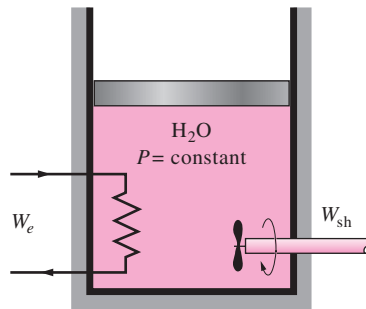


## CHE 260F – Thermodynamics and Heat Transfer

### Mid-Term Exam – 2016

*You have 110 minutes to do the following five problems. You may use any type of non-communicating calculator. All questions are worth equal marks.*

- 1) An insulated piston–cylinder device contains 5 L of saturated liquid water at a constant pressure of 175 kPa. The water is stirred by a paddle wheel while a current of 8 A flows for 45 min through a resistor placed in the water. If one-half of the liquid is evaporated during this constant- pressure process and the paddle-wheel work amounts to 400 kJ, determine the voltage applied across the resistor. Show the process on a  $P$ - $v$  diagram with respect to saturation lines.



- 2) Argon gas enters an adiabatic turbine steadily at 900 kPa and 450°C with a velocity of 80 m/s and leaves at 150 kPa with a velocity of 150 m/s. The inlet area of the turbine is 60 cm<sup>2</sup>. If the power output of the turbine is 250 kW, determine the exit temperature of the argon. Assume argon is an ideal gas with  $R=0.2081$  kJ/kgK and  $c_p=0.5203$  kJ/kgK.
- 3) A rigid container is divided by a wall into two equal-sized compartments, each 1 m<sup>3</sup> in volume. One is filled with a saturated water – steam mixture at 200 kPa with a quality of 0.8. The other contains steam at 2 MPa and a temperature of 400°C. The partition wall is removed and the water and steam are allowed to mix and lose heat to the surroundings until the system reaches a uniform state where its pressure is 1 MPa. Find the final temperature and the heat lost to the surroundings.
- 4) A 2 kg mass of ethane gas at 500 kPa and 100°C in a piston-cylinder system loses heat to the surrounding atmosphere at 20°C while undergoing a reversible expansion during which  $Pv^{1.3}=\text{constant}$ . The final gas temperature is 20°C. Calculate the total entropy generated during this process. Assume ethane is an ideal gas with  $c_p=1.766$  kJ/kgK,  $c_v=1.490$  kJ/kgK,  $R=0.276$  kJ/kgK.
- 5) An adiabatic steam turbine operates with inlet steam conditions of 400°C, 2 MPa and a measured outlet condition of 10 kPa,  $x=0.95$ .
  - a. How much work per unit mass of steam will this turbine produce?
  - b. If the turbine were reversible how much work could it produce for an outlet pressure of 10 kPa?

