11.42 (a) 55.7°C , 41.9°C ; (b) $2320 \text{ W/m}^2 \cdot \text{K}$; (d) 74.4°C , 0.55
11.43 (a) $11,200 \text{ m}^2$; (b) 1994 kg/s
11.45 (a) 189; (b) 27.2°C ; (c) 16.0 kg/s

- 11.46 (a) 661 W, 11.0 °C; (b) 10,100 W, 24.5°C; (c) \$1767
11.47 808 W/m² · K
11.48 (a) 61 W/m² · K; (b) 0.64; (c) 46.2°C
11.49 68, 7.1 m
11.50 (a) 29.4%
11.51 (a) 0.53 × 10⁵ W, 0.47
11.52 47.9°C, 34.6°C, 100 m²
11.53 36.6°C, 143.5°C
11.55 36,900 m²
11.56 23,700 m²
11.57 (a) 204 kW, 57.3°C, 42.7°C; (b) 2.33 m
11.59 (a) 0.752 m²; (b) 0.576 m², 0.0855 kg/s; (c) 0.723 m², 317 K
11.60 (a) 335 K; (b) 8.11 m; (c) 0.666
11.61 (a) 30.3%; (b) 27.5 kg/s
11.62 (a) 44.6 kW; (b) 0.65; (c) 0.55
11.63 (a) 0.0354 m or 0.261 m, 0.34 m
11.64 41 m²
11.65 (a) 26.8°C
11.66 (a) 2 × 10⁵ W, 19.6°C, 19.6°C
11.67 (a) 73.9 W/m² · K; (b) 496 K, 369 K
11.69 1.35 s
11.70 46.3°C
11.72 810 W
11.73 58.4 W
- 11S 147 W/m² · K
11S.2 29.6 W/m² · K
11S.3 4.75 m²
11S.4 5.74 × 10⁻⁴ m² · K/W
11S.5 (a) 1.5 m²
11S.6 33.1 m²
11S.7 (a) 9.6 m
11S.8 (a) 11,100 m²; (b) 1994 kg/s
11S.9 878 W/m² · K
11S.10 243 m²
11S.11 4.8 m
11S.12 66.3 W/m² · K
11S.13 0.082 m³, ~13, ~11, 0.54 m
11S.14 56.2 W/m² · K, 0.026 m³
11S.15 3
11S.16 285 K
11S.17 ~11
11S.18 564 K

CHAPTER 12

- 12.1 0.36, 0.80, 1800 W/m^2 , -900 W/m^2
12.2 (a) 0.60; (b) -200 W/m^2 ; (c) 1200 W/m^2
12.3 1963 W/m^2 , 963 W/m^2 , -0.415 K/s
12.4 7000 W/m^2 , 0.94
12.5 12.1 W/m^2 , 28.0 W/m^2 , 19.8 W/m^2
12.6 (a) 193 mm; (b) 940 W/m^2
12.7 (a) 60 mW; (b) $95.5 \text{ W/m}^2 \cdot \text{sr}$; (c) 47.8 μW
12.8 $2.41 \times 10^{-8} \text{ W}$
12.9 (a) 1446 W/m^2
12.10 (a) 0.393 m
12.12 0.25
12.13 (a) 0.10 W; (b) $1273 \text{ W/m}^2 \cdot \text{sr}$; (d) 0.10 W; (e) $3.6 \times 10^{-7} \text{ W}$, 90 mW/m^2 ; (f) $5.09 \times 10^{-7} \text{ W}$, 127 mW/m^2 ; (g) 63.7 mW/m^2
12.14 (a) 133 W, 75.7 W, 232 W, 5.54 μm
12.15 (a) $6.74 \times 10^{-5} \text{ sr}$; (b) $2.03 \times 10^7 \text{ W/m}^2 \cdot \text{sr}$
12.16 13614 W/m^2
12.17 (a) 15,970 K; (b) 18,783 K
12.18 498 K
12.19 279 K
12.20 3.93 MW
12.21 (a) $\sim 0.7\%$; (b) $\sim 8\%$
12.22 (a) 9.84 kW/m^2 , (b) 6.24 kW/m^2
12.24 278.4 W
12.25 (b) 0.90 K, 7.1 K
12.27 (a) 0.25, $2.27 \times 10^5 \text{ W/m}^2$
12.29 0.636, 76.9 kW/m^2
12.30 300 K; 0.486, 223 W/m^2 , 1538 W/m^2 , 6014 W/m^2 , 9.66 μm , 4 μm , 4 μm
12.32 (c) 995.3 K
12.33 0.373, -5.78 K/s , 311 s
12.34 34.7 kW/m^2
12.35 (b) 7500 W/m^2 ; (c) 2250 W/m^2 ; (d) 0.30
12.36 (a) 0.50, 0.60; (b) $3.62 \times 10^5 \text{ W/m}^2$, $5.44 \times 10^5 \text{ W/m}^2$; (c) $0.126 \text{ W/m}^2 \cdot \mu\text{m}$; (d) 10.3 μm
12.37 4930 W/m^2 , 3480 W/m^2 ; 3870 W/m^2 , 2420 W/m^2 ; 2930 W/m^2 , 1470 W/m^2 ; 4310 W/m^2 , 2860 W/m^2 ; 4490 W/m^2 , 3040 W/m^2 ; 2930 W/m^2 , 1470 W/m^2
12.38 (a) 0.383; (b) 0.958, 0.240
12.39 $2.51 \times 10^{-6} \text{ W}$
12.40 (a) 0.774; (b) 0.1
12.41 (a) 0.45; (b) 0.56; (c) $-22,750 \text{ W/m}^2$
12.42 (b) 0.599, 0.086, 0.315; (c) 1; (d) -615 W/m^2
12.43 (a) 0.00099; (b) 0.295; (c) 0.861
12.44 (a) 0.839, 0.568; (b) 0.329, 0.217

