

ANSWERS TO END-OF-CHAPTER PROBLEMS

Fundamentals of Heat and Mass Transfer (5th Edition)

Introduction to Heat Transfer (4th Edition)

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CHAPTER 1

- 1.1 378°C
- 1.3 4312 W, \$4.14/d
- 1.4 0.10 W/m·K
- 1.5 8400W
- 1.6 19,600 W, 120 W
- 1.7 54 mm
- 1.8 16.6 W/m², 35.9 W
- 1.9 375 mm
- 1.10 110.40°C, 110.25°C
- 1.11 1.1°C
- 1.12 (a) 9800 W/m²
- 1.13 (a) 1400 W/m²; (b) 18,000 W/m²
- 1.14 (a) 22.0 W/m²·K; (b) 22.12, 0.6
- 1.15 4570 W/m²·K, 65 W/m²·K
- 1.16 51.8°C, 3200°C
- 1.17 6.3 m/s
- 1.18 0.35 W, 5.25 W
- 1.19 2.94 W
- 1.21 15 mW
- 1.22 6.4 W/m²·K
- 1.23 102.5°C
- 1.25 254.7 K
- 1.27 726 W, 547 W
- 1.28 (a) 18,400 W; (b) \$6450
- 1.30 3.5%
- 1.31 (a) 0.223 W; (b) 3.44 W
- 1.32 (a) 8.1 W; (b) 0.23 kg/h
- 1.33 100°C
- 1.34 (a) 0, 144 W, 144 W, 0; 0, 0, 144 W, -144 W; (b) 2.04×10^5 W/m³; (c) 39.0 W/m²·K
- 1.35 (a) 0.052°C/s; (b) 48.4°C
- 1.36 364 K, 380 K
- 1.37 6380 kWh, \$510 or \$170
- 1.38 (a) 4180 s; (b) 319 K, 359 K; (c) 830 K
- 1.39 (a) 0.0181 m³/s, 4.7 m/s
- 1.40 840 kW
- 1.41 (a) 32.5 kW/m², 126 kW/m², 17.6 K/s, 68.4 K/s
- 1.43 (a) 104 K/s; (b) 1251 K

- 1.46 (a) 1950 A
 1.47 132 J/kg·K
 1.48 (a) -0.089 K/s ; (b) 439 K
 1.49 (a) $1.41 \times 10^{-3} \text{ kg/s}$
 1.50 3.2 h
 1.51 (a) $60.6 \times 10^{-3} \text{ kg/s}\cdot\text{m}^2$, 121 g/m^2 ; (b) $32.3 \times 10^{-3} \text{ kg/s}\cdot\text{m}^2$
 1.53 49°C
 1.54 (a) $7.13 \times 10^{-3} \text{ m}^3/\text{s}$; (b) 70°C
 1.55 (a) 86.7°C ; (b) 47°C
 1.56 (a) 79.1 K; (b) 457 mW
 1.59 37.9°C
 1.60 (a) 600 K
 1.61 $375 \text{ W/m}^2\cdot\text{K}$
 1.62 (a) 5500 W/m^2 ; (b) 87.8°C
 1.63 (a) 5268 W; (b) 41°C
 1.65 345°C
 1.66 (a) 84°C
 1.67 214 K, 20.0 mW
 1.68 (a) 190.6 W
 1.69 (a) 153°C
 1.70 (a) 386 W/m^2 ; (b) 27.7°C ; (c) 55%
 1.71 (a) 47.0°C or 39.9°C

CHAPTER 2

- 2.7 (a) 200 K/m, -5000 W/m^2 ; (b) 225°C , 6250 W/m^2 ; (c) -20°C , -5000 W/m^2 ; (d) -85°C , -160 K/m ; (e) -30°C , 120 K/m
 2.8 (a) -280 K/m , 14.0 kW/m^2 ; (b) 80 K/m, -4.0 kW/m^2 ; (c) 110°C , -8.0 kW/m^2 ; (d) 60°C , 4.0 kW/m^2 ; (e) -20°C , -10.0 kW/m^2
 2.9 (a) 2000 K/m, -200 kW/m^2 ; (b) -2000 K/m , 200 kW/m^2 ; (c) 2000 K/m, -200 kW/m^2
 2.11 0, 60 K/m
 2.12 100°C , 18.75 W; -40°C , 16.25 W
 2.14 (a) 197 W; (b) 87 W; (c) 8.0 W; (d) 7.3 W; (e) 0.093 W; (f) 0.026 W; (g) 0.69 W
 2.15 (a) 593 kW/m^2 ; (b) 151 kW/m^2 ; (c) 33.5 kW/m^2 ; (d) 9.95 kW/m^2 ; (e) 0.88 kW/m^2 ; (f) 3.5 kW/m^2
 2.17 (a) $15.0 \text{ W/m}\cdot\text{K}$, 400 K; (b) $70.0 \text{ W/m}\cdot\text{K}$, 380 K
 2.18 (a) $51.9 \text{ W/m}\cdot\text{K}$, 350 K
 2.19 $765 \text{ J/kg}\cdot\text{K}$, $36.0 \text{ W/m}\cdot\text{K}$
 2.22 (a) 0, $0.98 \times 10^5 \text{ W/m}$; (b) 56.8 K/s
 2.23 (a) $2 \times 10^5 \text{ W/m}^3$; (b) 0, $10,000 \text{ W/m}^2$
 2.24 (a) 200 W/m^2 , 182 W/m^2 , 18 W/m^2 ; (b) $4.3 \text{ W/m}^2\cdot\text{K}$
 2.25 (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) 10^6 W/m^3 ; (b) 120°C , 10^4 K/m , -10^5 K/m^2 ; (c) 220°C , 10^4 K/m , -10^5 K/m^2 ; (d) 220°C , $2 \times 10^4 \text{ K/m}$, $-2 \times 10^5 \text{ K/m}^2$
 2.40 (a) 0.20 m; (b) 0; (c) $-144,765 \text{ W}$; (d) 72,380 W, $-72,380 \text{ W}$
 2.41 (d) 133°C , 122°C , 133.1°C
 2.43 (d) 52.5°C

- 2.45 (c) 18.0 kW/m^2 , -360 K/m ; (d) $8.73 \times 10^6 \text{ J/m}^2$; (e) $8.73 \times 10^6 \text{ J/m}^2$
 2.51 (a) $1.8 \times 10^6 \text{ W/m}^3$; (c) $1.8 \times 10^5 \text{ W/m}^2$; (d) $7.77 \times 10^7 \text{ J/m}^2$
 2.53 (a) 25°C , 35°C ; (b) 50°C , 30°C ; (c) 86.1°C
 2.54 (b) $3.18 \times 10^8 \text{ W/m}^3$, $1.59 \times 10^5 \text{ W/m}^2$

CHAPTER 3

- 3.2 (a) 7.7°C , 4.9°C
 3.3 (a) 1270 W/m^2
 3.4 (b) 2830 W/m^2
 3.5 14.1 W/m^2
 3.6 (a) $996 \text{ W/m}^2 \cdot \text{K}$, 0.40% ; (b) $14.5 \text{ W/m}^2 \cdot \text{K}$, 37.9%
 3.7 (a) 0.553 ; (b) 22.1°C , 10.8°C ; (c) -56.3°C
 3.8 (a) 29.4 W
 3.9 $1.53 \text{ W/m} \cdot \text{K}$
 3.10 $40.4 \text{ W/m}^2 \cdot \text{K}$, $50.7 \text{ W/m}^2 \cdot \text{K}$
 3.11 (b) 86 mm
 3.12 (a) 15 W ; (b) 130 W ; (c) 76 W
 3.13 (b) 4.2 kW ; (c) 0.5%
 3.14 $1.3 \times 10^8 \text{ J}$
 3.15 0.185 K/W
 3.16 2.13
 3.17 (b) 64 m , 8 , 307 kW , 40%
 3.18 (b) 515°C
 3.19 (b) 327°C
 3.20 (a) $34,600 \text{ W/m}^2$
 3.21 $3.70 \times 10^4 \text{ W/m}^2$, 55.6°C
 3.22 (a) 762 W
 3.24 590 W
 3.25 (a) 83% ; (b) 1512 W ; 259 W ; (c) $\$0.68$
 3.26 5.7 W
 3.27 (b) 49°C ; (c) $67,200 \text{ W/m}^2$
 3.28 (a) 0.27 W
 3.29 (b) 5.76 kW
 3.30 (b) 189 W
 3.35 (a) 603 W/m
 3.36 0.784 m , 0.784 m , 0.025 m
 3.37 2380 W/m
 3.39 (a) 12.6 W/m ; (b) 7.7 W/m
 3.40 (a) 214 mm , 420 W/m
 3.41 (a) 251 W/m ; (b) 23.5°C
 3.42 (a) 4 W/m , $1.27 \times 10^6 \text{ W/m}^3$; (b) 58°C ; (c) 37.6°C , 34.8°C
 3.43 4.5 W/m , 13 mm
 3.44 (b) 239°C
 3.45 (a) 47.1 W/m ; (c) 3.25 h
 3.47 (a) 779°C ; (b) 1153°C , 779°C ; (c) 0.0175 m , 318°C
 3.48 (a) 3727 W/m , 163 W/m ; (b) 0.26 yr
 3.49 1830 W/m
 3.51 5 mm
 3.52 (b) 1040 W/m , 407 K , 325 K

