國立成功大學 104 學年度碩士班招生考試試題

系所組別：機械工程學系甲組

考試科目：熱力學

考試日期：0211，節次：2

※ 考生請注意：本試題可使用計算機。 請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

1. For a fixed amount of an ideal gas going through a reversible, isothermal, compression process, which is required, **Heat addition** or **Heat rejection**? Why? (7%)

2. The data listed below are claimed for a heat engine operating between reservoirs at T_H (727°C) and T_L (127°C). The engine receives heat Q_H (300 kJ) from high energy reservoir. For each of the following cases, determine the cycle is **Possible** or **Impossible**. (18%)

   (a) W_{cycle} = 170 kJ; Q_L = 140 kJ

   (b) W_{cycle} = 180 kJ; Q_L = 120 kJ

   (c) W_{cycle} = 100 kJ; Q_L = 200 kJ

   (d) W_{cycle} = 200 kJ; Q_L = 100 kJ

   (e) W_{cycle} = 0 kJ; Q_L = 300 kJ

   (f) W_{cycle} = 300 kJ; Q_L = 0 kJ

3. A mass-and atmosphere-loaded piston/cylinder assembly contains 2 kg of water at 200 kPa, 20°C. A nozzle in a line to the cylinder is opened to enable a flow to the outside atmosphere at 100 kPa. The process continues until half the mass has flowed out. Assume there is no heat transfer and water temperature is constant. Find the exit velocity and total work done, and total entropy generation in the process.

   Properties: water at 20°C, v = 0.001002 m^3/kg, u = 83.94 kJ/kg, h = 83.94 kJ/kg, and s = 0.2966 kJ/kg-K (25%)

4. A supply line carries a gas at $T_1 = 200K$. A small fraction of the flow in line is diverted through an insulated throttling valve and exhausted to the surroundings at 1 *bar*. The temperature of the exhausted gas is measured as $T_2 = 180K$. Determine the pressure of the gas in the supply line in *bar* by using the equation of state expressed as

$$Z = 1 + \left(b - \frac{a}{T}\right)\frac{P}{RT}$$

and the heat capacity expressed as

$$c_p = 4.19\ (10 + 0.02T)\ J/(mole \cdot K)$$

where $a = 40000(K \cdot cm^3)/mole$, $b = 20\ cm^3/mole$ and T in K. (20%)

5. Consider the Joule ideal-gas cycle which consists of four internally reversible processes in series. The first process from state 1 to state 2 is an adiabatic process and the second process from state 2 to state 3 is an isobaric process, while the third process from state 3 to state 4 is an adiabatic process and the fourth process from state 4 returns to state 1 is an isobaric process. Assume that the specific heats and the specific heat ratio $k = c_p / c_v$ are constant. (a) Plote this cycle on a PV diagram. (b) Show that the efficiency of an engine performing this cycle is

$$\eta = 1 - \left(\frac{P_1}{P_2}\right)^{(k-1)/k}.$$ (15%)

6. Air enters the turbine of a gas turbine at 1200 *kPa*, 1220 *K*, and expands to 100 *kPa* in two stages. Between the stages, the air is reheated at a constant pressure of 350 *kPa* to 1220 *K*. The expansion through each turbine stage is isentropic. The air is modeled as an ideal gas, and so you can using the Table attached to determine (a) the work developed by each turbine stage and (b) the heat transfer for the reheat process in *kJ per kg* of air flow. (15%)

Ideal gas properties of air (for problem 6)

T(K), h and u(kJ/kg), s°(kJ/kg · K)

				when $\Delta s = 0$[1]						when $\Delta s = 0$	
T	h	u	s°	p_r	v_r	T	h	u	s°	p_r	v_r
750	767.29	551.99	2.64737	37.35	57.63	1300	1395.97	1022.82	3.27345	330.9	11.275
760	778.18	560.01	2.66176	39.27	55.54	1320	1419.76	1040.88	3.29160	352.5	10.747
770	789.11	568.07	2.67595	41.31	53.39	1340	1443.60	1058.94	3.30959	375.3	10.247
780	800.03	576.12	2.69013	43.35	51.64	1360	1467.49	1077.10	3.32724	399.1	9.780
790	810.99	584.21	2.70400	45.55	49.86	1380	1491.44	1095.26	3.34474	424.2	9.337
800	821.95	592.30	2.71787	47.75	48.08	1400	1515.42	1113.52	3.36200	450.5	8.919
820	843.98	608.59	2.74504	52.59	44.84	1420	1539.44	1131.77	3.37901	478.0	8.526
840	866.08	624.95	2.77170	57.60	41.85	1440	1563.51	1150.13	3.39586	506.9	8.153
860	888.27	641.40	2.79783	63.09	39.12	1460	1587.63	1168.49	3.41247	537.1	7.801
880	910.56	657.95	2.82344	68.98	36.61	1480	1611.79	1186.95	3.42892	568.8	7.468
900	932.93	674.58	2.84856	75.29	34.31	1500	1635.97	1205.41	3.44516	601.9	7.152
920	955.38	691.28	2.87324	82.05	32.18	1520	1660.23	1223.87	3.46120	636.5	6.854
940	977.92	708.08	2.89748	89.28	30.22	1540	1684.51	1242.43	3.47712	672.8	6.569
960	1000.55	725.02	2.92128	97.00	28.40	1560	1708.82	1260.99	3.49276	710.5	6.301
980	1023.25	741.98	2.94468	105.2	26.73	1580	1733.17	1279.65	3.50829	750.0	6.046
1000	1046.04	758.94	2.96770	114.0	25.17	1600	1757.57	1298.30	3.52364	791.2	5.804
1020	1068.89	776.10	2.99034	123.4	23.72	1620	1782.00	1316.96	3.53879	834.1	5.574
1040	1091.85	793.36	3.01260	133.3	22.39	1640	1806.46	1335.72	3.55381	878.9	5.355
1060	1114.86	810.62	3.03449	143.9	21.14	1660	1830.96	1354.48	3.56867	925.6	5.147
1080	1137.89	827.88	3.05608	155.2	19.98	1680	1855.50	1373.24	3.58335	974.2	4.949
1100	1161.07	845.33	3.07732	167.1	18.896	1700	1880.1	1392.7	3.5979	1025	4.761
1120	1184.28	862.79	3.09825	179.7	17.886	1750	1941.6	1439.8	3.6336	1161	4.328
1140	1207.57	880.35	3.11883	193.1	16.946	1800	2003.3	1487.2	3.6684	1310	3.944
1160	1230.92	897.91	3.13916	207.2	16.064	1850	2065.3	1534.9	3.7023	1475	3.601
1180	1254.34	915.57	3.15916	222.2	15.241	1900	2127.4	1582.6	3.7354	1655	3.295
1200	1277.79	933.33	3.17888	238.0	14.470	1950	2189.7	1630.6	3.7677	1852	3.022
1220	1301.31	951.09	3.19834	254.7	13.747	2000	2252.1	1678.7	3.7994	2068	2.776
1240	1324.93	968.95	3.21751	272.3	13.069	2050	2314.6	1726.8	3.8303	2303	2.555
1260	1348.55	986.90	3.23638	290.8	12.435	2100	2377.4	1775.3	3.8605	2559	2.356
1280	1372.24	1004.76	3.25510	310.4	11.835	2150	2440.3	1823.8	3.8901	2837	2.175
						2200	2503.2	1872.4	3.9191	3138	2.012
						2250	2566.4	1921.3	3.9474	3464	1.864