- 12.45 $0.85, 3.9 \times 10^6 \text{ W/m}^2, 4.6 \times 10^6 \text{ W/m}^2, 0.297, 0.106, 137 \text{ W/m}^2, 4.6 \times 10^6 \text{ W/m}^2, 1.38 \times 10^6 \text{ W/m}^2$
- 12.46 (a) 0.574; (b) 0.145; (c) 0.681, 0.539
- 12.47 0, 0.3, 0.7, 0.303, $606 \text{ W/m}^2, 952 \text{ W/m}^2 \cdot \text{K}$
- 12.48 340 K, $838 \text{ W/m}^2, 838 \text{ W/m}^2$
- 12.49 (a) 0, 577.4 K; (b) 0.89, 0.10; (c) $5600 \text{ W/m}^2, 630 \text{ W/m}^2$; (d) 0.89, 0.10
- 12.50 (a) 1750 W/m^2 , (b) 1140 W/m^2
- 12.51 (a) 0.225, 0.388, 0.5; (b) 443 kW/m^2
- 12.52 (a) 0.375; (b) 0.702; (c) 0.375
- 12.53 29.2 W, 344 K
- 12.54 (b) $1.42 \times 10^5 \text{ W/m}^2$
- 12.55 714 W/m^2
- 12.56 0.361, -3.24 K/s, 463 s
- 12.57 (a) 0.748; (b) 29.6°C ; (c) 402 W/m^2
- 12.58 (a) 22.2°C
- 12.59 $1479 \mu\text{W}$
- 12.60 (a) $1.76 \times 10^{-4} \text{ W}$; (b) $0.384 \times 10^{-4} \text{ W}$
- 12.62 (a) 839 K; (b) 770 K; (c) 850 K
- 12.63 (a) 25°C
- 12.64 (a) 1.286; (b) 353 K, 145 K
- 12.65 (a) 394.1 K; (b) $1.50 \mu\text{m}$
- 12.66 (a) 19.8 W; (b) 538.2 K; (c) 855 s
- 12.67 (a) 145 W/m^2 ; (b) $9.23 \mu\text{W}$; (c) $8.10 \mu\text{W}$
- 12.68 $8.08 \times 10^{-8} \text{ W}$
- 12.69 $3.38 \times 10^{-7} \text{ W}$
- 12.70 999 K
- 12.71 (a) 23°C ; (b) 44.6°C
- 12.72 571 m/s, -15.5 m/s, 146 m, 0.256 s
- 12.73 (a) 134 K
- 12.74 (a) 5441 W/m^2
- 12.75 (a) 0.375; (b) 0.702; (c) 0.375
- 12.76 (a) $2.93 \text{ W/m} \cdot \text{K}$
- 12.77 (a) $0.689 \mu\text{m} - 1.127 \mu\text{m}$; (b) 0.142; (c) 429 W/m^2
- 12.78 (a) 1425 K, $1.87 \times 10^5 \text{ W/m}^2$; (b) $5.95 \times 10^{-5} \text{ W}$
- 12.79 (a) 0.643; (b) 0.200; (c) 1646 kW/m^2 ; (e) 119 s
- 12.80 (a) 839 K; (b) 770 K; (c) 850 K
- 12.81 (a) 0.799, 0.536; (b) 11.7 K/s; (c) 0.536; (d) 82 s
- 12.82 (a) 763 W; (b) 930 K; (c) 537 s
- 12.83 (a) 0.80, 0.713; (b) $233 \text{ kW/m}^2, 9.75 \text{ K/s}$; (c) 413 s
- 12.84 0.129 m, 39.1%
- 12.85 380 K, 656 K
- 12.86 439 K
- 12.87 (a) 837 W, 1026 W