- 3.53 0.01 m, 770 W/m, 909 W/m, 55 mm
- 3.54 8670 W
- 3.55 (a) 99.8%
- 3.57 0.062 W/m·K
- 3.59 5.34 mm
- 3.60 (a) 489 W, (b) 120°C
- 3.61 13.5 mm, 91%
- 3.63 181 W/m²·K
- 3.64 (b) 35.5 mW, 44.9 mW
- 3.65 3000 W/m²
- 3.67 (a) 1.69 m
- 3.68 77.9°C
- 3.69 0.157 W
- 3.72 212°C
- 3.73 (a) 4.0×10^6 W/m³, 15.3 W/m·K; (c) 835°C, 360°C
- 3.74 (a) 261°C, 210°C, 107 kW/m², 132 kW/m²; (b) 233°C, 470°C, 371°C, 227°C, 95 kW/m², 144 kW/m²
- 3.76 (c) 50°C; (d) 180°C
- 3.78 (a) 530°C, 380°C; (b) 328°C, 290°C
- 3.79 (b) 60°C, 65°C; (c) 200 W/m²; (d) 55°C
- 3.86 29 A, 3.0 m, 3.2 kW
- 3.88 (b) 1458 K
- 3.89 (a) 6400 A; (b) 15,240 W; (c) -10,990 W/m, -11,350 W/m, 4250 W/m, 3890 W/m
- 3.90 804 s
- 3.91 (a) 938 K, 931 K; (b) 3×10^8 W/m³
- 3.92 (a) 71.8°C, 51.0°C; (b) 192°C
- 3.95 (a) 36.6°C; (b) 129.4°C; (c) 337.7°C
- 3.96 (a) 5.26°C, 5.14°C
- 3.99 63.7°C, 160 W/m
- 3.102 (c) -17.2 W, 23.6 W
- 3.103 (b) 164.3°C, 145.1°C
- 3.105 (b) 347°C
- 3.106 262 W
- 3.107 (b) 160°C
- 3.109 300°C
- 3.113 (a) 305°C, (b) 272°C
- 3.115 (c) 62.4°C
- 3.116 (b) 508 W
- 3.117 (c) 0.333, 607°C
- 3.119 (a) 420%; (b) 29%
- 3.120 156.5°C, 128.9°C, 107.0°C
- 3.121 (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, 0.17 m·K/W, 25°C
- 3.122 (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
- 3.123 Rectangular fin: 130 W/m, 0.98, 4.5×10^{-5} m²
Triangular fin: 117 W/m, 0.98, 2.3×10^{-5} m²
Parabolic fin: 116 W/m, 0.96, 1.5×10^{-5} m²

- 3.124 121 W
 3.125 (a) 0.37 W; (b) 1.04×10^5 W
 3.127 17.5 W/m-K
 3.129 56.6 W/m-K
 3.130 (b) 5995 W, 4278 W
 3.131 (a) 2.44×10^{-3} K/W
 3.132 (a) 31.8 W
 3.133 (a) 152 W
 3.134 (b) 50.9 W
 3.136 (a) 276 W
 3.138 (a) 26.9 W, 21.4 W; (b) 26.9 W
 3.140 (b) 2830 W/m
 3.141 1315%
 3.142 Rectangular profile: 0.79, 6.1, 218 W/m
 Triangular profile: 0.78, 5.2, 187 W/m
 3.143 (a) 0.99, 6.0; (b) 110.8 W/m
 3.144 (a) 12.8 W; (b) 2.91 kW/m
 3.145 (a) 0.97, 11.1; (b) 6.82 kW/m
 3.146 18.2 W, 24.4 W
 3.147 394 K, 383 K, 381 K
 403 K, 392 K, 382 K, 381 K
 3.148 39,300 W/m, 405 K, 393 K, 384 K, 382 K
 3.150 4025 W/m
 3.151 3857 W/m, 3922 W/m, 5799 W/m, 3591 W/m

CHAPTER 4

- 4.2 94.5°C
 4.3 5.6 kW/m
 4.5 2.83ℓ, 7.34 kW/m
 4.6 4.26ℓ, 245 W/m
 4.7 (a) 50°C; (b) 0.53ℓ, 3975 W/m; (d) 1.70ℓ, 12,750 W/m
 4.8 2.34ℓ
 4.9 2.58ℓ, 11,600 W/m; 1.55ℓ, 6975 W/m
 4.10 (a) 7.8 kW/m; (b) 0.24 m
 4.11 4ℓ, 45.6 kW/m; 3.5ℓ, 39.9 kW/m
 4.12 700 W/m, 900 W/m
 4.14 92.7°C
 4.15 84 W/m
 4.16 9.9 W/m
 4.17 94.9°C
 4.18 110 W/m
 4.19 (a) 6.72 L, 612 W/m; (b) 1.5 L
 4.20 1122 W/m
 4.21 12.5 W/m, 11.3 W/m
 4.22 5.30 kW
 4.23 316 kW
 4.24 (a) 1.62 kW/m; (b) 93°C
 4.25 (a) 0.1°C
 4.26 3.62 kW, 254°C, 251°C
 4.27 (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
 4.28 (a) 1.1°C

- 4.29 (b) 88.6 W
 4.30 (a) 57°C; (b) 238 W
 4.31 156.3 W, 81.3°C
 4.32 (a) 745 W/m; (b) 3.54 kg/s
 4.33 (a) 74.6 kW/m; (b) 2.38×10^8 W/m³, 315°C
 4.34 0.70 W
 4.45 6710 W/m
 4.46 (b) 156 W/m
 4.47 (a) 362.4 K, 390.2 K, 369.0 K; (b) 7500 W/m
 4.48 (a) 122.0°C, 94.5°C, 95.8°C, 79.7°C; (b) 1117 W/m; (c) -1383 W/m
 4.49 (a) T₁ = 46.6°C, T₂ = 45.7°C, T₃ = 45.4°C, T₄ = 49.2°C, T₅ = 48.5°C, T₆ = 48.0°C, T₇ = 47.9°C, 10,340 W/m
 4.50 (a) T₁ = 160.7°C, T₂ = 95.6°C, T₃ = 48.7°C; (b) 743 W/m
 4.51 (a) 1.473 W/m; (b) T₃ = 89.2°C
 4.52 (a) 205.0 W/m; (b) 156.3 W/m
 4.53 (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
 4.54 (a) 272.2°C, 952 W/m; (b) 271.0°C, 834 W/m
 4.55 (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
 4.56 3.00 kW/m
 4.57 (a) 1.57 kW/m; (b) 1.52 kW/m
 4.58 456 W/m
 4.60 1487 W/m
 4.61 (a) 7.72 kW/m; (b) 7.61 kW/m
 4.62 94.0°C
 4.63 1477 W/m
 4.64 (a) 100 W/m, 1
 4.66 (a) 1010 W/m, 100°C, 1; (b) 805 W/m, 100°C
 4.67 (b) 128 W/m
 4.68 (b) 1.48×10^8 W/m³
 4.69 (b) 1135 W/m, (c) -1365 W/m
 4.71 (a) 2939 W/m²
 4.72 (b) 1205 W/m
 4.73 1.604 W
 4.75 (c) 25.0 W/m
 4.77 (a) 3.03×10^{-3} m-K/W; (b) 2.38×10^{-3} m-K/W; (c) 3.64×10^{-3} m-K/W
 4.79 (a) 878 W/m, 5.69×10^{-2} m-K/W, 220 W
 4.80 (a) 131 W/m; (b) 129 W/m
 4.81 (a) 1683 W/m
 4.82 (a) 52.6 kW/m²
 4.84 (b) 2.43×10^7 W/m³; (c) 47.5°C, 0.45

CHAPTER 5

- 5.5 1122 s
 5.6 35.3 W/m²·K
 5.7 7.04 h
 5.8 168 s
 5.9 859 s
 5.10 968 s, 456°C

- 5.11 984 s, 272.5°C
5.12 0.0041 m²·K/W
5.13 (a) 84.1°C, 83.0°C
5.14 21.8 m
5.15 1.08 h, 1220 K
5.16 (a) 209 s, 105 m; (b) 1.03 m/s, 1.69 m/s
5.17 88.7°C, 8.31 s
5.18 (b) 825 s, 127°C
5.19 (b) 63.8°C
5.20 3.54 m
5.21 (d) 1.04 h, 0.826 h, 0.444 h
5.22 2.52 m, 0.022 J
5.23 (a) 1190 s, 199 s; (b) 24.1 s; (c) 21.0 s
5.24 (a) 1 ms
5.25 1.56×10^{-4} s, 2.28×10^{-5} s
5.26 80°C, 38.3 s
5.27 45.7°C, 13.0 s
5.28 (a) 25.8 s, 9.5 s, 616 s; 118.9 s, 43.8 s, 2840 s; 40 s; (b) 29.5 s, 11.0 s, 708 s
5.29 (a) 98.1°C; (b) 1.67 h
5.31 960 s
5.32 (a) 56.3 min
5.33 1170 s, 537°C, 410°C
5.34 861 s
5.35 (a) 45.4°C, 43.1°C, -7305 W/m², -2.72×10^7 J/m; (b) 4.4 min
5.36 (a) 33,800 s
5.37 491 s
5.38 (a) 164 s, 367 s
5.39 (a) 10.9 s
5.40 (a) 63 s; (b) -2.36×10^4 °C/m
5.41 (a) 1100 s
5.42 0.613 W/m·K, 2.73×10^6 J/m³·K
5.43 (a) 46.5 min; (b) 1.90×10^7 J/m²
5.44 96 W/m²·K
5.45 63.8 s, 51.8°C
5.46 0.0073 m/s
5.47 7.6 min
5.48 (a) 486 K
5.49 (a) 145 s
5.50 (a) 194 s
5.51 515 K
5.52 (a) 3507 s; (b) 49°C
5.53 254°C
5.54 36 min, 7.08 kW
5.55 579 s
5.58 3.4 s
5.59 199°C
5.60 150 s, 33 mm/s
5.61 (a) 41 s, 115°C; (b) 40 kW
5.62 12 s, -1.0°C, -3.4 J
5.63 (b) 74 s; (c) 7125 W/m²; (d) 3691 J; (e) 440 K
5.64 (b) 1.8 min, (c) 3257 J