TABLE A-4

Saturated water—Temperature table

Temp., $T$ °C	Specific volume, $m^3/kg$			Internal energy, $kJ/kg$			Enthalpy, $kJ/kg$			Entropy, $kJ/kg \cdot K$		
	Sat. press., $P_{sat}$ kPa	Sat. liquid, $v_f$	Sat. vapor, $v_g$	Sat. liquid, $u_f$	Evap., $u_{fg}$	Sat. vapor, $u_g$	Sat. liquid, $h_f$	Evap., $h_{fg}$	Sat. vapor, $h_g$	Sat. liquid, $s_f$	Evap., $s_{fg}$	Sat. vapor, $s_g$
0.01	0.6117	0.001000	206.00	0.000	2374.9	2374.9	0.001	2500.9	2500.9	0.0000	9.1556	9.1556
5	0.8725	0.001000	147.03	21.019	2360.8	2381.8	21.020	2489.1	2510.1	0.0763	8.9487	9.0249
10	1.2281	0.001000	106.32	42.020	2346.7	2388.7	42.022	2477.2	2519.2	0.1511	8.7488	8.8999
15	1.7057	0.001001	77.885	62.980	2332.5	2395.5	62.982	2465.4	2528.3	0.2245	8.5559	8.7803
20	2.3392	0.001002	57.762	83.913	2318.4	2402.3	83.915	2453.5	2537.4	0.2965	8.3696	8.6661
25	3.1698	0.001003	43.340	104.83	2304.3	2409.1	104.83	2441.7	2546.5	0.3672	8.1895	8.5567
30	4.2469	0.001004	32.879	125.73	2290.2	2415.9	125.74	2429.8	2555.6	0.4368	8.0152	8.4520
35	5.6291	0.001006	25.205	146.63	2276.0	2422.7	146.64	2417.9	2564.6	0.5051	7.8466	8.3517
40	7.3851	0.001008	19.515	167.53	2261.9	2429.4	167.53	2406.0	2573.5	0.5724	7.6832	8.2566
45	9.5953	0.001010	15.251	188.43	2247.7	2436.1	188.44	2394.0	2582.4	0.6386	7.5247	8.1633
50	12.352	0.001012	12.026	209.33	2233.4	2442.7	209.34	2382.0	2591.3	0.7038	7.3710	8.0748
55	15.763	0.001015	9.5639	230.24	2219.1	2449.3	230.26	2369.8	2600.1	0.7680	7.2218	7.9898
60	19.947	0.001017	7.6670	251.16	2204.7	2455.9	251.18	2357.7	2608.8	0.8313	7.0769	7.9082
65	25.043	0.001020	6.1935	272.09	2190.3	2462.4	272.12	2345.4	2617.5	0.8937	6.9360	7.8296
70	31.202	0.001023	5.0396	293.04	2175.8	2468.9	293.07	2333.0	2626.1	0.9551	6.7989	7.7540
75	38.597	0.001026	4.1291	313.99	2161.3	2475.3	314.03	2320.6	2634.6	1.0158	6.6655	7.6812
80	47.416	0.001029	3.4053	334.97	2146.6	2481.6	335.02	2308.0	2643.0	1.0756	6.5355	7.6111
85	57.868	0.001032	2.8261	355.96	2131.9	2487.8	356.02	2295.3	2651.4	1.1346	6.4089	7.5435
90	70.183	0.001036	2.3593	376.97	2117.0	2494.0	377.04	2282.5	2659.6	1.1929	6.2853	7.4782
95	84.609	0.001040	1.9808	398.00	2102.0	2500.1	398.09	2269.6	2667.6	1.2504	6.1647	7.4151
100	101.42	0.001043	1.6720	419.06	2087.0	2506.0	419.17	2256.4	2675.6	1.3072	6.0470	7.3542
105	120.90	0.001047	1.4186	440.15	2071.8	2511.9	440.28	2243.1	2683.4	1.3634	5.9319	7.2952
110	143.38	0.001052	1.2094	461.27	2056.4	2517.7	461.42	2229.7	2691.1	1.4188	5.8193	7.2382
115	169.18	0.001056	1.0360	482.42	2040.9	2523.3	482.59	2216.0	2698.6	1.4737	5.7092	7.1829
120	198.67	0.001060	0.89133	503.60	2025.3	2528.9	503.81	2202.1	2706.0	1.5279	5.6013	7.1292
125	232.23	0.001065	0.77012	524.83	2009.5	2534.3	525.07	2188.1	2713.1	1.5816	5.4956	7.0771
130	270.28	0.001070	0.66808	546.10	1993.4	2539.5	546.38	2173.7	2720.1	1.6346	5.3919	7.0265
135	313.22	0.001075	0.58179	567.41	1977.3	2544.7	567.75	2159.1	2726.9	1.6872	5.2901	6.9773
140	361.53	0.001080	0.50850	588.77	1960.9	2549.6	589.16	2144.3	2733.5	1.7392	5.1901	6.9294
145	415.68	0.001085	0.44600	610.19	1944.2	2554.4	610.64	2129.2	2739.8	1.7908	5.0919	6.8827
150	476.16	0.001091	0.39248	631.66	1927.4	2559.1	632.18	2113.8	2745.9	1.8418	4.9953	6.8371
155	543.49	0.001096	0.34648	653.19	1910.3	2563.5	653.79	2098.0	2751.8	1.8924	4.9002	6.7927
160	618.23	0.001102	0.30680	674.79	1893.0	2567.8	675.47	2082.0	2757.5	1.9426	4.8066	6.7492
165	700.93	0.001108	0.27244	696.46	1875.4	2571.9	697.24	2065.6	2762.8	1.9923	4.7143	6.7067
170	792.18	0.001114	0.24260	718.20	1857.5	2575.7	719.08	2048.8	2767.9	2.0417	4.6233	6.6650
175	892.60	0.001121	0.21659	740.02	1839.4	2579.4	741.02	2031.7	2772.7	2.0906	4.5335	6.6242
180	1002.8	0.001127	0.19384	761.92	1820.9	2582.8	763.05	2014.2	2777.2	2.1392	4.4448	6.5841
185	1123.5	0.001134	0.17390	783.91	1802.1	2586.0	785.19	1996.2	2781.4	2.1875	4.3572	6.5447
190	1255.2	0.001141	0.15636	806.00	1783.0	2589.0	807.43	1977.9	2785.3	2.2355	4.2705	6.5059
195	1398.8	0.001149	0.14089	828.18	1763.6	2591.7	829.78	1959.0	2788.8	2.2831	4.1847	6.4678
200	1554.9	0.001157	0.12721	850.46	1743.7	2594.2	852.26	1939.8	2792.0	2.3305	4.0997	6.4302

TABLE A-4

Saturated water—Temperature table (Continued)

