

# 國立清華大學 100 學年度碩士班入學考試試題

系所班組別：工程與系統科學系乙組

考試科目（代碼）：熱力學(2902)

共 8 頁，第 1 頁 \*請在【答案卷、卡】作答

## 1. Explain

- (a) What is the closed system (2%)
- (b) What is the isolated system (4%)
- (c) What is the isothermal process (2%)
- (d) What is isochoric process (2%)
- (e) What is the adiabatic process (2%)
- (f) What is the isentropic process (4%)
- (g) Write down the polytropic equation with function of  $(P, V, k)$  (4%), where  $k=C_p/C_v$ ,  $C_p$  is the heat capacity at constant pressure,  $C_v$  is the heat capacity at constant volume.

## 2. Explain:

- (a) Intensive properties and give two examples (4%)
- (b) Extensive properties and give two examples (4%)
- (c) Based on (a) and (b), for which one do you think that can be directly measured from instrument (2%)
- (d) From thermal dynamic view, why do you think the food is much delicious made by using pressure cooker (壓力鍋) (2%) and sketch the process line from initial state to final state on T-V diagram on fig. 1, (Please point out the initial state point and final state point) (4%)
- (e) Please sketch the process line on the fig.2, when cooking the food from subcooled liquid to saturated two phase mixture with the lid of the pan is opened (Please point out the initial state point and final state point) (4%).