- 5.65 (a) 98.6 s, (b) 100°C
 5.66 1020 s, 257.3°C
 5.67 (a) 100 s
 5.68 (a) 4.85 s, 67.8°C
 5.69 (a) 94.2 s, 0.0025; (b) 3.0 s
 5.71 $-4.99 \times 10^5 \text{ J/m}^2$
 5.72 1793 s
 5.74 (a) 2.81 min; (b) 56 kJ
 5.76 53.5°C
 5.77 (a) 0.34 mm, 2.36 mm
 5.78 1.41 W/m·K
 5.79 0.45 W/m·K
 5.80 (a) 276°C, 315°C
 5.81 (a) 310 s
 5.84 365.9 K
 5.85 0.43 s
 5.87 1.83 h
 5.88 434 K, 320 K
 5.89 (a) 260°C
 5.90 ~2.75 h
 5.91 561 K, 604 K
 5.92 (a) 402.7 K, 370.5 K, 362.4 K
 5.97 (b) 230°C
 5.99 24.1°C, 71.5°C
 5.105 161 s, 1364°C, 2.42 m
 5.106 275°C, 312°C
 5.107 502.3 K, 300.1 K
 5.108 (a) 119.3°C, 45.1°C
 5.109 (a) 66°C, 32°C
 5.113 (a) ~230 s
 5.114 (a) ~14.3 s
 5.115 (b) 550 s
 5.116 (a) 136 s; (b) 73 s
 5.118 (b) 158°C
 5.120 54.8°C
 5.123 (b) 806 K, 1.17 s
 5.124 (a) 402.7 K, (b) 368.7 K, (c) 362.5 K
 5.128 (a) 54 days; (b) 13 days

CHAPTER 6

- 6.1 2.0
 6.2 1.33
 6.4 1.0
 6.5 $42.5 \text{ W/m}^2 \cdot \text{K}$
 6.9 600 W/m^2 , 18.9 W
 6.11 $705 \text{ W/m}^2 \cdot \text{K}$, -171.4°C/m , $-17,060^\circ\text{C/m}$
 6.12 -9200 W/m^2
 6.13 (a) 20.9 m/s
 6.14 31.4 m, 0.157 m
 6.15 7.95 m, 0.43 m, 275 m, 0.06 m
 6.17 40.8°C

- 6.18 (b) -1508 W/m , 1508 W/m
- 6.19 (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
- 6.20 0.0028, 0.0056, 13.4; 3.38
- 6.22 117°C
- 6.23 (a) $6.66 \times 10^7 \text{ W/m}^3$; (b) 1460 W ; (c) 81.2°C , 303°C
- 6.27 $40 \text{ W/m}^2 \cdot \text{K}$
- 6.28 2066 W
- 6.29 (a) $34.3 \text{ W/m}^2 \cdot \text{K}$; (b) $59.0 \text{ W/m}^2 \cdot \text{K}$
- 6.30 1.11
- 6.32 2.0
- 6.33 6.69
- 6.35 42.5°C
- 6.37 88.6
- 6.38 167, 64,400, 11,700
- 6.39 $38.3 \text{ W/m}^2 \cdot \text{K}$
- 6.40 240 W
- 6.41 2.66 kW
- 6.42 26.0 N/m^2
- 6.43 4260 W/m^2
- 6.44 14.3 W
- 6.45 $1.55 \times 10^{-3} \text{ m/s}$
- 6.46 (a) 0.0179 m/s ; (b) $0.75 \times 10^{-5} \text{ kg/s}$; (c) $5.31 \times 10^{-5} \text{ kg/s}$
- 6.47 $2.76 \times 10^{-5} \text{ kg/s} \cdot \text{m}^2$, $1.37 \times 10^{-3} \text{ m/s}$
- 6.48 $10^{-6} \text{ kg/s} \cdot \text{m}^2$
- 6.53 (e) $6.7 \times 10^{-4} \text{ kg/s}$
- 6.54 0.025 m/s
- 6.55 385, 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
- 6.56 (a) $120 \text{ W/m}^2 \cdot \text{K}$; (d) 0.051 m/s
- 6.57 (a) $4.64 \times 10^{-4} \text{ kg/s}$; (b) 1247 W
- 6.58 (a) $0.975 \times 10^{-3} \text{ kmol/m}^3$, 0.0258 atm; (b) $9.28 \times 10^{-4} \text{ kg/s} \cdot \text{m}^2$
- 6.59 (a) $1.63 \times 10^{-4} \text{ kg/s}$; (b) 282.2 K
- 6.60 $359 \text{ W/m}^2 \cdot \text{K}$
- 6.61 (a) 0.031, 0.80; (b) $198 \text{ W/m}^2 \cdot \text{K}$; (c) 74%
- 6.62 $2 \times 10^{-3} \text{ kg/s} \cdot \text{m}^2$
- 6.63 0.00395 m/s
- 6.64 9.92 W
- 6.65 7.78 km
- 6.66 (a) 10^{-5} kg/s ; (b) 28.9 W , 3583 W/m^2
- 6.67 (a) $+795 \text{ W/m}^2$, $+131 \text{ W/m}^2$, -563.1 W/m^2
- 6.68 784 W
- 6.69 (a) 0.70 kg/h ; (b) 85.6°C
- 6.70 21.8 W
- 6.71 2950 W
- 6.72 (a) 4.7°C ; (b) 0.0238 m/s ; (c) 16.2°C
- 6.73 (a) 0.0142 bar, 0.214; (b) 0.225; (c) 17.6°C
- 6.74 0.192

- 6.75 (a) $22.7 \text{ W/m}^2\cdot\text{K}$, 454 W; (b) $2.12 \times 10^{-2} \text{ m/s}$, 3.32 kg/h; (c) 2685 W
 6.76 (a) 0.172 m/s, 65.3 s; (b) $173 \text{ W/m}^2\cdot\text{K}$, $77,500 \text{ W/m}^2$; (c) 429°C
 6.77 (a) $6.71 \times 10^{-3} \text{ m/s}$; (b) $8.97 \text{ W/m}^2\cdot\text{K}$
 6.78 (a) 0.0113 m/s; (b) 90 J
 6.79 (b) -0.32 K/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) 0.147 m, 0.0143 m; (b) -1300 W/m^2 , 0.0842 N/m^2 ; (c) 0.337 N/m , -5200 W/m
 7.3 (a) 0.126 mm, 0.399 mm, 1.262 mm, 141 mm; 6.07 N/m^2 , 1.92 N/m^2 , 0.61 N/m^2 , 0.528 m/s, 0.167 m/s, 0.053 m/s
 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
 7.10 13,600 W/m, 9800 W/m, 5600 W/m
 7.12 (c) $4100 \text{ W/m}^2\cdot\text{K}$, $4500 \text{ W/m}^2\cdot\text{K}$, $5100 \text{ W/m}^2\cdot\text{K}$
 7.13 3.2×10^5 , 1.5×10^6
 7.14 (a) 55.0 kW/m; (b) 31.1 kW/m; (c) 90.7 kW/m
 7.15 17.6 W, 143.6 W
 7.16 (a) 5830 W/m
 7.17 29°C
 7.18 (a) 29.2°C
 7.19 (a) 266 K
 7.20 (a) 33.8°C , 797 W; (b) 675 W; (c) 90.6 kW
 7.21 1570 W
 7.22 (a) 49.4 W; (b) 22.7°C
 7.23 (a) $8.7 \text{ W/m}^2\cdot\text{K}$, $14.5 \text{ W/m}^2\cdot\text{K}$, $11.1 \text{ W/m}^2\cdot\text{K}$
 7.24 (b) $\pm 4\%$
 7.25 6780 W, -0.26°C/s
 7.26 (b) 213°C
 7.27 (b) 256°C ; (c) 210°C
 7.28 -0.99 K/s , -1.47 K/s , 1.91 m
 7.29 (a) 58°C
 7.30 39.5°C
 7.31 (a) 2137 W; (b) 16.5 kW
 7.32 (a) 27°C ; (b) 77°C
 7.33 (a) 64°C ; (c) 6.6 m/s
 7.34 42.5°C
 7.35 (a) 98.3°C , $17.1 \text{ W/m}^2\cdot\text{K}$; (b) 86.1°C
 7.36 (a) ∞ , $2.61 \text{ W/m}^2\cdot\text{K}$; ∞ , $2.74 \text{ W/m}^2\cdot\text{K}$; (b) $4.22 \text{ W/m}^2\cdot\text{K}$, $5.41 \text{ W/m}^2\cdot\text{K}$
 7.37 (a) 55 W; (b) 39 W
 7.38 0.30 W, 0.81 W
 7.39 0.66 W, 0.60 W
 7.40 (a) $30.8 \text{ W/m}^2\cdot\text{K}$, $56.7 \text{ W/m}^2\cdot\text{K}$; (b) 0.633, 0.555
 7.41 (a) 71.1 W/m, 20.4 kW/m, 1640 W/m
 7.42 3.24 N/m, 520 W/m
 7.43 (a) 603 K; (b) 200 s
 7.44 (a) 562 K; (b) 155 s
 7.45 70.4 W
 7.46 (a) 2.20 W; (b) 37.4 mm; (c) 89.6; (d) 435%

