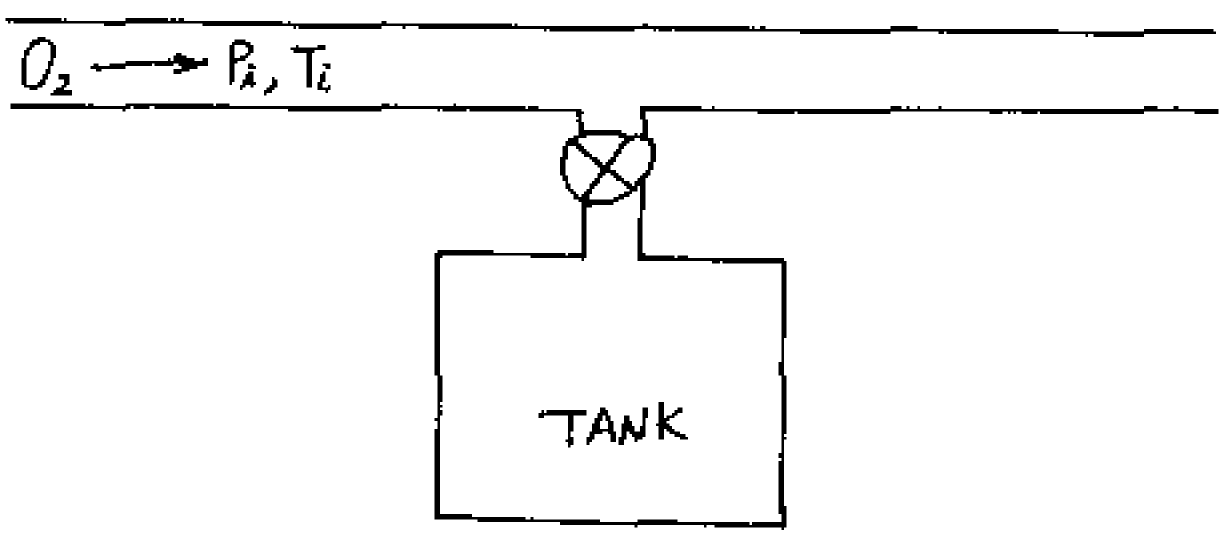
1. Two insulated tanks are connected by a valve. One tank initially contains m_1 kg of air at T_1, P_1, and the other contains m_2 kg of air at T_2, P_2. The valve is opened and the two quantities of air are allowed to mix until equilibrium is attained. Assuming the air at these conditions may be treated as an ideal gas with a constant volume specific heat of C_v. Determine

   (a) the final temperature
   (b) the final pressure
   (c) the amount of entropy produced (25%)

2. Oxygen at P_i and T_i is flowing in a pipe as shown. An evaculated tank is connected to this pipe through a valve. The valve is opened, tank fills with oxygen until the pressure is P_i, and then the valve is closed. The process takes place adiabatically. The changes in kinetic and potential energies may be neglected. Show that the final internal energy of the oxygen in the tank is equal to the enthalpy of oxygen flowing in the pipe.

(20%)



3. Consider a Rankine power cycle with superheat and reheat using steam as the working fluid. Steam enters the first-stage turbine at 8.0 MPa, 480 ℃ and expands to 0.7 MPa. It is then reheated to 440 ℃ before entering the second stage turbine, where it expands to the condenser pressure of 0.008 MPa. The net power out is 200 MW. Both turbines have an isentropic efficiency of 90%. Determine the cycle efficiency. (25%)

4. Considering a **reversible** engine operates between a high temperature heat source and low temperature heat sink. The mass, constant volume specific heat and initial temperature for the heat source are m_H, C_H and T_H, respectively. On the other hand, the mass, constant volume specific heat and initial temperature for the heat sink are m_L, C_L and T_L, respectively. During the process the volume of both heat source and heat sink remains unchanged and m_H, C_H, m_L and C_L may be treated as constants, while T_H and T_L are changing due to heat transfer with the engine until heat source and heat sink reach the same temperature, i.e., the equilibrium temperature, T_e.

(a) Determine the maximum work can be done by the engine throughout the process.

(b) Obtain an expression for T_e.