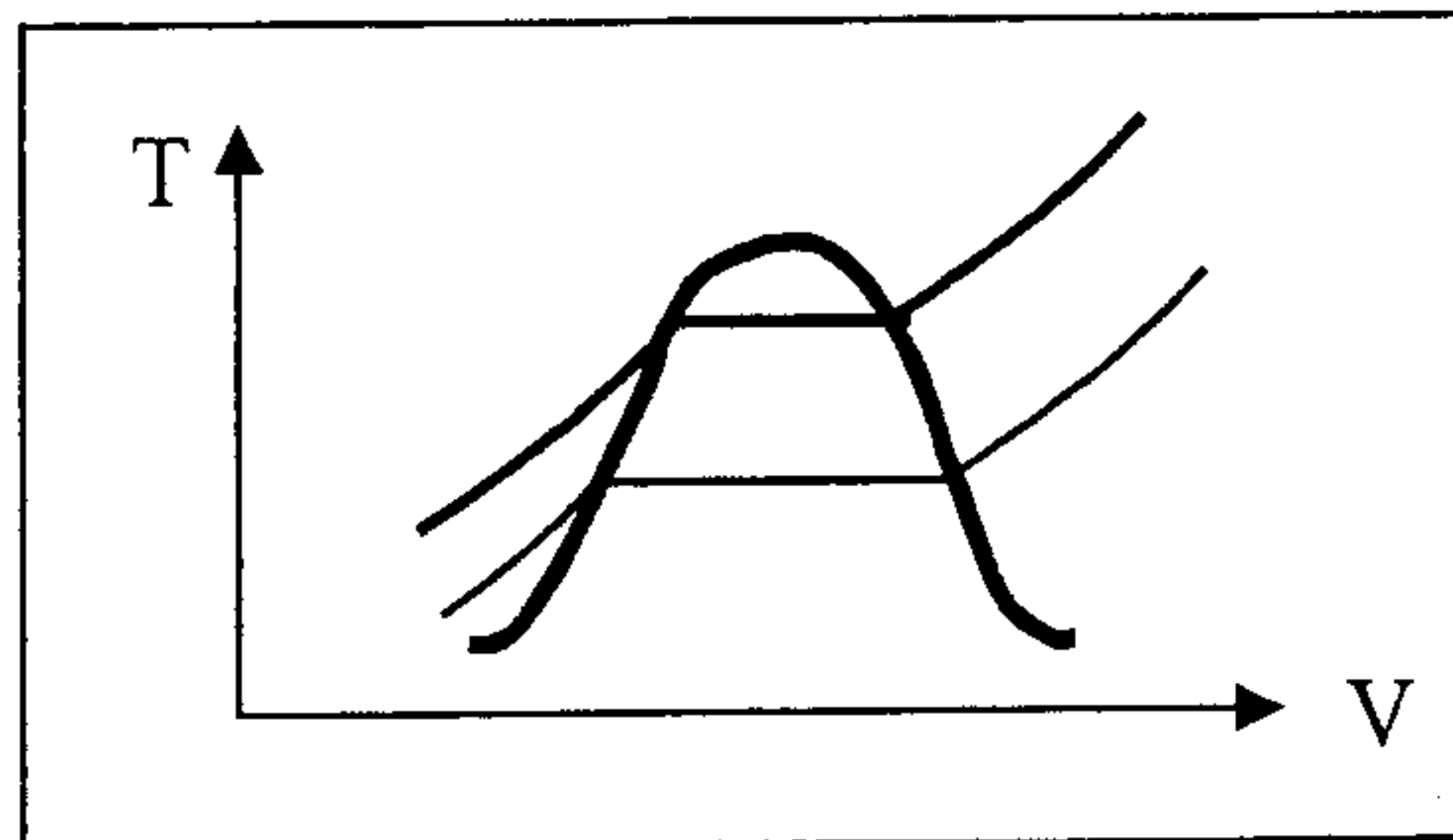


Fig. 1

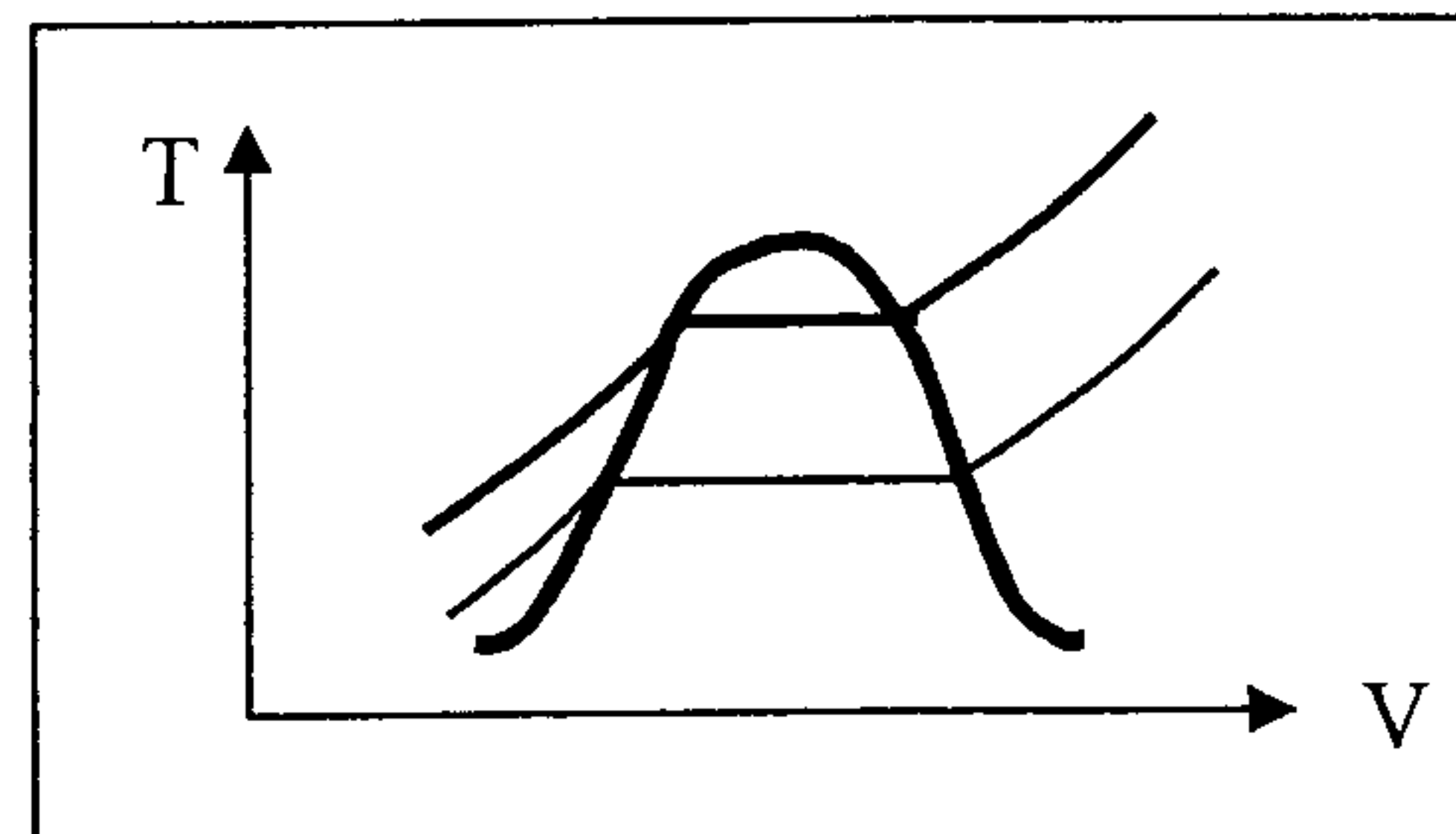


Fig. 2

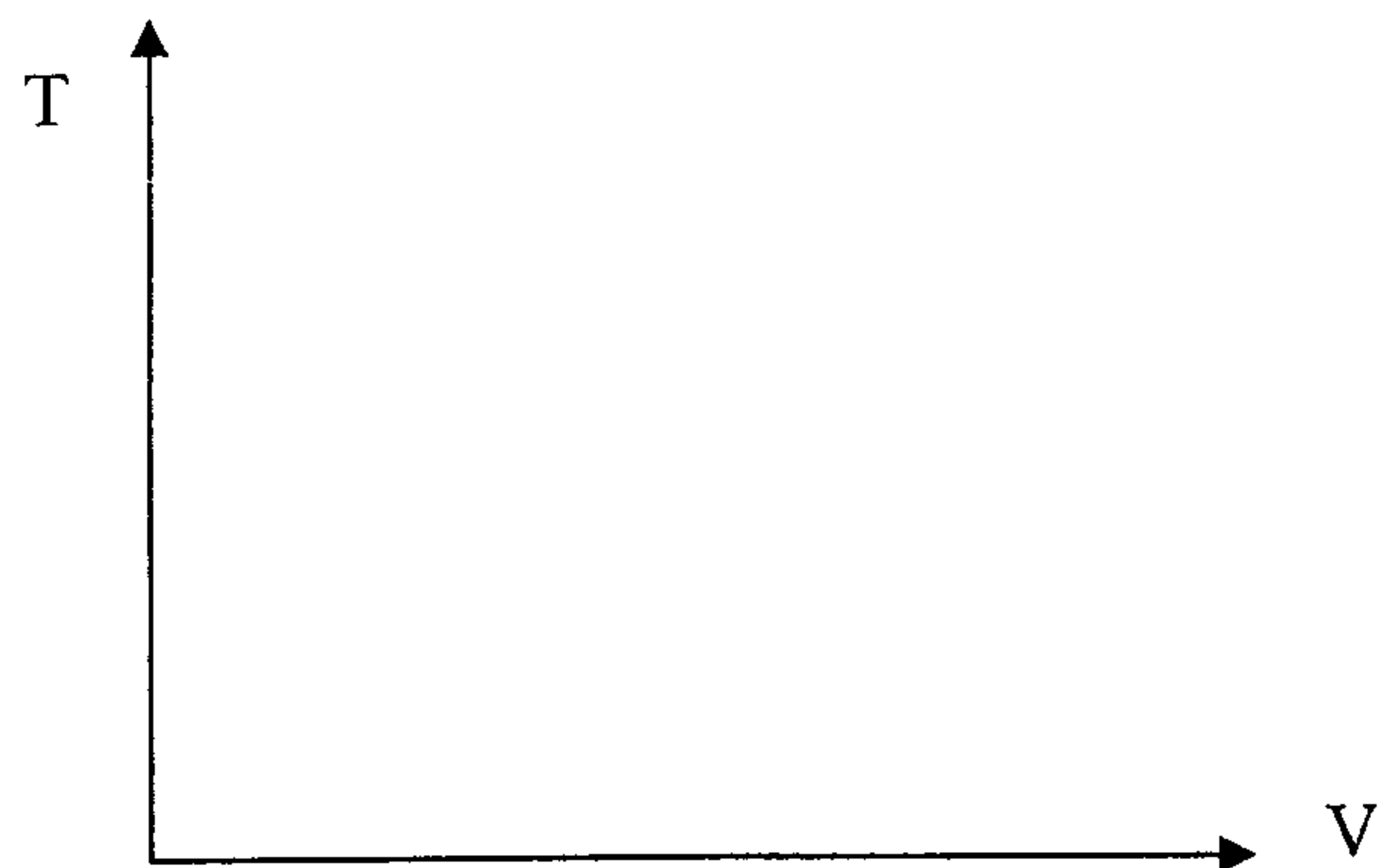
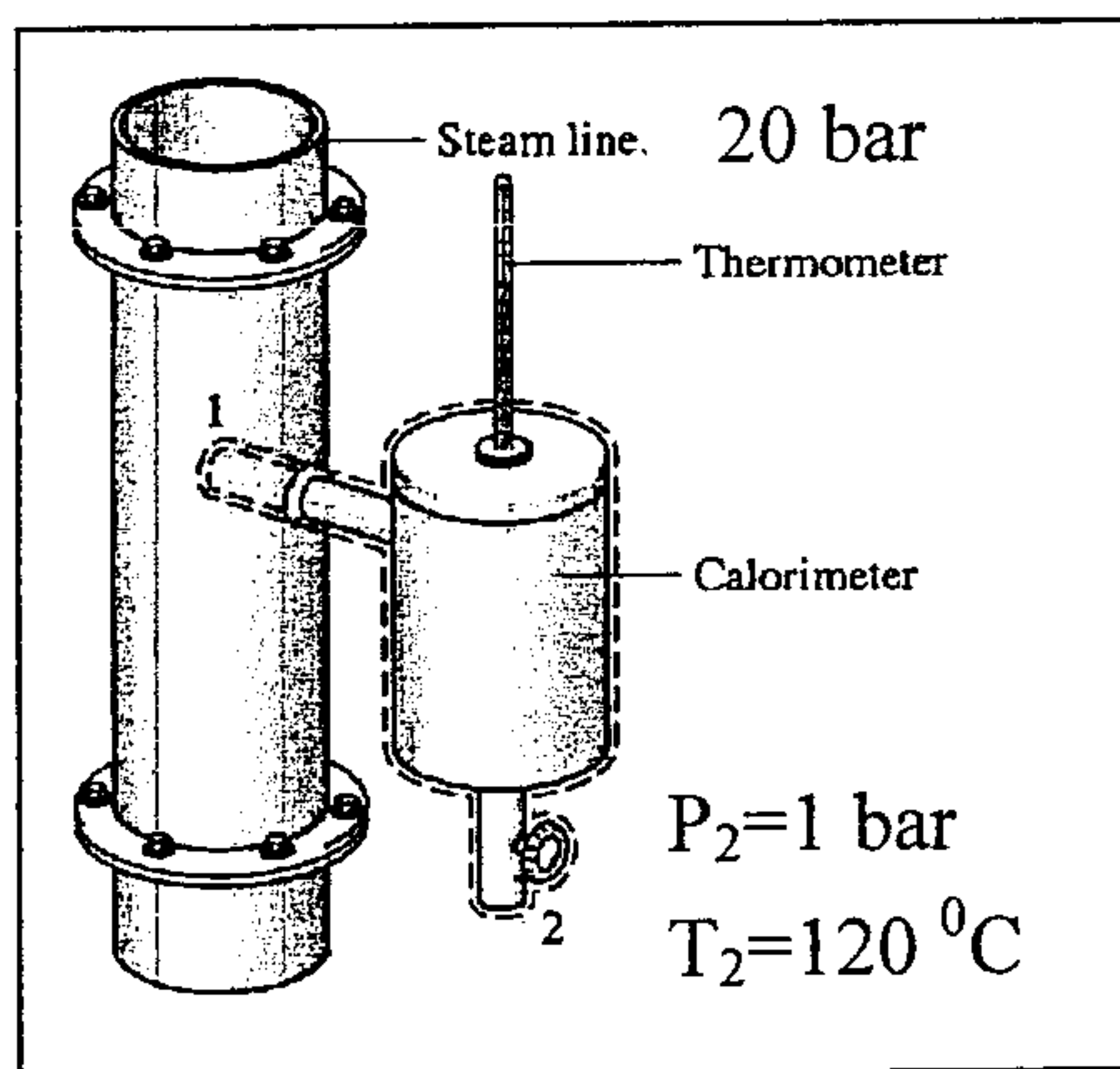
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共 8 頁，第 2 頁 \*請在【答案卷、卡】作答

3. A supply line carries a two-phase liquid-vapor mixture of steam at 20 bar (state 1). A small fraction of the flow in the line is diverted through a throttling calorimeter and exhausted to the atmosphere at 1 bar (state 2). The temperature of the exhaust steam is measured as 120°C. **【Attached A】** is the steam table
- Determine the temperature at state 1 in (°C) (2%)
  - Determine the enthalpy of the state 1 (4%) and state 2 in (KJ/Kg)(2%).
  - What is the state of the state 2? (subcooled, saturated or superheated) (2%)
  - Determine of the quality of the steam in the supply line (4%).
  - Draw the T-V diagram from the state 1 to state 2, and mark (T<sub>1</sub>, P<sub>1</sub>) (T<sub>2</sub>, P<sub>2</sub>) (6%).