- 7.47 (a) $235 \text{ W/m}^2 \cdot \text{K}$; (b) 0.87 W ; (c) 1.02 W
7.48 (a) 1012°C , 1014°C
7.49 (b) 97 m/s
7.50 (b) 195 mA
7.52 (a) 27.6°C ; (b) 27.6°C
7.53 (a) 45.8°C ; (b) 68.3°C
7.54 76.6°C , 35 W
7.55 (a) $\$0.415/\text{m}\cdot\text{d}$; (b) $\$0.363/\text{m}\cdot\text{d}$
7.56 (a) 3640 W/m
7.57 1990 W
7.58 452.2 K
7.59 (b) 18.7 mm
7.61 (a) 0.20 m/s ; (b) $2.80 \times 10^4 \text{ W/m}^2$, 52%
7.62 (a) 15.2 s
7.63 (b) 340°C ; (c) 309°C
7.65 1.64 N , 1020 W
7.66 (a) 0.011 N ; (b) 3.14 W
7.67 (a) 0.489 N , 510 W ; (b) $0.452 \times 10^{-3} \text{ N}$, 1.59 W
7.68 10.3 W
7.69 (a) 67 s ; (b) 48 s
7.70 (a) 18.7°C ; (b) 672°C
7.71 35 m
7.72 (a) 737°C ; (b) 230 s
7.73 2.1 m/s , 1.6 m
7.74 1.1 m/s , 10.3 m
7.75 (a) 0.0011 s , 166.7 m/s ; (b) $7.8 \times 10^{-4} \text{ s}$
7.76 180 mm
7.77 (a) 13.3 m/s ; (b) 7 s
7.78 (a) 6.83 s ; (b) 936 K
7.79 (b) 337°C
7.80 726 K , 735 K
7.81 (a) 92.2 W ; (b) $1.76 \times 10^8 \text{ W/m}^3$, 1422 K ; (c) 1789 K
7.82 (a) 20.4 ; (b) 45.8°C
7.83 $234 \text{ W/m}^2 \cdot \text{K}$, 0.0149 bar , 28.4 kW/m
7.84 58.5 kW , $5.9 \times 10^{-3} \text{ bar}$
7.85 16 , 684 N/m^2
7.86 -532 kW/m
7.87 (a) 7670 W , 47.6°C ; (b) 195 N/m^2 , 56 W
7.88 39°C , 0.00993 bar , 6.26 kW
7.89 (a) $435 \text{ W/m}^2 \cdot \text{K}$; (b) 321 K , 2453 W
7.91 (a) 363 K ; (b) 355 kW , 0.163 kg/s
7.92 1.68 W
7.93 1.45 K/s
7.94 (c) 0.179 kg/s
7.96 $11,600 \text{ W}$, 140 W
7.97 (a) $903 \text{ W/m}^2 \cdot \text{K}$; (b) 31.9°C
7.98 2445 s
7.99 65.7 kW
7.100 (a) 700 K ; (b) 838 K
7.101 (a) 10.5°C , 0.0134 kg/s

- 7.102 (a) 41.2°C, 0.0154 kg/s
 7.103 0.0728 m/s, 0.0028 kg/s
 7.104 (a) 9.29×10^{-4} kg/s·m, 2265 W/m
 7.105 5.93 kW
 7.106 (a) 0.0137 kg/s·m
 7.107 3.57 W
 7.108 (a) 4.48×10^{-3} kg/s·m²; (b) 11,800 W/m²; (c) 9.95×10^{-4} kg/s·m
 7.109 (a) 9.5×10^{-4} kg/s, 9.5×10^{-4} kg/s, 9.3×10^{-4} kg/s; (b) 334.7 K, 332.8 K, 327.1 K
 7.111 (a) 0.123 kg/h, 44.9 W; (b) 52.3°C
 7.112 (b) 2.12×10^{-4} kg/s·m²
 7.113 28.6 min
 7.114 337 W/m, 483 W/m, 589 W/m
 7.115 (b) 5.35×10^{-4} kg/s·m; (c) 1.275 kW/m
 7.116 2.73×10^6 kg/day
 7.117 2775 W, -0.13°C/s
 7.118 0.0016 kg/s·m²
 7.119 (a) 4.81×10^{-4} kg/s·m², 1268 W/m²
 7.120 (a) 20.3 kg/h; (b) 102 days
 7.121 (a) 4.76×10^{-2} m/s
 7.122 (a) 2.31×10^{-4} kg/s·m
 7.123 (a) 0.30 kg/h·m, 110 W/m; (b) 52.3°C
 7.125 (a) 485 W; (b) 3135 W
 7.127 (a) 9424 W/m, 0.0036 kg/s·m
 7.128 45.6°C, 0.21
 7.129 1.82×10^{-7} kg/s, -8.9 K/s
 7.130 159 s
 7.131 3.60×10^{-8} kg/s
 7.132 278 K
 7.133 9.43×10^{-8} kg/s
 7.134 9.06×10^{-8} kg/s
 7.135 1.12×10^{-8} kg/s, 2.3 K
 7.136 (a) 1.83; (b) 28.0°C, 0.00129
 7.137 0.0016 kg/s·m²

CHAPTER 8

- 8.1 0.041 m/s, -0.86×10^{-5} bar/m
 8.2 0.0215 bar
 8.3 (a) 0.289 bar, 1.42 kW; (b) 0.419 bar, 2.06 kW
 8.5 (a) 53.8 bar, 146 W
 8.6 (c) 96; (d) 1.06 m/s, 667
 8.7 1.82 m, 1.06 m, 0.035 m; 2.8×10^{-4} m, 0.18 m, 1.4 m
 8.8 367 K
 8.9 0.50 m/s, 20.0°C
 8.10 (a) 39.4°C; (b) 37°C
 8.11 (b) 44.2°C
 8.15 (b) 60.8°C
 8.16 (a) 471 W, 113.5°C, 60°C, 153.5°C; (b) 353 W, 90.2°C, 20°C, 150.2°C

- 8.17 (b) 362 K
8.21 (c) 6018 W
8.22 (a) $222 \text{ W/m}^2 \cdot \text{K}$; (b) 90.9°C
8.23 (a) 35°C , 16,000 W
8.24 (a) 28.4°C , 44.9°C ; 73.3°C , 64.5°C ; 73.3°C , 65.1°C
8.25 159 kg/h, 1432 W
8.26 1281 W, 15.4 m
8.27 $12,680 \text{ W/m}^2$, 152°C , 69.4°C
8.28 (b) 1266 s
8.29 (a) $6.87 \times 10^{-2} \text{ kg/s}$, 15.3 m, 30.8 mm
8.30 (a) 61.3°C , 1519 W
8.31 (a) 1.56 m, 28.3 days
8.32 13.7 m, 0.078 W
8.33 (a) 10.6 m
8.34 (a) 47.5°C , 188 kW
8.35 $\$0.411/\text{m}\cdot\text{d}$
8.36 (a) 8.87 m, (b) 52.4°C
8.37 (a) 81.7°C ; (b) $8.98 \times 10^{-4} \text{ bars}$, 0.19 W
8.38 (a) 64°C ; (b) 65.5°C
8.39 (a) 29.9°C , -1212 W, 4.03 N/m^2
8.40 99°C , 5 atm, $1.14 \times 10^{-3} \text{ kg/s}$
8.41 0.11 m
8.42 0.39 m
8.43 8730 W/m^2 , 7580 W/m^2
8.44 (a) 50°C
8.45 (a) 578°C , 8.26 W
8.46 (a) 1384 K; (b) $5.2 \times 10^{-2} \text{ kg/s}$, 890 K
8.47 (a) 198°C , 71 N/m^2 , 221 W; (b) 195°C , 119 N/m^2 , 415 W
8.48 (a) 85.6°C , 661 W
8.49 (a) 42.2°C , 7500 W, 1.29 h; (b) 0.324 h
8.51 (a) 100 kW; (b) 2.67 kW
8.52 312 W/m
8.53 80.3 W/m
8.54 (a) 543°C , 232°C
8.55 81.4°C
8.56 (a) 37.1°C ; (b) 47.4°C
8.57 (a) 100 m; (b) 12 m
8.58 (a) 35.1°C ; (b) 95.8°C ; (c) 96.9°C
8.59 489 W/m
8.60 (a) 10 kW; (b) 3.4 m
8.62 (a) $409 \text{ W/m}^2 \cdot \text{K}$; (b) $97.5 \text{ W/m}^2 \cdot \text{K}$; (c) $78.8 \text{ W/m}^2 \cdot \text{K}$, 15°C
8.63 8.15 m
8.64 15.7°C , 438 W
8.65 (b) 111°C , $9.1 \times 10^6 \text{ W}$
8.67 47.6°C
8.68 (a) 35°C ; (b) 5.6; (d) $732 \text{ W/m}^2 \cdot \text{K}$; (e) -66.7 W; (f) 0.81 m
8.69 244 W/m, 187°C
8.70 0.90, 308.3 K
8.71 (b) 53°C
8.72 85°C , 53 mm