(30%)

TABLE A-3 Properties of Saturated Water (Liquid–Vapor): Pressure Table *Note: 1 bar = 0.1 MPa*

		Specific Volume m³/kg		Internal Energy kJ/kg		Enthalpy kJ/kg			Entropy kJ/kg · K		
Press. bars	Temp. °C	Sat. Liquid $v_f \times 10^3$	Sat. Vapor v_g	Sat. Liquid u_f	Sat. Vapor u_g	Sat. Liquid h_f	Evap. h_{fg}	Sat. Vapor h_g	Sat. Liquid s_f	Sat. Vapor s_g	Press. bars
0.04	28.96	1.0040	34.800	121.45	2415.2	121.46	2432.9	2554.4	0.4226	8.4746	0.04
0.06	36.16	1.0064	23.739	151.53	2425.0	151.53	2415.9	2567.4	0.5210	8.3304	0.06
0.08	41.51	1.0084	18.103	173.87	2432.2	173.88	2403.1	2577.0	0.5926	8.2287	0.08
0.10	45.81	1.0102	14.674	191.82	2437.9	191.83	2392.8	2584.7	0.6493	8.1502	0.10
0.20	60.06	1.0172	7.649	251.38	2456.7	251.40	2358.3	2609.7	0.8320	7.9085	0.20
0.30	69.10	1.0223	5.229	289.20	2468.4	289.23	2336.1	2625.3	0.9439	7.7686	0.30
0.40	75.87	1.0265	3.993	317.53	2477.0	317.58	2319.2	2636.8	1.0259	7.6700	0.40
0.50	81.33	1.0300	3.240	340.44	2483.9	340.49	2305.4	2645.9	1.0910	7.5939	0.50
0.60	85.94	1.0331	2.732	359.79	2489.6	359.86	2293.6	2653.5	1.1453	7.5320	0.60
0.70	89.95	1.0360	2.365	376.63	2494.5	376.70	2283.3	2660.0	1.1919	7.4797	0.70
0.80	93.50	1.0380	2.087	391.58	2498.8	391.66	2274.1	2665.8	1.2329	7.4346	0.80
0.90	96.71	1.0410	1.869	405.06	2502.6	405.15	2265.7	2670.9	1.2695	7.3949	0.90
1.00	99.63	1.0432	1.694	417.36	2506.1	417.46	2258.0	2675.5	1.3026	7.3594	1.00
1.50	111.4	1.0528	1.159	466.94	2519.7	467.11	2226.5	2693.6	1.4336	7.2233	1.50
2.00	120.2	1.0605	0.8857	504.49	2529.5	504.70	2201.9	2706.7	1.5301	7.1271	2.00
2.50	127.4	1.0672	0.7187	535.10	2537.2	535.37	2181.5	2716.9	1.6072	7.0527	2.50
3.00	133.6	1.0732	0.6058	561.15	2543.6	561.47	2163.8	2725.3	1.6718	6.9919	3.00
3.50	138.9	1.0786	0.5243	583.95	2546.9	584.33	2148.1	2732.4	1.7275	6.9405	3.50
4.00	143.6	1.0836	0.4625	604.31	2553.6	604.74	2133.8	2738.6	1.7766	6.8959	4.00
4.50	147.9	1.0882	0.4140	622.25	2557.6	623.25	2120.7	2743.9	1.8207	6.8565	4.50
5.00	151.9	1.0926	0.3749	639.68	2561.2	640.23	2108.5	2748.7	1.8607	6.8212	5.00
6.00	158.9	1.1006	0.3157	669.90	2567.4	670.56	2086.3	2756.8	1.9312	6.7600	6.00
7.00	165.0	1.1080	0.2729	696.44	2572.5	697.22	2066.3	2763.5	1.9922	6.7080	7.00
8.00	170.4	1.1148	0.2404	720.22	2576.8	721.11	2048.0	2769.1	2.0462	6.6628	8.00
9.00	175.4	1.1212	0.2150	741.83	2580.5	742.83	2031.1	2773.9	2.0946	6.6226	9.00
10.0	179.9	1.1273	0.1944	761.68	2583.6	762.81	2015.3	2778.1	2.1387	6.5863	10.0
15.0	198.3	1.1539	0.1318	843.16	2594.5	844.84	1947.3	2792.2	2.3150	6.4448	15.0
20.0	212.4	1.1767	0.09963	906.44	2600.3	908.79	1890.7	2799.5	2.4474	6.3409	20.0
25.0	224.0	1.1973	0.07998	959.11	2603.1	962.11	1841.0	2803.1	2.5547	6.2575	25.0
30.0	233.9	1.2165	0.06668	1004.8	2604.1	1008.4	1795.7	2804.2	2.6457	6.1869	30.0
35.0	242.6	1.2347	0.05707	1045.4	2603.7	1049.8	1753.7	2803.4	2.7253	6.1253	35.0
40.0	250.4	1.2522	0.04978	1082.3	2602.3	1087.3	1714.1	2801.4	2.7964	6.0701	40.0
45.0	257.5	1.2692	0.04406	1116.2	2600.1	1121.9	1676.4	2798.3	2.8610	6.0199	45.0
50.0	264.0	1.2859	0.03944	1147.8	2597.1	1154.2	1640.1	2794.3	2.9202	5.9734	50.0
60.0	275.6	1.3187	0.03244	1205.4	2589.7	1213.4	1571.0	2784.3	3.0267	5.8892	60.0
70.0	285.9	1.3513	0.02737	1257.6	2580.5	1267.0	1505.1	2772.1	3.1211	5.8133	70.0
80.0	295.1	1.3842	0.02352	1305.6	2569.8	1316.6	1441.3	2758.0	3.2068	5.7432	80.0
90.0	303.4	1.4178	0.02048	1350.5	2557.8	1363.3	1378.9	2742.1	3.2858	5.6772	90.0
100.	311.1	1.4524	0.01803	1393.0	2544.4	1407.6	1317.1	2724.7	3.3596	5.6141	100.
110.	318.2	1.4886	0.01599	1433.7	2529.8	1450.1	1255.5	2705.6	3.4295	5.5527	110.