Temp., $T$ °C	Specific volume, $m^3/kg$			Internal energy, $kJ/kg$			Enthalpy, $kJ/kg$			Entropy, $kJ/kg \cdot K$		
	Sat. press., $P_{sat}$ kPa	Sat. liquid, $v_f$	Sat. vapor, $v_g$	Sat. liquid, $u_f$	Evap., $u_{fg}$	Sat. vapor, $u_g$	Sat. liquid, $h_f$	Evap., $h_{fg}$	Sat. vapor, $h_g$	Sat. liquid, $s_f$	Evap., $s_{fg}$	Sat. vapor, $s_g$
205	1724.3	0.001164	0.11508	872.86	1723.5	2596.4	874.87	1920.0	2794.8	2.3776	4.0154	6.3930
210	1907.7	0.001173	0.10429	895.38	1702.9	2598.3	897.61	1899.7	2797.3	2.4245	3.9318	6.3563
215	2105.9	0.001181	0.094680	918.02	1681.9	2599.9	920.50	1878.8	2799.3	2.4712	3.8489	6.3200
220	2319.6	0.001190	0.086094	940.79	1660.5	2601.3	943.55	1857.4	2801.0	2.5176	3.7664	6.2840
225	2549.7	0.001199	0.078405	963.70	1638.6	2602.3	966.76	1835.4	2802.2	2.5639	3.6844	6.2483
230	2797.1	0.001209	0.071505	986.76	1616.1	2602.9	990.14	1812.8	2802.9	2.6100	3.6028	6.2128
235	3062.6	0.001219	0.065300	1010.0	1593.2	2603.2	1013.7	1789.5	2803.2	2.6560	3.5216	6.1775
240	3347.0	0.001229	0.059707	1033.4	1569.8	2603.1	1037.5	1765.5	2803.0	2.7018	3.4405	6.1424
245	3651.2	0.001240	0.054656	1056.9	1545.7	2602.7	1061.5	1740.8	2802.2	2.7476	3.3596	6.1072
250	3976.2	0.001252	0.050085	1080.7	1521.1	2601.8	1085.7	1715.3	2801.0	2.7933	3.2788	6.0721
255	4322.9	0.001263	0.045941	1104.7	1495.8	2600.5	1110.1	1689.0	2799.1	2.8390	3.1979	6.0369
260	4692.3	0.001276	0.042175	1128.8	1469.9	2598.7	1134.8	1661.8	2796.6	2.8847	3.1169	6.0017
265	5085.3	0.001289	0.038748	1153.3	1443.2	2596.5	1159.8	1633.7	2793.5	2.9304	3.0368	5.9662
270	5503.0	0.001303	0.035622	1177.9	1415.7	2593.7	1185.1	1604.6	2789.7	2.9762	2.9542	5.9305
275	5946.4	0.001317	0.032767	1202.9	1387.4	2590.3	1210.7	1574.5	2785.2	3.0221	2.8723	5.8944
280	6416.6	0.001333	0.030153	1228.2	1368.2	2586.4	1236.7	1543.2	2779.9	3.0681	2.7898	5.8579
285	6914.6	0.001349	0.027756	1253.7	1328.1	2581.8	1263.1	1510.7	2773.7	3.1144	2.7066	5.8210
290	7441.8	0.001366	0.025594	1279.7	1296.9	2576.5	1289.8	1476.9	2766.7	3.1608	2.6225	5.7834
295	7999.0	0.001384	0.023528	1306.0	1264.5	2570.5	1317.1	1441.6	2758.7	3.2076	2.5374	5.7450
300	8587.9	0.001404	0.021659	1332.7	1230.9	2563.6	1344.8	1404.8	2749.6	3.2548	2.4511	5.7059
305	9209.4	0.001425	0.019932	1360.0	1195.9	2555.8	1373.1	1366.3	2739.4	3.3024	2.3633	5.6657
310	9865.0	0.001447	0.018333	1387.7	1159.3	2547.1	1402.0	1325.9	2727.9	3.3506	2.2737	5.6243
315	10556	0.001472	0.016849	1416.1	1121.1	2537.2	1431.6	1283.4	2715.0	3.3994	2.1821	5.5816
320	11284	0.001499	0.015470	1445.1	1080.9	2526.0	1462.0	1238.5	2700.6	3.4491	2.0881	5.5372
325	12061	0.001528	0.014183	1475.0	1038.5	2513.4	1493.4	1191.0	2684.3	3.4998	1.9911	5.4908
330	12888	0.001560	0.012979	1505.7	993.5	2499.2	1525.8	1140.3	2666.0	3.5516	1.8906	5.4422
335	13707	0.001597	0.011848	1537.5	945.5	2483.0	1559.4	1086.0	2645.4	3.6050	1.7857	5.3907
340	14601	0.001638	0.010783	1570.7	893.8	2464.5	1594.6	1027.4	2622.0	3.6602	1.6756	5.3358
345	15541	0.001685	0.009772	1605.5	837.7	2443.2	1631.7	963.4	2595.1	3.7179	1.5585	5.2765
350	16529	0.001741	0.008806	1642.4	775.9	2418.3	1671.2	892.7	2563.9	3.7788	1.4326	5.2114
355	17570	0.001808	0.007872	1682.2	706.4	2388.6	1714.0	812.9	2526.9	3.8442	1.2942	5.1384
360	18666	0.001895	0.006950	1726.2	625.7	2351.9	1761.5	720.1	2481.6	3.9165	1.1373	5.0537
365	19822	0.002015	0.006009	1777.2	526.4	2303.6	1817.2	605.5	2422.7	4.0004	0.9489	4.9493
370	21044	0.002217	0.004953	1844.5	385.6	2230.1	1891.2	443.1	2334.3	4.1119	0.6890	4.8009
373.95	22064	0.003106	0.003106	2015.7	0	2015.7	2084.3	0	2084.3	4.4070	0	4.4070