4. (a) The differential of pressure obtained from a certain equation of state is given as the following. Write down the equation of state. (10%)

$$dp = \left( \frac{R}{V-b} - \frac{a}{V^3} \right) dT + \left[ \frac{-RT}{(V-b)^2} + \frac{3aT}{V^4} \right] dV$$

- (b) According to the state of equation from problem (1), please prove internal energy change  $du$  is temperature function only. (10%)

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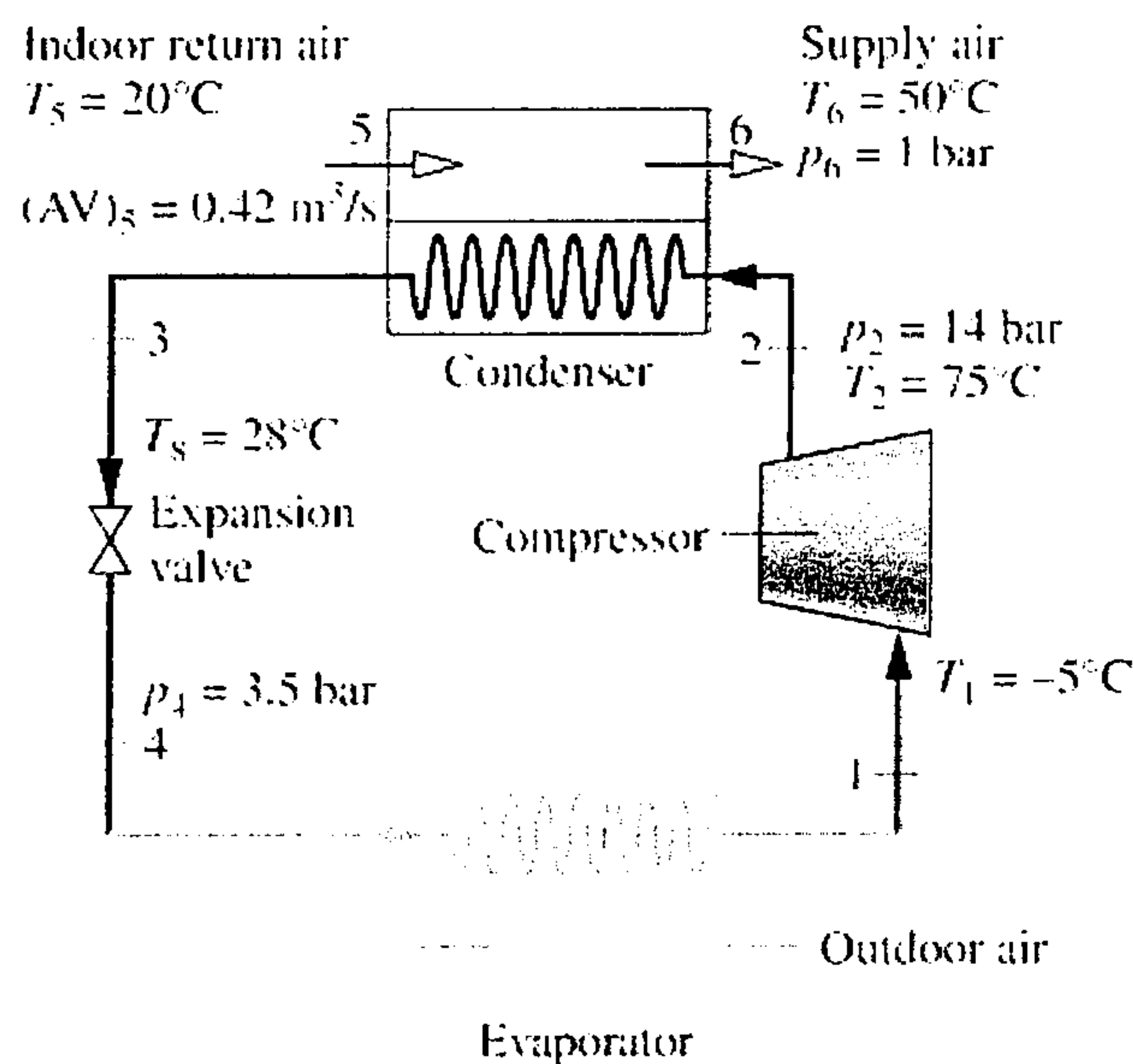
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共 8 頁，第 3 頁 \*請在【答案卷、卡】作答