八十七學年度 工程與系統科學系（所）＿＿＿＿組碩士班研究生入學考試

科目 工程熱力學 科號 4003 / 4012 共 4 頁第 4 頁 *請在試卷【答案卷】內作答

TABLE A-4 (Continued) Properties of superheated steam

p = 5.0 bars = 0.50 MPa (T_{sat} = 151.86°C)

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K
Sat.	0.3749	2561.2	2748.7	6.8213
180	0.4045	2609.7	2812.0	6.9656
200	0.4249	2642.9	2855.4	7.0592
240	0.4646	2707.6	2939.9	7.2307
280	0.5034	2771.2	3022.9	7.3865
320	0.5416	2834.7	3105.6	7.5308
360	0.5796	2898.7	3188.4	7.6660
400	0.6173	2963.2	3271.9	7.7938
440	0.6548	3028.6	3356.0	7.9152
500	0.7109	3128.4	3483.9	8.0873
600	0.8041	3299.6	3701.7	8.3522
700	0.8969	3477.5	3925.9	8.5952

p = 7.0 bars = 0.70 MPa (T_{sat} = 164.97°C)

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K
Sat.	0.2729	2572.5	2763.5	6.7080
180	0.2847	2599.8	2799.1	6.7880
200	0.2999	2634.8	2844.8	6.8865
240	0.3292	2701.8	2932.2	7.0641
280	0.3574	2766.9	3017.1	7.2233
320	0.3852	2831.3	3100.9	7.3697
360	0.4126	2895.8	3184.7	7.5063
400	0.4397	2960.9	3268.7	7.6350
440	0.4667	3026.6	3353.3	7.7571
500	0.5070	3126.8	3481.7	7.9299
600	0.5738	3298.5	3700.2	8.1956
700	0.6403	3476.6	3924.8	8.4391

p = 10.0 bars = 1.0 MPa (T_{sat} = 179.91°C)

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K
Sat.	0.1944	2583.6	2778.1	6.5865
200	0.2060	2621.9	2827.9	6.6940
240	0.2275	2692.9	2920.4	6.8817
280	0.2480	2760.2	3008.2	7.0465
320	0.2678	2826.1	3093.9	7.1962
360	0.2873	2891.6	3178.9	7.3349
400	0.3066	2957.3	3263.9	7.4651
440	0.3257	3023.6	3349.3	7.5883
500	0.3541	3124.4	3478.5	7.7622
540	0.3729	3192.6	3565.6	7.8720
600	0.4011	3296.8	3697.9	8.0290
640	0.4198	3367.4	3787.2	8.1290

p = 15.0 bars = 1.5 MPa (T_{sat} = 198.32°C)