TABLE A-5

Saturated water—Pressure table

Press., P kPa	Sat. temp., T <sub>sat</sub> °C	Specific volume, m <sup>3</sup> /kg		Internal energy, kJ/kg			Enthalpy, kJ/kg			Entropy, kJ/kg · K	
		Sat. liquid, v <sub>f</sub>	Sat. vapor, v <sub>g</sub>	Sat. liquid, u <sub>f</sub>	Evap., u <sub>fg</sub>	Sat. vapor, u <sub>g</sub>	Sat. liquid, h <sub>f</sub>	Evap., h <sub>fg</sub>	Sat. vapor, h <sub>g</sub>	Sat. liquid, s <sub>f</sub>	Sat. vapor, s <sub>g</sub>
1.0	6.97	0.001000	129.19	29.302	2355.2	2384.5	29.303	2484.4	2513.7	0.1059	8.8690
1.5	13.02	0.001001	87.964	54.686	2338.1	2392.8	54.688	2470.1	2524.7	0.1956	8.6314
2.0	17.50	0.001001	66.990	73.431	2325.5	2398.9	73.433	2459.5	2532.9	0.2606	8.4621
2.5	21.08	0.001002	54.242	88.422	2315.4	2403.8	88.424	2451.0	2539.4	0.3118	8.3302
3.0	24.08	0.001003	45.654	100.98	2306.9	2407.9	100.98	2443.9	2544.8	0.3543	8.2222
4.0	28.96	0.001004	34.791	121.39	2293.1	2414.5	121.39	2432.3	2553.7	0.4224	8.0510
5.0	32.87	0.001005	28.185	137.75	2282.1	2419.8	137.75	2423.0	2560.7	0.4762	7.9176
7.5	40.29	0.001008	19.233	168.74	2261.1	2429.8	168.75	2405.3	2574.0	0.5763	7.6738
10	45.81	0.001010	14.670	191.79	2245.4	2437.2	191.81	2392.1	2583.9	0.6492	7.4996
15	53.97	0.001014	10.020	225.93	2222.1	2448.0	225.94	2372.3	2598.3	0.7549	7.2522
20	60.06	0.001017	7.6481	251.40	2204.6	2456.0	251.42	2357.5	2608.9	0.8320	7.0752
25	64.96	0.001020	6.2034	271.93	2190.4	2462.4	271.96	2345.5	2617.5	0.8932	6.9370
30	69.09	0.001022	5.2287	289.24	2178.5	2467.7	289.27	2335.3	2624.6	0.9441	6.8234
40	75.86	0.001026	3.9933	317.58	2158.8	2476.3	317.62	2318.4	2636.1	1.0261	6.6430
50	81.32	0.001030	3.2403	340.49	2142.7	2483.2	340.54	2304.7	2645.2	1.0912	6.5019
75	91.76	0.001037	2.1272	384.36	2111.8	2495.1	384.44	2278.0	2662.4	1.2132	6.2426
100	99.61	0.001043	1.6941	417.40	2088.2	2505.6	417.51	2257.5	2675.0	1.3028	6.0562
101.325	99.97	0.001043	1.6734	418.95	2087.0	2506.0	419.06	2256.5	2675.6	1.3069	6.0476
125	105.97	0.001048	1.3750	444.23	2068.8	2513.0	444.36	2240.6	2684.9	1.3741	5.9100
150	111.35	0.001053	1.1594	466.97	2052.3	2519.2	467.13	2226.0	2693.1	1.4337	5.7894
175	116.04	0.001057	1.0037	486.82	2037.7	2524.5	487.01	2213.1	2700.2	1.4850	5.6865
200	120.21	0.001061	0.88578	504.50	2024.6	2529.1	504.71	2201.6	2706.3	1.5302	5.5968
225	123.97	0.001064	0.79329	520.47	2012.7	2533.2	520.71	2191.0	2711.7	1.5706	5.5171
250	127.41	0.001067	0.71873	535.08	2001.8	2536.8	535.35	2181.2	2716.5	1.6072	5.4453
275	130.58	0.001070	0.65732	548.57	1991.6	2540.1	548.86	2172.0	2720.9	1.6408	5.3800
300	133.52	0.001073	0.60582	561.11	1982.1	2543.2	561.43	2163.5	2724.9	1.6717	5.3200
325	136.27	0.001076	0.56199	572.84	1973.1	2545.9	573.19	2155.4	2728.6	1.7005	5.2645
350	138.86	0.001079	0.52422	583.89	1964.6	2548.5	584.26	2147.7	2732.0	1.7274	5.2128
375	141.30	0.001081	0.49133	594.32	1956.6	2550.9	594.73	2140.4	2735.1	1.7526	5.1645
400	143.61	0.001084	0.46242	604.22	1948.9	2553.1	604.66	2133.4	2738.1	1.7765	5.1191
450	147.90	0.001088	0.41392	622.65	1934.5	2557.1	623.14	2120.3	2743.4	1.8205	5.0356
500	151.83	0.001093	0.37483	639.54	1921.2	2560.7	640.09	2108.0	2748.1	1.8604	4.9603
550	155.46	0.001097	0.34261	655.16	1908.8	2563.9	655.77	2096.6	2752.4	1.8970	4.8916
600	158.83	0.001101	0.31560	669.72	1897.1	2566.8	670.38	2085.8	2756.2	1.9308	4.8285
650	161.98	0.001104	0.29260	683.37	1886.1	2569.4	684.08	2075.5	2759.6	1.9623	4.7699
700	164.95	0.001108	0.27278	696.23	1875.6	2571.8	697.00	2065.8	2762.8	1.9918	4.7153
750	167.75	0.001111	0.25552	708.40	1865.6	2574.0	709.24	2056.4	2765.7	2.0195	4.6642