- 12.88 (a) 30.9°C , 2746 W; (b) -7.6°C , 4720 W; (c) 80.0°C , 9565 W
12.89 (a) 308 K, 279 K; (b) 211 K, 178 K
12.90 (b) $\sim 5.5 \times 10^6$ s
12.91 (a) 57.9°C , 180 W; (b) 71.7°C ; (c) -30.4°C
12.92 (a) 48.5°C
12.93 1086 W/m^2
12.94 $95.5 \text{ W/m}^2 \cdot \text{sr}$
12.95 139°C , 3.47 W
12.96 329.2 K
12.97 (a) 0.8, 0.625; (b) 352 K
12.98 (a) 0.634; (b) 0.25; (c) 460 W/m^2
12.100 (a) 248 K, 268 K, 271 K; (b) 194 K
12.101 25.7°C , 28.4°C
12.102 (b) 35.5°C
12.103 (a) $8.16 \times 10^5 \text{ W/m}^2$
12.105 (a) 0.704; (b) 0.20; (c) $6.07 \text{ W/m}^2 \cdot \text{K}$
12.106 342 W/m^2
12.107 (a) 4.887 W; (c) 43.5°C
12.108 4.7°C , 16.2°C
12.110 25°C , $3.11 \times 10^{-4} \text{ kg/s}$
12.111 (a) 0.0436 kg/m^3 , 0.0144 kg/m^3 , $6.76 \times 10^{-6} \text{ kg/s}$, 21.2 W; (b) 503 W/m^2 , 3105 W/m^2 , 627 W/m^2

CHAPTER 13

- 13.1 (a) 0.50, 0.25; (b) 1.0, 0.424, (c) 0.50, 0.707; (d) 0.5, 0; (e) 1.0, 0.125; (f) 0.5, 0.637; (g) 0.50, 0.637 (h) 1.0, 0.255
13.2 0, 0.658, 0.342, 0.000229; 0, 0.998, 0.000898, 0.000898
13.3 (c) -0.62
13.4 (b) 0.0767, 0.553; 0.0343, 0.800
13.6 (b) 0.781; (c) 0.110; (d) 0.463; (e) 0.741
13.8 (a) 0.09
13.9 (a) 0.038; (b) 0.23
13.10 0.41
13.12 $27.7 \mu\text{W/m}^2$
13.13 (a) 354 mW/m^2 ; (b) 1695 mW/m^2
13.14 $0.0756 \text{ kg/s} \cdot \text{m}$
13.15 (a) 0.64; (b) 1579 W
13.16 36,900 W
13.17 456 K
13.18 (a) 413 K; (b) 1312 W
13.19 544 K, 828 K
13.20 (a) 255 W; (b) 970 K, 837.5 K

