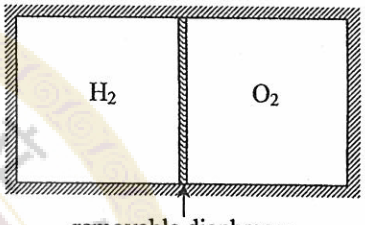
1. (25%) Assume that a gas obeys Van der Waal's equation of state,

$$\left(p+\frac{a}{v^2}\right)(v-b)=RT$$

where p is the pressure, R the gas constant, v the specific volume per mole, and a and b are positive constant peculiar to a given system.
Determine the following:
(a) Change in internal energy, u;
(b) Change in enthalpy, h;
(c) Change in entropy, s.
[Hint: To find the change of internal energy, u, it means that you need to find out du first and then integrate $\int_1^2 du$ from some state 1 to state 2 and find the change. Do similarly for the others.]

2. (25%) 1 kg of oxygen at pressure 1×10^5 Pa and temperature 450 K is mixed with 1 kg of hydrogen at the same temperature and pressure by removing the diaphragm as shown in the figure. Determine the loss in availability if the surrounding temperature is $T_0 = 300$ K. Assume that the system is fully isolated.
[Hint: The gas constant of oxygen is $R_{O_2} = 259.6$ J/kgK and the gas constant of hydrogen is $R_{H_2} = 4157$ J/kgK .]



3. (20%) Please explain the following terminology or statement with key descriptions. (2% each)
(1) Web-bulb temperature.
(2) The zeroth law of thermodynamics.
(3) The critical point of a pure substance.
(4) The compressibility factor of a real gas.
(5) The work done to accelerate a body of mass m from an initial velocity V_1 to a final velocity of V_2.
(6) Carnot efficiency.
(7) T-s diagram of the ideal Diesel cycle.
(8) P-v diagram of the Stirling cycle.
(9) Joule-Thomson coefficient.
(10) Helmholtz function and Gibbs function.

4. (12%) A rigid spherical tank with an inner diameter of 50cm is initially filled with steam at 1.0 MPa and 320°C. The steam is now cooled to 69.1°C.
(a) Determine the heat removed from the tank. (8%)
(b) Calculate the entropy change in the tank. (4%)

5. (10%) Steam flows steadily through an adiabatic turbine at a rate of 5kg/s. The steam enters the turbine with the inlet conditions of $P_1 = 6$ MPa, $T_1 = 500$°C, and $V_1 = 55$ m/s. The outlet conditions of the turbine are $P_2 = 10$ kPa, $x_2 = 90.4\%$, and $V_2 = 200$ m/s.
(a) Determine the turbine inlet area. (3%)
(b) Calculate the power delivered by the turbine. (7%)

6. (8%) The steam turbine in Problem 5 is replaced by a two-stage turbine with the same inlet and outlet conditions. However, the steam exited from the first stage turbine is reheated to $T = 500$°C in an isobaric process, and then enters the second stage turbine. Determine the pressure at which the stream should be reheated to meet the outlet conditions at the exit of the second stage turbine.

見背面

國立臺灣大學101學年度碩士班招生考試試題

Properties of Saturated Water (Liquid–Vapor): Pressure Table

Press. bars	Temp. °C	Specific Volume m³/kg: Sat. Liquid $v_f \times 10^3$	Specific Volume m³/kg: Sat. Vapor v_g	Internal Energy kJ/kg: Sat. Liquid u_f	Internal Energy kJ/kg: Sat. Vapor u_g	Enthalpy kJ/kg: Sat. Liquid h_f	Enthalpy kJ/kg: Evap. h_{fg}	Enthalpy kJ/kg: Sat. Vapor h_g	Entropy kJ/kg · K: Sat. Liquid s_f	Entropy kJ/kg · K: Sat. Vapor s_g	Press. bars
0.10	45.81	1.0102	14.674	191.82	2437.9	191.83	2392.8	2584.7	0.6493	8.1502	0.10
0.30	69.10	1.0223	5.229	289.20	2468.4	289.23	2336.1	2625.3	0.9439	7.7686	0.30
0.50	81.33	1.0300	3.240	340.44	2483.9	340.49	2305.4	2645.9	1.0910	7.5939	0.50
0.70	89.95	1.0360	2.365	376.63	2494.5	376.70	2283.3	2660.0	1.1919	7.4797	0.70
1.00	99.63	1.0432	1.694	417.36	2506.1	417.46	2258.0	2675.5	1.3026	7.3594	1.00
3.00	133.6	1.0732	0.6058	561.15	2543.6	561.47	2163.8	2725.3	1.6718	6.9919	3.00
5.00	151.9	1.0926	0.3749	639.68	2561.2	640.23	2108.5	2748.7	1.8607	6.8212	5.00
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
30.0	233.9	1.2165	0.06668	1004.8	2604.1	1008.4	1795.7	2804.2	2.6457	6.1869	30.0
40.0	250.4	1.2522	0.04978	1082.3	2602.3	1087.3	1714.1	2801.4	2.7964	6.0701	40.0