TABLE A-5

Saturated water—Pressure table (Continued)

Press., P kPa	Sat. temp., T <sub>sat</sub> °C	Specific volume, m <sup>3</sup> /kg		Internal energy, kJ/kg			Enthalpy, kJ/kg			Entropy, kJ/kg · K	
		Sat. liquid, v <sub>f</sub>	Sat. vapor, v <sub>g</sub>	Sat. liquid, u <sub>f</sub>	Evap., u <sub>fg</sub>	Sat. vapor, u <sub>g</sub>	Sat. liquid, h <sub>f</sub>	Evap., h <sub>fg</sub>	Sat. vapor, h <sub>g</sub>	Sat. liquid, s <sub>f</sub>	Sat. vapor, s <sub>g</sub>
800	170.41	0.001115	0.24035	719.97	1856.1	2576.0	720.87	2047.5	2768.3	2.0457	4.6160
850	172.94	0.001118	0.22690	731.00	1846.9	2577.9	731.95	2038.8	2770.8	2.0705	4.5705
900	175.35	0.001121	0.21489	741.55	1838.1	2579.6	742.56	2030.5	2773.0	2.0941	4.5273
950	177.66	0.001124	0.20411	751.67	1829.6	2581.3	752.74	2022.4	2775.2	2.1166	4.4862
1000	179.88	0.001127	0.19436	761.39	1821.4	2582.8	762.51	2014.6	2777.1	2.1381	4.4470
1100	184.06	0.001133	0.17745	779.78	1805.7	2585.5	781.03	1999.6	2780.7	2.1785	4.3735
1200	187.96	0.001138	0.16326	796.96	1790.9	2587.8	798.33	1985.4	2783.8	2.2159	4.3058
1300	191.60	0.001144	0.15119	813.10	1776.8	2589.9	814.59	1971.9	2786.5	2.2508	4.2428
1400	195.04	0.001149	0.14078	828.35	1763.4	2591.8	829.96	1958.9	2788.9	2.2835	4.1840
1500	198.29	0.001154	0.13171	842.82	1750.6	2593.4	844.55	1946.4	2791.0	2.3143	4.1287
1750	205.72	0.001166	0.11344	876.12	1720.6	2596.7	878.16	1917.1	2795.2	2.3844	4.0033
2000	212.38	0.001177	0.099587	906.12	1693.0	2599.1	908.47	1889.8	2798.3	2.4467	3.8923
2250	218.41	0.001187	0.088717	933.54	1667.3	2600.9	936.21	1864.3	2800.5	2.5029	3.7926
2500	223.95	0.001197	0.079952	958.87	1643.2	2602.1	961.87	1840.1	2801.9	2.5542	3.7016
3000	233.85	0.001217	0.066667	1004.6	1598.5	2603.2	1008.3	1794.9	2803.2	2.6454	3.5402
3500	242.56	0.001235	0.057061	1045.4	1557.6	2603.0	1049.7	1753.0	2802.7	2.7253	3.3991
4000	250.35	0.001252	0.049779	1082.4	1519.3	2601.7	1087.4	1713.5	2800.8	2.7966	3.2731
5000	263.94	0.001286	0.039448	1148.1	1448.9	2597.0	1154.5	1639.7	2794.2	2.9207	3.0530
6000	275.59	0.001319	0.032449	1205.8	1384.1	2589.9	1213.8	1570.9	2784.6	3.0275	2.8627
7000	285.83	0.001352	0.027378	1258.0	1323.0	2581.0	1267.5	1505.2	2772.6	3.1220	2.6927
8000	295.01	0.001384	0.023525	1306.0	1264.5	2570.5	1317.1	1441.6	2758.7	3.2077	2.5373
9000	303.35	0.001418	0.020489	1350.9	1207.6	2558.5	1363.7	1379.3	2742.9	3.2866	2.3925
10,000	311.00	0.001452	0.018028	1393.3	1151.8	2545.2	1407.8	1317.6	2725.5	3.3603	2.2556
11,000	318.08	0.001488	0.015988	1433.9	1096.6	2530.4	1450.2	1256.1	2706.3	3.4299	2.1245
12,000	324.68	0.001526	0.014264	1473.0	1041.3	2514.3	1491.3	1194.1	2685.4	3.4964	1.9975
13,000	330.85	0.001566	0.012781	1511.0	985.5	2496.6	1531.4	1131.3	2662.7	3.5606	1.8730
14,000	336.67	0.001610	0.011487	1548.4	928.7	2477.1	1571.0	1067.0	2637.9	3.6232	1.7497
15,000	342.16	0.001657	0.010341	1585.5	870.3	2455.7	1610.3	1000.5	2610.8	3.6848	1.6261
16,000	347.36	0.001710	0.009312	1622.6	809.4	2432.0	1649.9	931.1	2581.0	3.7461	1.5005
17,000	352.29	0.001770	0.008374	1660.2	745.1	2405.4	1690.3	857.4	2547.7	3.8082	1.3709
18,000	356.99	0.001840	0.007504	1699.1	675.9	2375.0	1732.2	777.8	2510.0	3.8720	1.2343
19,000	361.47	0.001926	0.006677	1740.3	598.9	2339.2	1776.8	689.2	2466.0	3.9396	1.0860
20,000	365.75	0.002038	0.005862	1785.8	509.0	2294.8	1826.6	585.5	2412.1	4.0146	0.9164
21,000	369.83	0.002207	0.004994	1841.6	391.9	2233.5	1888.0	450.4	2338.4	4.1071	0.7005
22,000	373.71	0.002703	0.003644	1951.7	140.8	2092.4	2011.1	161.5	2172.6	4.2942	0.2496
22,064	373.95	0.003106	0.003106	2015.7	0	2015.7	2084.3	0	2084.3	4.4070	0
22,064	373.95	0.003106	0.003106	2015.7	0	2015.7	2084.3	0	2084.3	4.4070	0