- 13.21 $1.58 \times 10^4 \text{ W/m}^2$
13.22 -0.288 W
13.23 -11.87 kW
13.24 (c) 17 kW/m^2 ; (d) $635 \mu\text{W}$
13.25 (a) 69 mW ; (b) 934.5 W/m^2 ; (c) 1085 W/m^2
13.26 (a) 1.19 W ; (b) $1.48 \mu\text{W}$
13.27 (a) 308 K
13.28 807 K
13.29 (a) 48.8 K/s ; (b) 15 s ; (c) 14.6 s , 12.0 s , 6.8 s
13.30 (a) 109.7 W/m , 110.1 W/m ; (b) 98.5 W/m , 103.8 W/m
13.31 (a) 14.2 kW/m^2 , (b) 56.7 kW/m^2 ; (c) 14.2 kW/m^2 ; (d) 42.5 kW/m^2
13.32 (a) 3.16 , 28.5 , 1.05 , 9.49
13.33 (a) 1.58 W ; (b) 0.986
13.34 168 W/m^2 , 4.76 W/m^2 , 9.25 W/m^2
13.35 (a) 2000 W/m^2 , 76.1 W/m^2 ; (b) 181 W/m^2
13.36 46.2 kW/m^2 , 0.814
13.38 (a) 0.105 ; (b) 0.092 ; (c) 0.052
13.39 30.2 W/m
13.40 (a) 30.13 W ; (b) 30.65 W ; (c) 31.41 W ; (d) 55.8 W/kg , 79.2 W/kg , 75.1 W/kg
13.41 69°C
13.42 $9.92 \times 10^{-5} \text{ kg/s}$
13.45 0.138
13.46 89.8 mW
13.47 9
13.48 472°C
13.49 643 K , -1586 W/m
13.50 1225 K , 1167 K
13.51 (a) 896 K , 986 K ; (b) 950 K , 990 K
13.52 423 K
13.53 7.46 kW/m
13.54 (a) 1.83
13.55 4100 W
13.56 (a) 25.3 kW ; (b) 18.2 kW
13.57 (a) 1228 K ; (b) 1117 K
13.58 (a) 9870 W/m ; (b) 853 K
13.59 266 W/m
13.60 0.033 mm , 0.045 mm , 0.059 mm , 300 K , 389 K , 488 K
13.61 (a) 8520 W/m ; (b) 732 K
13.62 (a) 37 W/m ; (b) 9.2%
13.63 (b) 1.32 W
13.64 (a) 1842 W ; (b) 1840 W
13.65 -538 W , -603 W , 1141 W

- 13.66 68.0 W/m, 83.4 W/m; 80.6 W/m, 89.9 W/m; 91.8 W/m, 95.7 W/m
13.67 31.1 W, 656 K
13.68 -200 W, 5037 W, -4799 W, 0 W, 0 W
13.69 317 W
13.70 (a) 41.3 kW; (b) 6.55 kW
13.71 (a) 1/6, 5/6, 0.0471, 0.0471, 0.953, 0.191, 0.762; (b) 1188 K, -20 W
13.72 (a) -1153 W; (b) 0.57 K/s; (c) 715 K
13.73 (b) 842.5 K
13.74 (a) 14.0°C, 8.6°C
13.75 4600 W, 64 W/m² · K
13.76 (a) 54.0 kW/m; (b) 1180 K, 38.3 kW/m
13.77 (a) 373 K, 0.76; (b) 388 K, 1.84; (c) 362 K, 0.40
13.78 (a) 29.5 W/m, 482 K; (b) 441 W/m, 352 K
13.79 (a) 35 W/m² · K; (b) 484 K
13.80 (a) 792.2 K, 792 K; (b) 783.2 K, 783 K
13.81 526 K
13.82 (a) 289 W/m²; (b) 376 W/m²; (c) 329 W/m²
13.83 (b) 366 K, 1920 W/m²; 598 K, 10,850 W/m²
13.84 5700 K/W
13.85 19.2 W
13.86 (a) 145 W/m²; (b) 306 W/m²; (c) 165 W/m², 156 W/m²
13.87 669 W/m², 199 W/m²
13.88 (a) 131 W/m
13.89 (a) 54.6 W; (b) 413 K
13.90 (a) 8075 W/m; (b) 796 K, 10.1 kW/m
13.91 0.023 kg/s
13.92 (a) 3.45 m; (b) 0.88 m
13.93 (b) 1213 W/m; (c) 576 W/m; (d) 502 K
13.94 (a) 0.0197; (b) 825 K, 108 kW
13.95 (a) 4.3 m⁻¹; (b) 0.999, 0.001, 0.001
13.96 15.1 kW
13.97 21.9 kW/m
13.98 98 kW/m
13.99 135 kW/m²
13.100 380 K, 89.6 kW/m²
13.101 0.515 kg/s
13.102 0.004 kg/s, 4.53 m/s, 367 K
13.103 (a) 530 K; (b) 0.00613 m/s
13.104 0.00141 kg/s · m, 721 K, 537 K
13.105 (a) 0.00341 kg/s · m; (b) 889 K, 811 K