- 8.76 33.2°C
 8.77 379 K, 406 K
 8.78 88°C
 8.79 (a) 53,700 W/m²; (b) 123,400 W/m²
 8.80 2720 W, 312 K
 8.81 (a) 2600 W/m
 8.82 (a) 1.8 m
 8.83 9330 W/m²·K, 1960 W/m²·K
 8.84 (b) 305.3 K, 15.7 kW
 8.86 30°C, 156 N/m²
 8.87 (a) 3.35 kW; (b) 69 s
 8.88 310 K, 418 W
 8.89 (a) 307.8 K, 373 W; (b) 704 W
 8.90 (a) 298.6 K, 45 W; (b) 349.9 K, 3.0 W
 8.91 (a) 0.48°C; (b) 43.3°C, 27.4°C
 8.92 59.7°C, 20°C, 75.7°C; 27.9°C, 20°C, 37.5°C
 8.93 442 W/m²
 8.95 116.5°C, 5 atm, 1.38 × 10⁻³ kg/s
 8.96 2.51 m, 388°C
 8.97 (a) 704.5 K; (b) 683 K, 1087 K, 300 K
 8.98 (a) ~30.3°C
 8.99 19.7 m, 1575 W/m²
 8.100 58.4 m
 8.101 (a) 20.6°C, 0.085 W; 18.9°C, 0.128 W; (c) 21.5°C
 8.102 2.42 × 10⁻² m/s
 8.103 0.0032 m/s
 8.104 0.024 m/s
 8.105 3.89 × 10⁻² m/s, 107 W/m²·K; 1.12 × 10⁻² m/s, 31 W/m²·K
 8.106 (a) 50.6 W; (b) 34.2°C
 8.108 0.017 kg/m³, 4.33 × 10⁻⁶ kg/s
 8.109 2.1 m
 8.110 3.64 m, 46.7 W
 8.111 (a) 8.7 mm Hg, 0.0326 kg/m³; (b) 3.2 × 10⁻⁵ kg/s
 8.112 (a) 0.0050 m/s; (b) 0.067 liter/day
 8.113 (d) 0.181 kg/m³

CHAPTER 9

- 9.1 3 × 10⁻⁴ K⁻¹
 9.2 2.5 × 10⁷, 5.35 × 10⁵, 1.7 × 10⁶, 2.5 × 10⁸
 9.3 727, 12.5, 512, 9.4 × 10⁵
 9.4 5.8, 663, 209
 9.5 0.881
 9.6 (a) 17.5 mm; (b) 0.47 m/s; (c) 5.0 W/m²·K; (d) 0.60 m
 9.7 12.6 mm
 9.8 4.42 W/m²·K
 9.9 (a) 34 mm; (b) 16.8 W
 9.10 (a) 3.03 W/m²·K; (b) 2.94 W/m²·K
 9.12 (b) 1154 s

- 9.13 11.7 W
9.14 (b) -0.099 K/s
9.15 $6.5 \text{ W/m}^2 \cdot \text{K}$
9.17 153 W
9.18 (b) 223 W, \$0.43/day
9.19 273.8 K, 174.8 W
9.20 274.4 K, 273.2 K, 168.8 W
9.21 (a) 4010 W; (b) 2365 s
9.22 (a) $347 \text{ W/m}^2 \cdot \text{K}$
9.23 740 W
9.24 -0.136 K/s
9.25 (a) 118 kW/m^3
9.26 24.8 W/m^2
9.27 74°C , 68°C
9.28 (a) 35.8°C ; (b) 28.8°C ; (c) 68.8°C , 49.5°C
9.29 (a) 94.3 W
9.30 (a) 74.9°C , 1225 W; (b) 71.4°C , 1262 W
9.31 (a) $2.13 \times 10^6 \text{ W}$, 92%
9.33 (a) 104 W; (b) 515 W
9.34 85 W/m
9.35 (a) 19.3°C , 19.3°C , 20.1°C ; 21.6 W/m, 27.0 W/m, 26.2 W/m
9.36 468 W
9.37 (a) 238 W/m
9.38 $0.560 \text{ W/m} \cdot \text{K}$, 0.815
9.39 (a) $7.46 \text{ W/m}^2 \cdot \text{K}$; (b) $8.49 \text{ W/m}^2 \cdot \text{K}$, 264 K
9.40 90.2 W
9.41 442 W
9.42 45.3°C , 1007 W
9.43 (a) $2.91 \times 10^5 \text{ W}$; (b) $8.53 \times 10^4 \text{ W}$, 1463 K; (c) 0.13 m
9.45 (a) 250 W; (b) 181 s
9.46 (a) 42.9 min; (b) 11.0 min
9.47 (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
9.48 (a) 18.9 W; (b) 174°C
9.49 (a) $3.71 \text{ W/m}^2 \cdot \text{K}$, 44.5 W/m; (b) $4.50 \text{ W/m}^2 \cdot \text{K}$, 54.0 W; (c) $4.19 \text{ W/m}^2 \cdot \text{K}$, 50.3 W/m
9.50 (a) 92.7; (b) 85.2; (c) 83.2
9.51 21.6 kW
9.52 57°C
9.53 780 W/m
9.54 698 W/m
9.57 56.8°C , 1335 W, 7.27 h
9.58 (a) 929 W/m; (b) 2058 W/m; (c) 187 W/m
9.59 103 W/m
9.60 (a) 50.8 W/m, 0.953; (b) 56.9 W/m
9.61 79°C
9.62 64.8°C
9.63 (b) $8 \text{ W/m}^2 \cdot \text{K}$, 30.2 W/m
9.64 (a) 2.04 W; (b) 1.97 W
9.65 \$0.265/m-d
9.67 581°C , 183 s
9.69 (a) $207 \text{ W/m}^2 \cdot \text{K}$; (b) $387 \text{ W/m}^2 \cdot \text{K}$

- 9.70 (b) ~1.1 h
- 9.71 (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
- 9.72 (a) 163 W/m , 41.7°C ; (b) 60.8°C , 12.5°C , 52.8 W/m
- 9.73 (a) 12.5 m, ~20; (b) $\sim\pm 1\%$
- 9.74 (a) 33.3 kW; (b) ~855 s, 9.07 kg
- 9.75 (a) $13.6 \text{ W/m}^2 \cdot \text{K}$, $4.7 \text{ W/m}^2 \cdot \text{K}$, 70.2°C , 20.5
- 9.78 1.55 W, 187 W, 57.0 W
- 9.79 8.62 W
- 9.80 (a) $10.2 \text{ W/m}^2 \cdot \text{K}$, $1210 \text{ W/m}^2 \cdot \text{K}$
- 9.82 7.12 mm, 63.1 W
- 9.83 91.8 W
- 9.84 (a) 10.4 W; (b) 9.03 mm, 14.0 W
- 9.85 (a) 28.8 W
- 9.86 8.13 mm, 19, 677 W
- 9.87 (a) 18.0 W; (b) 19.6 mm
- 9.88 26.3 kW/m
- 9.89 7 mm
- 9.90 61 W
- 9.91 84 W/m^2
- 9.92 134 W, 171 W
- 9.93 123 W/m^2 , 146 W/m^2 , 26 W/m^2
- 9.94 (a) 1.57
- 9.96 (a) 9.1°C , -9.6°C , 35.7 W
- 9.97 (a) 74%, 35.4°C
- 9.98 10.4 W, 134°C
- 9.99 128 W/m^2 , 123 W/m^2
- 9.100 (a) 466 W
- 9.101 (a) 44.9 W/m ; (b) 46.8 W/m
- 9.102 43.4 W/m
- 9.103 2.75 kW/m
- 9.104 463 W/m
- 9.105 0.022 kg/s
- 9.106 64.0 W
- 9.108 2.0 m/s
- 9.109 (a) 54.6 W/m ; (b) 72.3 W/m ; (c) 70.7 W/m ; (d) 235 W/m
- 9.111 72.3 kW/m
- 9.112 43.9 W, 47.9 W
- 9.113 $6.2 \times 10^{-5} \text{ kg/s} \cdot \text{m}$
- 9.114 32.5 g/h , 26.2 W
- 9.115 (a) 9.18 W; (b) 4.9×10^5 ; (c) $4.25 \text{ W/m}^2 \cdot \text{K}$; (d) 0.0040 m/s, 1.45 kg/day, 40.5 W; (e) 59 W

CHAPTER 10

- 10.2 4640 W/m^2 , 8500 W/m^2 , $40,000 \text{ W/m}^2 \cdot \text{K}$
- 10.3 (c) 0.032 mm
- 10.4 $38,600 \text{ W/m}^2 \cdot \text{K}$, 0.017
- 10.5 $13,690 \text{ W/m}^2 \cdot \text{K}$
- 10.6 $30,790 \text{ W/m}^2$
- 10.7 73 kW/m^2 , 232 kW/m^2 ; 105 kW/m^2 , 439 kW/m^2
- 10.8 (b) 89°C