TABLE A-6

Superheated water

T °C	v m <sup>3</sup> /kg	u kJ/kg	h kJ/kg	s kJ/kg·K	v m <sup>3</sup> /kg	u kJ/kg	h kJ/kg	s kJ/kg·K	v m <sup>3</sup> /kg	u kJ/kg	h kJ/kg	s kJ/kg·K
<b>P = 0.01 MPa (45.81°C)*</b>												
Sat.	14.670	2437.2	2583.9	8.1488	3.2403	2483.2	2645.2	7.5931	1.6941	2505.6	2675.0	7.3589
50	14.867	2443.3	2592.0	8.1741	3.4187	2511.5	2682.4	7.6953	1.6959	2506.2	2675.8	7.3611
100	17.196	2515.5	2687.5	8.4489	3.8897	2585.7	2780.2	7.9413	1.9367	2582.9	2776.6	7.6148
150	19.513	2587.9	2783.0	8.6893	4.3562	2660.0	2877.8	8.1592	2.1724	2658.2	2875.5	7.8356
200	21.826	2661.4	2879.6	8.9049	4.8206	2735.1	2976.2	8.3568	2.4062	2733.9	2974.5	8.0346
250	24.136	2736.1	2977.5	9.1015	5.2841	2811.6	3075.8	8.5387	2.6389	2810.7	3074.5	8.2172
300	26.446	2812.3	3076.7	9.2827	5.7138	2888.3	3176.3	8.7000	2.8715	2886.7	3174.8	8.3862
350	28.758	2895.3	3176.3	9.4406	6.0577	2959.3	3276.3	8.8537	3.1027	2958.3	3274.8	8.5452
400	31.063	2969.3	3280.0	9.6094	6.4047	3030.1	3376.3	9.0000	3.3555	3032.8	3376.3	8.6959
450	33.368	3043.3	3389.7	9.7688	6.7513	3100.6	3476.3	9.1500	3.6083	3105.6	3476.3	8.8462
500	35.680	3117.3	3499.7	9.9282	7.1022	3170.6	3576.3	9.3000	3.8611	3180.6	3576.3	8.9965
550	37.996	3191.3	3609.7	10.0876	7.4531	3240.6	3676.3	9.4500	4.1139	3245.6	3676.3	9.1468
600	40.296	3265.3	3719.7	10.2470	7.8040	3310.6	3776.3	9.6000	4.3667	3315.6	3776.3	9.2970
650	42.596	3339.3	3829.7	10.4114	8.1549	3380.6	3876.3	9.7500	4.6195	3385.6	3876.3	9.4472
700	44.911	3413.3	3939.7	10.5758	8.5058	3450.6	3976.3	9.9000	4.8723	3455.6	3976.3	9.5974
750	47.226	3487.3	4049.7	10.7402	8.8567	3520.6	4076.3	10.0500	5.1251	3525.6	4076.3	9.7476
800	49.542	3561.3	4159.7	10.9046	9.2076	3590.6	4176.3	10.2000	5.3779	3595.6	4176.3	9.8978
850	51.857	3635.3	4269.7	11.0690	9.5591	3660.6	4276.3	10.3500	5.6307	3665.6	4276.3	10.0480
900	54.173	3709.3	4379.7	11.2334	9.9106	3730.6	4376.3	10.5000	5.8835	3735.6	4376.3	10.1982
950	56.488	3783.3	4489.7	11.3978	10.2621	3800.6	4476.3	10.6500	6.1363	3805.6	4476.3	10.3484
1000	58.804	3857.3	4599.7	11.5622	10.6136	3870.6	4576.3	10.8000	6.3891	3875.6	4576.3	10.4986
1050	61.119	3931.3	4709.7	11.7266	10.9651	3940.6	4676.3	10.9500	6.6419	3945.6	4676.3	10.6488
1100	63.435	4005.3	4819.7	11.8910	11.3166	4010.6	4776.3	11.1000	6.8947	4015.6	4776.3	10.7990
1150	65.750	4079.3	4929.7	12.0554	11.6681	4080.6	4876.3	11.2500	7.1475	4085.6	4876.3	10.9492
1200	68.066	4153.3	5039.7	12.2198	12.0196	4150.6	4976.3	11.4000	7.4003	4155.6	4976.3	11.0994
1250	70.381	4227.3	5149.7	12.3842	12.3711	4220.6	5076.3	11.5500	7.6531	4225.6	5076.3	11.2496