CHAPTER 14

- 14.1 0.233, 0.767
14.2 (b) 0.31, 0.27, 0.42; 0.35, 0.40, 0.25
14.3 0.04 kmol/m^3 , 1.78 kg/m^3 , 0.5, 0.61; 0.04 kmol/m^3 , 1.13 kg/m^3 , 0.5, 0.39
14.4 0.192 kg/m^3 , 0.159, 0.159 bar; 0.0641 kg/m^3 , 0.841, 0.841 bar
14.5 0.0838, 1.46 kg/m^3 , 0.0406 kmol/m^3 , 35.8 kg/kmol
14.6 $0.36 \times 10^{-4} \text{ m}^2/\text{s}$, $0.52 \times 10^{-4} \text{ m}^2/\text{s}$
14.10 $3.14 \times 10^{-15} \text{ kmol/s}$
14.12 (a) $5.43 \times 10^{-12} \text{ kmol/s}$; (b) $5.54 \times 10^{-12} \text{ kmol/s}$
14.15 $0.257 \text{ kg/m}^2 \cdot \text{h}$
14.16 $1.5 \times 10^{-8} \text{ kmol/m}^2 \cdot \text{s}$
14.20 (a) $14.8 \times 10^{-12} \text{ kg/s}$; (b) $-2.63 \times 10^{-7} \text{ bar/s}$
14.21 $-2.29 \times 10^{-7} \text{ bar/s}$, $-7.20 \times 10^{-7} \text{ bar/s}$
14.22 $1.39 \times 10^{-6} \text{ kmol/s} \cdot \text{m}$
14.23 (a) $0.874 \times 10^{-9} \text{ kmol/m}^2 \cdot \text{s}$; (b) 0.0605 kmol/m^3 , 0.0202 kmol/m^3
14.24 $4.05 \times 10^{-9} \text{ kg/s}$
14.25 48.5 years, 508 years, 48.2 years, 482 years
14.26 $4 \times 10^{-15} \text{ kg/s}$
14.27 (a) $191 \times 10^{-3} \text{ kmol/m}^3 \cdot \text{bar}$; (b) $0.32 \times 10^{-16} \text{ kmol/s}$; (c) $0.32 \times 10^{-16} \text{ kmol/s}$; (d) 0
14.28 0.0034
14.29 0.022 kg/h
14.30 0.067, $-4.67 \times 10^{-5} \text{ kg/s}$
14.31 $6.66 \times 10^{-9} \text{ kmol/s}$
14.33 0.0008, $7.48 \times 10^{-8} \text{ kmol/s} \cdot \text{m}^2$, $2.24 \times 10^{-7} \text{ kmol/s} \cdot \text{m}^2$
14.35 (c) $3 \times 10^{-5} \text{ kmol/m}^3$
14.36 (c) $5.11 \times 10^{-6} \text{ kmol/m}^3$, $2.18 \times 10^{-15} \text{ kmol/s}$
14.37 (b) 0.02 kmol/m^3 ; (d) $9.60 \times 10^{-5} \text{ kmol/m}^2 \cdot \text{s}$
14.39 (b) $5.38 \times 10^{-11} \text{ kmol/s} \cdot \text{m}^2$
14.40 (b) $9.08 \times 10^{-7} \text{ kmol/m}^3$
14.41 333 s
14.42 0.02 s
14.43 (a) 9.7 ms; (b) 1.17 ms
14.44 8.42 h
14.45 (b) 0.0314
14.46 (a) 60.9 μg ; (b) 703 μg
14.47 (b) 0.023
14.49 (a) 32 kg/m^3 ; (c) 42.9 h
14.50 (a) 32 kg/m^3 ; (c) 42.9 h; (d) 218 h
14.51 $3.3 \times 10^{-3} \text{ kmol/m}^3 \cdot \text{bar}$, $8.5 \times 10^{-13} \text{ m}^2/\text{s}$
14.53 (a) 2.5 μm ; (b) 1.7 h; (c) 3.9 h