- 10.9 1.34 MW/m^2 , 0.512 MW/m^2 , 0.241 MW/m^2 , 1.26 MW/m^2
- 10.10 8.16 kW , 13 kg/h , 0.367 , 30°C
- 10.11 (a) 110°C , $4.6 \times 10^9 \text{ W/m}^2$; (b) 109°C
- 10.12 (a) 2.9 W , 68°C
- 10.13 559 W , $6.89 \times 10^{-4} \text{ kg/s}$, 0.026
- 10.14 ≈ 9 , 119°C
- 10.15 152.6°C , 166.7°C
- 10.16 175 A
- 10.17 4.70 MW/m^2 , 23.8 MW/m^2
- 10.19 (b) 7.5 mm
- 10.20 1.56 MW/m^2 , 1.19 MW/m^2
- 10.21 0.81 MW/m^2
- 10.23 (a) 73.8°C , 82°C ; (b) $1.13 \times 10^5 \text{ W/m}^2$
- 10.24 (a) 0.013 ; (b) 144.6°C , 182.1°C
- 10.26 (a) $876 \text{ W/m}^2 \cdot \text{K}$, 0.014 ; (b) 333°C
- 10.27 3.20 kW
- 10.28 (a) 6.09 kW/m
- 10.29 6.62 kW/m
- 10.30 (a) 2470 W/m , $3.94 \text{ kg/h}\cdot\text{m}$; (b) 110.5°C , $3.94 \text{ kg/h}\cdot\text{m}$
- 10.31 (a) 6840 W ; (b) 753 K
- 10.32 0.475 MW/m
- 10.33 (a) 0.924 MW/m^2
- 10.34 $5.27 \times 10^5 \text{ W/m}^2$
- 10.35 (a) 0.76 s ; (b) 13.5 s
- 10.37 68.0 kW/m
- 10.38 26.2 kW/m
- 10.39 $6.37 \times 10^4 \text{ W/m}$
- 10.40 $1.11 \times 10^{-3} \text{ kg/s}$
- 10.41 6.57 mm , $1.31 \times 10^{-3} \text{ kg}$; $5.1 \times 10^{-2} \text{ kg}$
- 10.42 16.0 kW , $7.05 \times 10^{-3} \text{ kg/s}$
- 10.43 40.3 kW , $17.7 \times 10^{-3} \text{ kg/s}$
- 10.44 0.957 kg/s
- 10.45 (a) 78°C
- 10.46 (a) 1.07 MW , 0.444 kg/s ; (b) 0.98 MW , 0.407 kg/s
- 10.47 2.21 kW , $2.44 \times 10^{-3} \text{ kg/s}$
- 10.48 (a) 649 kW/m ; $0.272 \text{ kg/s}\cdot\text{m}$
- 10.50 4.8 MW/m , $1.93 \text{ kg/s}\cdot\text{m}$
- 10.51 (a) 48.6°C , 4270 W/m , $0.0018 \text{ kg/s}\cdot\text{m}$
- 1053 19.1 kW , $8.39 \times 10^{-3} \text{ kg/s}$
- 10.54 $4.28 \times 10^{-3} \text{ kg/s}\cdot\text{m}$
- 10.55 28.3 kW/m , $1.16 \times 10^{-2} \text{ kg/s}\cdot\text{m}$
- 10.56 (a) 144 mm
- 10.57 230 K
- 10.58 0.0056 kg/s , 0.0044 kg/s
- 10.59 (a) $459 \text{ kg/h}\cdot\text{m}$
- 10.60 $22,200 \text{ W/m}^2 \cdot \text{K}$, $12,900 \text{ W/m}^2 \cdot \text{K}$
- 10.61 (a) 0.0118 kg/s , $7.98 \times 10^{-3} \text{ kg/s}$; (b) 50.6°C , 55.4°C ; (c) 6.23 m

- 10.62 2.75×10^{-3} kg/s
 10.63 2.0 s, 3.91×10^{-5} kg
 10.64 $7100 \text{ W/m}^2 \cdot \text{K}$, 9.1×10^{-3} kg/s·m
 10.65 6.29×10^{-2} kg/s·m
 10.66 0.023 kg/s, 0.0014 kg/s
 10.67 2.11 W, 0.0346 m^2
 10.68 (a) 114.0°C ; (b) 80.3°C ; (c) 2.6×10^{-4} kg/s
 10.69 (a) 79.4°C , 55.7 W; (b) 16.4 mm
 10.70 (a) 0.286 kg/s, 0.089 kg/s; (b) 379.6 K, 1.27 bar

CHAPTER 11

- 11.2 (a) $92 \text{ W/m}^2 \cdot \text{K}$; (b) $690 \text{ W/m}^2 \cdot \text{K}$
 11.3 (a) $3250 \text{ W/m}^2 \cdot \text{K}$
 11.4 $250 \text{ W/m}^2 \cdot \text{K}$, $1140 \text{ W/m}^2 \cdot \text{K}$
 11.5 11,800 W/m
 11.6 920 W/m
 11.7 (a) $2255 \text{ W/m}^2 \cdot \text{K}$; (b) $1800 \text{ W/m}^2 \cdot \text{K}$; 29.4°C
 11.8 (a) $98 \text{ W/m}^2 \cdot \text{K}$; (b) $512 \text{ W/m}^2 \cdot \text{K}$
 11.9 $160 \text{ W/m}^2 \cdot \text{K}$
 11.10 $30 \text{ W/m}^2 \cdot \text{K}$
 11.11 (a) $11.8 \text{ W/m}^2 \cdot \text{K}$; (b) $68.0 \text{ W/m}^2 \cdot \text{K}$
 11.13 3.09 m^2 , 2.64 m^2 , 2.83 m^2 , 2.84 m^2
 11.14 4.75 m^2
 11.15 $5.74 \times 10^{-4} \text{ m}^2 \cdot \text{K/W}$
 11.16 (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 (a) 7600 W, 48.1°C ; (b) 40 m
 11.21 $0.0029 \text{ m}^2 \cdot \text{K/W}$
 11.22 59°C
 11.23 (a) 1.58 m^2
 11.24 (a) 356 K, 520 K
 11.25 (a) 785 W/K, 5.0 m; (b) 18.4°C
 11.26 (a) 13 m^2 , 679 kW, 37.5°C ; (b) \$178,000/yr
 11.27 (a) 74%; (b) 24°C
 11.28 76.4°C
 11.29 (a) 9.0 mm, 3.5 m
 11.30 79.8°C , 8.70×10^{-4} kg/s
 11.31 (a) 399 K, 70
 11.32 33.1 m^2
 11.33 (a) 130 m; (b) $1985 \text{ W/m}^2 \cdot \text{K}$; (d) 97 m
 11.34 (a) 3930 W; (b) 3.74 liter/min; (c) 0.24 m^2
 11.35 (a) $3550 \text{ W/m}^2 \cdot \text{K}$, 41.1°C , 0.85 kg/s
 11.36 (a) 344.4 K
 11.37 (a) 1.89 kg/s
 11.38 (a) 720, 0.858 m; (b) 0.513 m

- 11.39 41.9 m^2 , 20.7 kg/s ; 0.936 kg/s
 11.40 0.30
 11.41 1.12 m
 11.42 50°C , 61.7°C
 11.43 (a) 3.07 m^2 , 33.4°C
 11.44 (a) 9.6 m
 11.45 (a) $508 \text{ W/m}^2\cdot\text{K}$; (b) 1.95 m
 11.46 (a) 55.7°C , 42.4°C ; (b) $2300 \text{ W/m}^2\cdot\text{K}$; (d) 74.4°C , 0.55
 11.47 $11,100 \text{ m}^2$, 1994 kg/s
 11.48 (a) 300, 2, 1.03 m
 11.49 (a) 206; (b) 26.1°C ; (c) 17.4 kg/s
 11.50 $\sim 4.2 \text{ m}^2$, 840 kg/h
 11.51 (a) 129.7°C
 11.52 $880 \text{ W/m}^2\cdot\text{K}$
 11.53 $61 \text{ W/m}^2\cdot\text{K}$, 0.64, 46.2°C
 11.54 68, 7.1 m
 11.55 (a) 71 m^2
 11.56 $0.53 \times 10^5 \text{ W}$, 0.47
 11.57 34.1°C
 11.58 36.6°C , 143.5°C
 11.59 243 m^2
 11.60 (a) 33.5%
 11.61 1014 K, 800 K, 514 K, 0.70
 11.62 48.2°C , 0.031 kg/s
 11.63 44.6 kW, 0.65, 1.82
 11.64 (a) 8280 W; (b) 98.4°C , 87.2°C ; (d) 5470 W, 0.66
 11.65 (a) 9.46 m; (b) 4.73 m
 11.66 670 kW, 52.1°C , 36.0°C
 11.67 41 m^2
 11.68 (a) 26.8°C
 11.69 (a) $2 \times 10^5 \text{ W}$, 19.6°C , 19.6°C
 11.70 4.56 m
 11.71 (a) $76.7 \text{ W/m}^2\cdot\text{K}$; (b) 496 K, 369 K
 11.72 (a) 104°C
 11.74 (a) $1.26 \times 10^{-3} \text{ K/W}$; (b) 63%
 11.75 (a) 0.672 kW; (b) 8°C , 61°C , 1.43 kW
 11.76 (a) 335 K; (b) 8.11 m; (c) 0.666
 11.77 (a) 30.3%; (b) 27.5 kg/s
 11.78 (a) 86.5 kW/K
 11.79 $65.4 \text{ W/m}^2\cdot\text{K}$
 11.80 0.088 m^3 , ~ 13 , ~ 11 , 0.58 m
 11.81 $54.7 \text{ W/m}^2\cdot\text{K}$, 0.0273 m^3
 11.82 3
 11.83 283.7 K
 11.84 ~ 11
 11.85 564 K