1300	72.697	4301.3	5259.7	12.5486	12.7226	4290.6	5176.3	11.7000	7.9059	4295.6	5176.3	11.3998
1350	75.012	4375.3	5369.7	12.7130	13.0741	4360.6	5276.3	11.8500	8.1587	4365.6	5276.3	11.5500
1400	77.327	4449.3	5479.7	12.8774	13.4256	4430.6	5376.3	12.0000	8.4115	4435.6	5376.3	11.7002
1450	79.642	4523.3	5589.7	13.0418	13.7771	4500.6	5476.3	12.1500	8.6643	4505.6	5476.3	11.8504
1500	81.957	4597.3	5699.7	13.2062	14.1286	4570.6	5576.3	12.3000	8.9171	4575.6	5576.3	11.9996
1550	84.272	4671.3	5809.7	13.3706	14.4801	4640.6	5676.3	12.4500	9.1699	4645.6	5676.3	12.1498
1600	86.587	4745.3	5919.7	13.5350	14.8316	4710.6	5776.3	12.6000	9.4227	4715.6	5776.3	12.2990
1650	88.902	4819.3	6029.7	13.6994	15.1831	4780.6	5876.3	12.7500	9.6755	4785.6	5876.3	12.4492
1700	91.217	4893.3	6139.7	13.8638	15.5346	4850.6	5976.3	12.9000	9.9283	4855.6	5976.3	12.5994
1750	93.532	4967.3	6249.7	14.0282	15.8861	4920.6	6076.3	13.0500	10.1811	4925.6	6076.3	12.7496
1800	95.847	5041.3	6359.7	14.1926	16.2376	4990.6	6176.3	13.2000	10.4339	4995.6	6176.3	12.8998
1850	98.162	5115.3	6469.7	14.3570	16.5891	5060.6	6276.3	13.3500	10.6867	5065.6	6276.3	13.0490
1900	100.477	5189.3	6579.7	14.5214	16.9406	5130.6	6376.3	13.5000	10.9395	5135.6	6376.3	13.1992
1950	102.792	5263.3	6689.7	14.6858	17.2921	5200.6	6476.3	13.6500	11.1923	5205.6	6476.3	13.3494
2000	105.107	5337.3	6799.7	14.8502	17.6436	5270.6	6576.3	13.8000	11.4451	5275.6	6576.3	13.4996
2050	107.422	5411.3	6909.7	15.0146	17.9951	5340.6	6676.3	13.9500	11.6979	5345.6	6676.3	13.6498
2100	109.737	5485.3	7019.7	15.1790	18.3466	5410.6	6776.3	14.1000	11.9507	5415.6	6776.3	13.7990
2150	112.052	5559.3	7129.7	15.3434	18.6981	5480.6	6876.3	14.2500	12.2035	5485.6	6876.3	13.9492
2200	114.367	5633.3	7239.7	15.5078	19.0496	5550.6	6976.3	14.4000	12.4563	5555.6	6976.3	14.0994
2250	116.682	5707.3	7349.7	15.6722	19.4011	5620.6	7076.3	14.5500	12.7091	5625.6	7076.3	14.2496
2300	118.997	5781.3	7459.7	15.8366	19.7526	5690.6	7176.3	14.7000	12.9619	5695.6	7176.3	14.3998
2350	121.312	5855.3	7569.7	16.0010	20.1041	5760.6	7276.3	14.8500	13.2147	5765.6	7276.3	14.5490
2400	123.627	5929.3	7679.7	16.1654	20.4556	5830.6	7376.3	15.0000	13.4675	5835.6	7376.3	14.6992
2450	125.942	6003.3	7789.7	16.3298	20.8071	5900.6	7476.3	15.1500	13.7203	5905.6	7476.3	14.8494
2500	128.257	6077.3	7899.7	16.4942	21.1586	5970.6	7576.3	15.3000	13.9731	5975.6	7576.3	14.9996
2550	130.572	6151.3	8009.7	16.6586	21.5101	6040.6	7676.3	15.4500	14.2259	6045.6	7676.3	15.1498
2600	132.887	6225.3	8119.7	16.8230	21.8616	6110.6	7776.3	15.6000	14.4787	6115.6	7776.3	15.2990