Properties of Superheated Water Vapor

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg · K
	p = 0.70 bar = 0.07 MPa (T_{sat} = 89.95°C)			
Sat.	2.365	2494.5	2660.0	7.4797
100	2.434	2509.7	2680.0	7.5341
120	2.571	2539.7	2719.6	7.6375
160	2.841	2599.4	2798.2	7.8279
200	3.108	2659.1	2876.7	8.0012
240	3.374	2719.3	2955.5	8.1611
280	3.640	2780.2	3035.0	8.3162
320	3.905	2842.0	3115.3	8.4504
360	4.170	2904.6	3196.5	8.5828
400	4.434	2968.2	3278.6	8.7086
440	4.698	3032.9	3361.8	8.8286
500	5.095	3131.8	3488.5	8.9991

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg · K
	p = 1.0 bar = 0.10 MPa (T_{sat} = 99.63°C)			
Sat.	1.694	2506.1	2675.5	7.3594
100	1.696	2506.7	2676.2	7.3614
120	1.793	2537.3	2716.6	7.4668
160	1.984	2597.8	2796.2	7.6597
200	2.172	2658.1	2875.3	7.8343
240	2.359	2718.5	2954.5	7.9949
280	2.546	2779.6	3034.2	8.1445
320	2.732	2841.5	3114.6	8.2849
360	2.917	2904.2	3195.9	8.4175
400	3.103	2967.9	3278.2	8.5435
440	3.288	3032.6	3361.4	8.6636
500	3.565	3131.6	3488.1	8.8342

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg · K
	p = 1.5 bars = 0.15 MPa (T_{sat} = 111.37°C)			
Sat.	1.159	2519.7	2693.6	7.2233
120	1.188	2533.3	2711.4	7.2693
160	1.317	2595.2	2792.8	7.4665
200	1.444	2656.2	2872.9	7.6433
240	1.570	2717.2	2952.7	7.8052
280	1.695	2778.6	3032.8	7.9555
320	1.819	2840.6	3113.5	8.0964
360	1.943	2903.5	3195.0	8.2293
400	2.067	2967.3	3277.4	8.3555
440	2.191	3032.1	3360.7	8.4757
500	2.376	3131.2	3487.6	8.6466
600	2.685	3301.7	3704.3	8.9101

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg · K
	p = 3.0 bars = 0.30 MPa (T_{sat} = 133.55°C)			
Sat.	0.606	2543.6	2725.3	6.9919
120				
160	0.651	2587.1	2782.3	7.1276
200	0.716	2650.7	2865.5	7.3115
240	0.781	2713.1	2947.3	7.4774
280	0.844	2775.4	3028.6	7.6299
320	0.907	2838.1	3110.1	7.7722
360	0.969	2901.4	3192.2	7.9061
400	1.032	2965.6	3275.0	8.0330
440	1.094	3030.6	3358.7	8.1538
500	1.187	3130.0	3486.0	8.3251
600	1.341	3300.8	3703.2	8.5892

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg · K
	p = 5.0 bars = 0.50 MPa (T_{sat} = 151.86°C)			
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

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg · K
	p = 10.0 bars = 1.0 MPa (T_{sat} = 179.91°C)			
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

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg · K
	p = 20.0 bars = 2.0 MPa (T_{sat} = 212.42°C)			
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

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg · K
	p = 40 bars = 4.0 MPa (T_{sat} = 250.4°C)			
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

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg · K
	p = 60 bars = 6.0 MPa (T_{sat} = 275.64°C)			
Sat.	0.03244	2589.7	2784.3	5.8892
280	0.03317	2605.2	2804.2	5.9252
320	0.03876	2720.0	2952.6	6.1846
360	0.04331	2811.2	3071.1	6.3782
400	0.04739	2892.9	3177.2	6.5408
440	0.05122	2970.0	3277.3	6.6853
500	0.05665	3082.2	3422.2	6.8803
540	0.06015	3156.1	3517.0	6.9999
600	0.06525	3266.9	3658.4	7.1677
640	0.06859	3341.0	3752.6	7.2731
700	0.07352	3453.1	3894.1	7.4234
740	0.07677	3528.3	3989.2	7.5190

試題隨卷繳回