CHAPTER 12

- 12.1 12.1 W/m^2 , 28.0 W/m^2 , 19.8 W/m^2
12.2 (a) $1.38 \times 10^{-3} \text{ W}$; (b) 2.76 W/m^2
12.3 $8 \times 10^{-6} \text{ J}$
12.4 (a) 193 mm; (b) 940 W/m^2
12.5 (a) 60 mW; (b) $95.5 \text{ W/m}^2 \cdot \text{sr}$; (c) $47.8 \mu\text{W}$
12.6 1086 W/m^2
12.7 (a) 1446 W/m^2
12.8 167.6 W/m^2
12.9 0.25
12.10 (a) 2000 W/m^2 ; (b) $637 \text{ W/m}^2 \cdot \text{sr}$; (c) 0.50
12.11 (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 ; 63.7 mW/m^2
12.13 (a) 0.393 m
12.14 (a) 133 W, 76 W, 232 W, $5.54 \mu\text{m}$
12.15 7348 W/m^2
12.16 498 K
12.17 279 K
12.18 (a) $6.3 \times 10^7 \text{ W/m}^2$; (b) 5774 K; (c) $0.50 \mu\text{m}$; (d) 278 K
12.19 (a) $6.74 \times 10^{-5} \text{ sr}$; (b) $2.0 \times 10^7 \text{ W/m}^2 \cdot \text{sr}$
12.20 $0.50 \mu\text{m}$, $1.16 \mu\text{m}$, $1.93 \mu\text{m}$, $9.50 \mu\text{m}$, $48.3 \mu\text{m}$; 0.125, 0.366, 0.509
12.21 (a) 0.226, 0.044; (b) $0.50 \mu\text{m}$, $1.0 \mu\text{m}$
12.22 (a) 5.6%
12.23 0.367
12.24 (a) 0.0136, 0.376; 0.359, 0.132
12.25 (a) 9.84 kW/m^2 , (b) 6.24 kW/m^2
12.26 278.4 W
12.28 (b) 0.90 K, 7.1 K
12.29 (a) 0.352; (b) -1977 K/s
12.30 (a) 0.249; (b) 0.358
12.32 (a) 0.25, $2.27 \times 10^5 \text{ W/m}^2$
12.33 (b) 0.31, 0.38
12.34 0.636, 76.9 kW/m^2
12.35 1.45
12.38 0.80
12.39 (c) 995.3 K
12.40 (a) 3.3%, 5.5%; (b) 10%
12.41 0.373, -5.78 K/s , 311 s
12.42 34.7 kW/m^2
12.43 (b) 7500 W/m^2 ; (c) 2250 W/m^2 ; (d) 0.30
12.44 (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) $10.3 \mu\text{m}$
12.45 (a) 0.383; (b) 0.958, 0.240
12.46 515 W/m^2 , 1306 W/m^2 , 1991 W/m^2 , 3164 W
12.47 $2.51 \times 10^{-6} \text{ W}$
12.48 $1480 \mu\text{W}$
12.49 0.774, 0.1
12.50 0.45, 0.56, $-22,750 \text{ W/m}^2$

- 12.51 $0.311, 74,750 \text{ W/m}^2, -60,750 \text{ W/m}^2$
 12.52 348 K
 12.53 (a) 0.669; (b) 0.745; (c) 111 kW/m^2 ; (d) 176 kW/m^2
 12.54 $1.76 \times 10^{-4} \text{ W}, 0.384 \times 10^{-4} \text{ W}$
 12.55 (a) 147 mm
 12.56 0.839, 0.568; 0.329, 0.217
 12.57 (b) 8.88 W, 78.2 W
 12.59 (b) 0.599, 0.086, 0.315; (c) 1; (d) -615 W/m^2
 12.60 0.85, 0.85, $3.9 \times 10^6 \text{ W/m}^2, 4.6 \times 10^6 \text{ W/m}^2, 4.6 \times 10^6 \text{ W/m}^2$; 0.297, 0.106, $137 \text{ W/m}^2, 4.6 \times 10^6 \text{ W/m}^2, 1.38 \times 10^6 \text{ W/m}^2$
 12.62 0, 0.5
 12.63 $433 \text{ W/m}^2, 233 \text{ W/m}^2, 333 \text{ W/m}^2, 0.769, 0.231, 0.066$
 12.64 (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
 12.65 0.34, 0.80, $1700 \text{ W/m}^2, -700 \text{ W/m}^2$
 12.66 0.60, $200 \text{ W/m}^2, -1200 \text{ W/m}^2$
 12.67 (b) $1.42 \times 10^5 \text{ W/m}^2$
 12.68 0.720, 0.756, -11.8 kW/m^2
 12.69 42 W/m^2
 12.70 (a) 0.225, 0.388, 0.5; (b) 443 kW/m^2
 12.71 $7000 \text{ W/m}^2, 0.94$
 12.72 29.2 W, 344 K
 12.73 (a) 0.748; (b) 29.6°C ; (c) 402 W/m^2
 12.74 (a) 117°C
 12.75 (a) 22.2°C
 12.76 (a) 25°C
 12.77 (a) 19.8 W; (b) 538.2 K; (c) 855 s
 12.78 (a) 145 W/m^2 ; (b) $9.23 \mu\text{W}$; (c) $8.10 \mu\text{W}$
 12.79 99 K
 12.80 $8.08 \times 10^{-8} \text{ W}$
 12.81 (a) $1.15 \mu\text{W}$; (b) $1.47 \mu\text{W}$
 12.82 $3.38 \times 10^{-7} \text{ W}$
 12.83 (a) $7.57 \times 10^{-3} \text{ W/m}^2$; (b) $7.9 \text{ W/m}^2 \cdot \mu\text{m} \cdot \text{sr}, 6.2 \text{ W/m}^2 \cdot \mu\text{m} \cdot \text{sr}$
 12.84 (a) 134 K
 12.85 (a) $1718 \mu\text{V}$; (c) $1382 \mu\text{V}, 878 \mu\text{V}, 373 \mu\text{V}$
 12.86 (a) $17.9 \text{ kW/m}^2, 571 \text{ W/m}^2 \cdot \text{sr}, 3189 \text{ W/m}^2, 1015 \text{ W/m}^2 \cdot \text{s}, 4983 \text{ W/m}^2$; (b) $8.17 \mu\text{W}$
 12.87 (a) 5441 W/m^2
 12.88 (a) 0.49; (b) 0.20; (c) 24.4 W
 12.89 (a) 0.375; (b) 0.702; (c) 0.375
 12.90 (a) 0.1, 0.676, $1050 \text{ W/m}^2, 5.7 \text{ W/m}^2 \cdot \text{K}$; (b) 477 K
 12.91 (b) 20 K/s
 12.92 (a) 2.93 W/m·K
 12.93 (a) 1425 K, $1.87 \times 10^5 \text{ W/m}^2$; (b) $5.95 \times 10^{-5} \text{ W}$
 12.94 (a) $314 \mu\text{W}$; (b) 871 K
 12.95 (a) 800 K
 12.96 (a) 0.643; (b) 0.200; (c) 1646 kW/m^2
 12.97 (a) 839 K; (b) 770 K; (c) 850 K
 12.98 30.7 s

- 12.99 (a) 1.83 s; (b) 54.3 W
- 12.100 (a) $1.56 \times 10^9 \text{ W/m}^3$; (b) 15.6 W/mm^2 , 7.8 W/mm^2 ; (c) 772 s
- 12.101 (a) $126 \text{ W/m}^2 \cdot \text{K}$
- 12.102 (a) 0.799, 0.536; (b) 11.7 K/s; (c) 0.536; (d) 82 s
- 12.103 (a) 763 W; (b) 930 K; (c) 537 s
- 12.104 (a) 0.80, 0.713; (b) 233 kW/m^2 , 9.75 K/s; (d) 186 s; (e) 413 s; (f) 899 s
- 12.105 (a) 0.51 μm , 8.33 μm ; (d) 73.5 kW/m^2
- 12.106 (a) 48.5°C
- 12.107 139°C, 3.47 W
- 12.109 329.2 K
- 12.110 (a) 0.8, 0.625; (b) 352 K
- 12.111 (a) 0.634; (b) 0.25; (c) 460 W/m^2
- 12.115 (b) 35.5°C
- 12.116 (a) $8.16 \times 10^5 \text{ W/m}^2$
- 12.117 0.129 m, 31%
- 12.118 (a) $1.60 \times 10^7 \text{ W}$, 75.8%
- 12.119 (b) 295.2 K; (c) 704 W
- 12.121 (a) 0.704; (b) 0.20; (c) $6.37 \text{ W/m}^2 \cdot \text{K}$
- 12.122 (a) 39.5°C; (b) 26.5°C
- 12.123 (a) 4887 W
- 12.124 96.5 W/m^2
- 12.125 (a) 77.6°C; (b) -35.3°C
- 12.126 379 K, 656 K
- 12.128 439 K
- 12.129 0.95
- 12.130 (a) 837 W, 1026 W
- 12.131 (a) 30.5°C, 2766 W; (b) -7.6°C, 4660 W; (c) 80°C, 9557 W
- 12.132 (a) 1.286; (b) 352 K, 145 K
- 12.133 646 W/m^2
- 12.134 197 K, 340 K
- 12.135 (b) $\sim 5.5 \times 10^6 \text{ s}$
- 12.136 2560 W
- 12.137 (a) 57.9°C, 180 W; (b) 171.7°C; (c) -30.4°C
- 12.138 4.7°C, 16.2°C
- 12.140 43.1°C, 29.2°C
- 12.141 25°C, $3.1 \times 10^{-4} \text{ kg/s}$
- 12.142 (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) 1.0, 0.424; (b) 0.50, 0.25; (c) 0.363; (d) 0.50, 0.707; (e) 0.5, 0; (f) 1.0, 0.125; (g) 0.50, 0.637
- 13.2 (c) ~ 0.62
- 13.4 (b) 0.0767, 0.553; 0.0343, 0.800
- 13.9 (a) 0.09
- 13.10 (b) 0.01
- 13.11 (a) 0.038; (b) 0.23
- 13.12 0.781, 0.110
- 13.13 0.163