2650	135.202	6299.3	8229.7	16.9874	22.2131	6180.6	7876.3	15.7500	14.7315	6185.6	7876.3	15.4492
2700	137.517	6373.3	8339.7	17.1518	22.5646	6250.6	7976.3	15.9000	14.9843	6255.6	7976.3	15.5994
2750	139.832	6447.3	8449.7	17.3162	22.9161	6320.6	8076.3	16.0500	15.2371	6325.6	8076.3	15.7496
2800	142.147	6521.3	8559.7	17.4806	23.2676	6390.6	8176.3	16.2000	15.4899	6395.6	8176.3	15.8998
2850	144.462	6595.3	8669.7	17.6450	23.6191	6460.6	8276.3	16.3500	15.7427	6465.6	8276.3	16.0490
2900	146.777	6669.3	8779.7	17.8094	23.9706	6530.6	8376.3	16.5000	15.9955	6535.6	8376.3	16.1992
2950	149.092	6743.3	8889.7	17.9738	24.3221	6600.6	8476.3	16.6500	16.2483	6605.6	8476.3	16.3494
3000	151.407	6817.3	8999.7	18.1382	24.6736	6670.6	8576.3	16.8000	16.5011	6675.6	8576.3	16.4996
3050	153.722	6891.3	9109.7	18.3026	25.0251	6740.6	8676.3	16.9500	16.7539	6745.6	8676.3	16.6498
3100	156.037	6965.3	9219.7	18.4670	25.3766	6810.6	8776.3	17.1000	17.0067	6815.6	8776.3	16.7990
3150	158.352	7039.3	9329.7	18.6314	25.7281	6880.6	8876.3	17.2500	17.2595	6885.6	8876.3	16.9492
3200	160.667	7113.3	9439.7	18.7958	26.0796	6950.6	8976.3	17.4000	17.5123	6955.6	8976.3	17.0994
3250	162.982	7187.3	9549.7	18.9602	26.4311	7020.6	9076.3	17.5500	17.7651	7025.6	9076.3	17.2496
3300	165.297	7261.3	9659.7	19.1246	26.7826	7090.6	9176.3	17.7000	18.0179	7095.6	9176.3	17.3998
3350	167.612	7335.3	9769.7	19.2890	27.1341	7160.6	9276.3	17.8500	18.2707	7165.6	9276.3	17.5490
3400	169.927	7409.3	9879.7	19.4534	27.4856	7230.6	9376.3	18.0000	18.5235	7235.6	9376.3	17.6992
3450	172.242	7483.3	9989.7	19.6178	27.8371	7300.6	9476.3	18.1500	18.7763	7305.6	9476.3	17.8494
3500	174.557	7557.3	10099.7	19.7822	28.1886	7370.6	9576.3	18.3000	19.0291	7375.6	9576.3	17.9996
3550	176.872	7631.3	10209.7	19.9466	28.5401	7440.6	9676.3	18.4500	19.2819	7445.6	9676.3	18.1498
3600	179.187	7705.3	10319.7	20.1110	28.8916	7510.6	9776.3	18.6000	19.5347	7515.6	9776.3	18.2990
3650	181.502	7779.3	10429.7	20.2754	29.2431	7580.6	9876.3	18.7500	19.7875	7585.6	9876.3	18.4492
3700	183.817	7853.3	10539.7	20.4398	29.5946	7650.6	9976.3	18.9000	20.0403	7655.6	9976.3	18.5994
3750	186.132	7927.3	10649.7	20.6042	29.9461	7720.6	10076.3	19.0500	20.2931	7725.6	10076.3	18.7496
3800	188.447	8001.3	10759.7	20.7686	30.2976	7790.6	10176.3	19.2000	20.5459	7795.6	10176.3	18.8998
3850	190.762	8075.3	10869.7	20.9330	30.6491	7860.6	10276.3	19.3500	20.7987	7865.6	10276.3	19.0490
3900	193.077	8149.3	10979.7	21.0974	31.0006	7930.6	10376.3	19.5000	21.0515	7935.6	10376.3	19.1992
3950	195.392	8223.3	11089.7	21.2618	31.3521	8000.6	10476.3	19.6500	21.3043	8005.6		