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K
Sat.	0.1318	2594.5	2792.2	6.4448
200	0.1325	2598.1	2796.8	6.4546
240	0.1483	2676.9	2899.3	6.6628
280	0.1627	2748.6	2992.7	6.8381
320	0.1765	2817.1	3081.9	6.9938
360	0.1899	2884.4	3169.2	7.1363
400	0.2030	2951.3	3255.8	7.2690
440	0.2160	3018.5	3342.5	7.3940
500	0.2352	3120.3	3473.1	7.5698
540	0.2478	3189.1	3560.9	7.6805
600	0.2668	3293.9	3694.0	7.8385
640	0.2793	3364.8	3783.8	7.9391

p = 20.0 bars = 2.0 MPa (T_{sat} = 212.42°C)

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K
Sat.	0.0996	2600.3	2799.5	6.3409
240	0.1085	2659.6	2876.5	6.4952
280	0.1200	2736.4	2976.4	6.6828
320	0.1308	2807.9	3069.5	6.8452
360	0.1411	2877.0	3159.3	6.9917
400	0.1512	2945.2	3247.6	7.1271
440	0.1611	3013.4	3335.5	7.2540
500	0.1757	3116.2	3467.6	7.4317
540	0.1853	3185.6	3556.1	7.5434
600	0.1996	3290.9	3690.1	7.7024
640	0.2091	3362.2	3780.4	7.8035
700	0.2232	3470.9	3917.4	7.9487

p = 30.0 bars = 3.0 MPa (T_{sat} = 233.90°C)

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K
Sat.	0.0667	2604.1	2804.2	6.1869
240	0.0682	2619.7	2824.3	6.2265
280	0.0771	2709.9	2941.3	6.4462
320	0.0850	2788.4	3043.4	6.6245
360	0.0923	2861.7	3138.7	6.7801
400	0.0994	2932.8	3230.9	6.9212
440	0.1062	3002.9	3321.5	7.0520
500	0.1162	3108.0	3456.5	7.2338
540	0.1227	3178.4	3546.6	7.3474
600	0.1324	3285.0	3682.3	7.5085
640	0.1388	3357.0	3773.5	7.6106
700	0.1484	3466.5	3911.7	7.7571

p = 40 bars = 4.0 MPa (T_{sat} = 250.4°C)

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K
Sat.	0.04978	2602.3	2801.4	6.0701
280	0.05546	2680.0	2901.8	6.2568
320	0.06199	2767.4	3015.4	6.4553
360	0.06788	2845.7	3117.2	6.6215
400	0.07341	2919.9	3213.6	6.7690
440	0.07872	2992.2	3307.1	6.9041
500	0.08643	3099.5	3445.3	7.0901
540	0.09145	3171.1	3536.9	7.2056
600	0.09885	3279.1	3674.4	7.3688
640	0.1037	3351.8	3766.6	7.4720
700	0.1110	3462.1	3905.9	7.6198
740	0.1157	3536.6	3999.6	7.7141

p = 80 bars = 8.0 MPa (T_{sat} = 295.06°C)

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K
Sat.	0.02352	2569.8	2758.0	5.7432
320	0.02682	2662.7	2877.2	5.9489
360	0.03089	2772.7	3019.8	6.1819
400	0.03432	2863.8	3138.3	6.3634
440	0.03742	2946.7	3246.1	6.5190
480	0.04034	3025.7	3348.4	6.6586
520	0.04313	3102.7	3447.7	6.7871
560	0.04582	3178.7	3545.3	6.9072
600	0.04845	3254.4	3642.0	7.0206
640	0.05102	3330.1	3738.3	7.1283
700	0.05481	3443.9	3882.4	7.2812
740	0.05729	3520.4	3978.7	7.3782

p = 120 bars = 12.0 MPa (T_{sat} = 324.75°C)

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K
Sat.	0.01426	2513.7	2684.9	5.4924
360	0.01811	2678.4	2895.7	5.8361
400	0.02108	2798.3	3051.3	6.0747
440	0.02355	2896.1	3178.7	6.2586
480	0.02576	2984.4	3293.5	6.4154
520	0.02781	3068.0	3401.8	6.5555
560	0.02977	3149.0	3506.2	6.6840
600	0.03164	3228.7	3608.3	6.8037
640	0.03345	3307.5	3709.0	6.9164
700	0.03610	3425.2	3858.4	7.0749
740	0.03781	3503.7	3957.4	7.1746