- 13.15 $27.7 \mu\text{W}/\text{m}^2$
13.16 (a) $354 \text{ mW}/\text{m}^2$; (b) $1695 \text{ mW}/\text{m}^2$
13.17 $36,900 \text{ W}$
13.18 $0.0492 \text{ kg}/\text{s}\cdot\text{m}$
13.19 $0.64, 1700 \text{ W}$
13.20 $1.69 \times 10^5 \text{ W}/\text{m}$
13.21 456 K
13.22 (a) 13.4 W , $6825 \text{ W}/\text{m}^2$
13.23 7.24 W , 3.53 W
13.24 (a) 413 K ; (b) 1312 W
13.25 544 K , 828 K
13.26 (a) 255 W ; (b) 970 K , 837.5 K
13.28 $1.58 \times 10^4 \text{ W}/\text{m}^2$
13.29 0.162 W
13.30 11.87 kW
13.31 (c) $17 \text{ kW}/\text{m}^2$; (d) $635 \mu\text{W}$
13.32 $63.8 \text{ W}/\text{m}^2$
13.33 (a) 1.19 W ; (b) $1.48 \mu\text{W}$
13.34 (a) 69 mW ; (b) $934.5 \text{ W}/\text{m}^2$; (c) $1085 \text{ W}/\text{m}^2$; (d) $1085 \text{ W}/\text{m}^2$
13.35 507 K , 439 K
13.36 (a) 308 K
13.37 774 K
13.38 (a) $48.8 \text{ K}/\text{s}$; (b) 15 s ; (c) 14.6 s , 12.0 s , 6.8 s
13.39 $1680 \text{ W}/\text{m}$, $2517 \text{ W}/\text{m}$, 916 K
13.40 (a) 555 W
13.41 $14.2 \text{ kW}/\text{m}^2$, $56.7 \text{ kW}/\text{m}^2$, $14.2 \text{ kW}/\text{m}^2$, $42.5 \text{ kW}/\text{m}^2$
13.42 (a) 1.58 W ; (b) 0.986
13.43 $46.2 \text{ kW}/\text{m}^2$, 0.814
13.46 (a) $21.5 \text{ kW}/\text{m}$, 0.268
13.47 (a) $15.2 \text{ W}/\text{m}$
13.48 66.4°C , 71.4°C
13.49 $30.2 \text{ W}/\text{m}$
13.50 69°C
13.51 $45.6 \text{ kW}/\text{m}^2$, $2.1 \text{ kW}/\text{m}^2$
13.52 $1.14 \times 10^{-4} \text{ kg}/\text{s}$
13.53 (a) 1995 W ; (b) 191 W ; (c) 998 W , 1.5%
13.54 548 K , 474 K
13.56 0.138
13.58 338 K , $25.3 \text{ W}/\text{m}^2$
13.59 90 mW
13.60 9
13.61 $0.50 \text{ W}/\text{m}$, -49%
13.62 472°C
13.63 1225 K , 1167 K
13.64 (a) 896 K , 986 K ; (b) 950 K , 990 K
13.65 (a) 288 W ; (b) -1692 W ; (c) 207 W ; (d) -1133 W
13.66 423 K
13.67 $10.1 \text{ kW}/\text{m}$
13.68 3295 W
13.69 (a) 12.6 W ; (b) 0.873 ; (c) 590 K

- 13.70 (a) 169 kW/m; (b) 1320 K
13.71 (a) 1.83
13.72 8520 W/m, 732 K
13.73 (a) 143 W; (b) 423 K
13.74 (a) 9870 W/m; (b) 853 K
13.75 (a) 25.3 kW; (b) 18.2 kW
13.76 1228 K, 1117 K
13.77 43.8 kW, 764 K
13.78 266 W/m
13.79 1046 W
13.80 (a) 37 W/m; (b) 9.2%
13.81 1.32 W
13.82 (b) 2875 W/m
13.83 1827 W
13.84 -538 W, -603 W, 1141 W
13.85 611 K
13.86 -200 W, 5037 W, -4799 W, 0, 0
13.87 (a) 1.30 W, 1; (b) 0.95 W, 0.734; (c) -1.27 W, 0.976
13.88 317 W
13.89 (a) 52.7 kW/m², 2.89 kW
13.90 (a) 41.3 kW; (b) 6.55 kW
13.91 (a) -1153 W; (b) 0.57 K/s; (c) 715 K
13.92 842.5 K
13.94 (a) 54 kW/m; (b) 1346 K, 25.7 kW/m
13.95 (a) 306 K; (b) 816 W/m²
13.96 4600 W, 64 W/m²·K
13.97 (a) 29.5 W/m, 483 K; (b) 441 W/m, 352 K
13.98 (a) 35 W/m²·K; (b) 484 K
13.99 (a) 792.2 K, 792 K; (b) 783.2 K, 783 K
13.100 526 K
13.101 (a) 577 K; (b) 156 W/m; (c) 3120 W
13.104 (b) 366 K, 1920 W/m²; 598 K, 10,850 W/m²
13.105 5700 K/W
13.106 19.2 W
13.107 159 W/m², 7.3 W/m²
13.108 (a) 145 W/m²; (b) 306 W/m²; (c) 165 W/m², 156 W/m²
13.109 (a) 8.8°C, -7.4°C, 91.3 W
13.110 669 W/m², 199 W/m²
13.111 (a) 131 W/m
13.112 59.5°C, 89 W/m
13.113 (a) 466 W, 1088 W
13.114 (a) 54.6 W; (b) 413 K
13.115 (a) 30 W/m²
13.116 (a) 8075 W/m; (b) 796 K, 10 kW/m
13.117 (a) 121 W/m
13.118 0.023 kg/s
13.119 (a) 3.45 m; (b) 0.88 m
13.120 (b) 1295 K, 498 K; (c) 8 kW/m
13.121 (b) 1213 W/m; (c) 576 W/m; (d) 502 K
13.122 (a) 178 W/m²·K, 543 K, 0.098 kg/s; (b) 0.140 kg/s
13.123 1040 K

- 13.124 (a) 0.0197; (b) 825 K, 108 kW
 13.125 15.1 kW
 13.126 21.9 kW/m
 13.127 98 kW/m
 13.128 135 kW/m^2
 13.129 380 K, 89.6 kW/m^2
 13.130 0.515 kg/s
 13.131 0.004 kg/s , 4.5 m/s , 367 K
 13.132 (a) 530 K; (b) 0.00613 m/s
 13.133 (a) $0.00341 \text{ kg/s}\cdot\text{m}$; (b) 889 K, 811 K

CHAPTER 14

- 14.1 0.233, 0.767
 14.2 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
 14.3 0.31, 0.27, 0.42; 0.35, 0.40, 0.25
 14.4 (a) 0.0194, 0.0120; 1; (b) 0.205, 0.226; 5.53×10^{-6} , 9.83×10^{-6}
 14.6 $14.7 \times 10^{-12} \text{ kg/s}$, $-3.5 \times 10^{-7} \text{ bar/s}$
 14.7 $1.5 \times 10^{-8} \text{ kmol/s}\cdot\text{m}^2$
 14.8 $0.36 \times 10^{-4} \text{ m}^2/\text{s}$, $0.52 \times 10^{-4} \text{ m}^2/\text{s}$
 14.13 $1.31 \times 10^{-9} \text{ kmol/s}\cdot\text{m}^2$, 0.0807 kmol/m^3 , 0.0404 kmol/m^3
 14.14 $4.05 \times 10^{-9} \text{ kg/s}$
 14.15 $1.45 \times 10^{-11} \text{ kg/s}$, $7.06 \times 10^{-5} \text{ bar}$
 14.16 $1.9 \times 10^{-14} \text{ kg/s}\cdot\text{m}$
 14.17 $4 \times 10^{-15} \text{ kg/s}$
 14.18 $2.78 \times 10^{-6} \text{ kg/s}\cdot\text{m}$
 14.19 $4 \times 10^{-12} \text{ kg/s}\cdot\text{m}$
 14.20 0.10, $5.61 \times 10^{-5} \text{ kg/s}$
 14.21 $6.66 \times 10^{-9} \text{ kmol/s}$
 14.22 $1.81 \times 10^{-8} \text{ kmol/s}$
 14.24 0.0008 , $7.48 \times 10^{-8} \text{ kmol/s}\cdot\text{m}^2$, $2.24 \times 10^{-7} \text{ kmol/s}\cdot\text{m}^2$
 14.25 $3.72 \times 10^{-9} \text{ kg/s}$
 14.26 0.949
 14.27 $1.09 \times 10^{-8} \text{ kmol/s}$, $1.10 \times 10^{-8} \text{ kmol/s}$
 14.30 (a) 0.00316 kg/week ; (b) 0.1467 kg/week
 14.32 $0.257 \text{ kg/h}\cdot\text{m}^2$
 14.33 (b) $5.38 \times 10^{-11} \text{ kmol/s}\cdot\text{m}^2$
 14.34 (c) $3 \times 10^{-5} \text{ kmol/m}^3$
 14.35 (c) $5.11 \times 10^{-6} \text{ kmol/m}^3$, $2.18 \times 10^{-15} \text{ kmol/s}$
 14.36 (b) $7.86 \times 10^{-8} \text{ kmol/s}$, 0.0169
 14.38 (b) 0.02 kmol/m^3 ; (d) $9.6 \times 10^{-5} \text{ kmol/s}\cdot\text{m}^2$
 14.39 (b) $9.1 \times 10^{-7} \text{ kmol/m}^3$, 0
 14.41 333 s
 14.42 (a) 32 kg/m^3 ; (c) 42.9 h
 14.43 (a) 32 kg/m^3 ; (c) 42.9 h; (d) 218 h
 14.44 0.02 s

14.45 8.42 h

14.46 (b) 0.0314

14.47 (a) 2071 days; (b) 198.7 kg/m³; (c) 198.7 kg/m³

14.48 (b) 2.435×10^{-5}