5. Components of a heat pump for supplying heated air to a dwelling are shown in the schematic below. At steady state, **Refrigerant 22** enters the compressor at  $-5^{\circ}\text{C}$ , and is compressed adiabatically to  $75^{\circ}\text{C}$ , 14 bar. From the compressor, the refrigerant passes through the condenser, where it condenses to liquid at  $28^{\circ}\text{C}$ . Assume there is no friction loss on condenser or evaporator. The refrigerant expands through a throttling valve to 3.5 bar. Return air from the dwelling enters the condenser at  $20^{\circ}\text{C}$  with a volumetric flow rate of  $0.42\text{ m}^3/\text{s}$  and exits at  $50^{\circ}\text{C}$ , 1 bar with a negligible change in pressure. Using the ideal gas model for the air and neglecting kinetic and potential energy effects, (a) Determine  $s_1$ ,  $s_2$ , and  $s_3$  in (KJ/Kg,K) (3%),  $h_1$ ,  $h_2$ , and  $h_3$  in (KJ/Kg) (3%) (b) Determine  $T_4$  in ( $^{\circ}\text{C}$ ),  $h_4$  in (KJ/Kg),  $s_4$  in (KJ/Kg,K) and quality  $x_4$  (4%) (c) Determine air mass flowrate (1%) and Refrigerant 22 mass flowrate (1%) in (Kg/s) (d) Determine the actual power for compressor in (KJ/Kg) (2%), the isentropic temperature at state 2,  $T_{2s}$  in ( $^{\circ}\text{C}$ ) (2%), the isentropic compressor work  $W_{c,s}$  in (KJ/Kg) (2%) and the isentropic efficiency (2%).

$R=8.314\text{ KJ/Kmole,K}$ ,  $C_{p,\text{air}}=1.005\text{KJ/Kg,K}$ ,  $M_{\text{air}}=28.97\text{ Kg/Kmole}$ ,  $1\text{ bar}=10^5\text{ N/m}^2$ ,  $1\text{ KJ}=1000\text{N}\cdot\text{m}$ , **【Attached B】 is the R22 table**





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**【Attached A】**

共 8 頁，第 4 頁

\*請在【答案卷、卡】作答

762 Tables in SI Units

TABLE A-3 Properties of Saturated Water (Liquid-Vapor): Pressure Table

H <sub>2</sub> O	Press. bar	Temp. °C	Specific Volume m <sup>3</sup> /kg		Internal Energy kJ/kg		Enthalpy kJ/kg			Entropy kJ/kg · K		Press. bar
			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 $s_g$	
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.	

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**【Attached A】**

共 8 頁，第 5 頁

\*請在【答案卷、卡】作答

764 Tables in SI Units

**TABLE A-4** Properties of Superheated Water Vapor

$T$ °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	
$p = 0.06 \text{ bar} = 0.006 \text{ MPa}$ ( $T_{\text{sat}} = 36.16^\circ\text{C}$ )					$p = 0.35 \text{ bar} = 0.035 \text{ MPa}$ ( $T_{\text{sat}} = 72.69^\circ\text{C}$ )				
H <sub>2</sub> O	Sat.	23.739	2425.0	2567.4	8.3304	4.526	2473.0	2631.4	7.7158
	80	27.132	2487.3	2650.1	8.5804	4.625	2483.7	2645.6	7.7564
	120	30.219	2544.7	2726.0	8.7840	5.163	2542.4	2723.1	7.9644
	160	33.302	2602.7	2802.5	8.9693	5.696	2601.2	2800.6	8.1519
	200	36.383	2661.4	2879.7	9.1398	6.228	2660.4	2878.4	8.3237
	240	39.462	2721.0	2957.8	9.2982	6.758	2720.3	2956.8	8.4828
	280	42.540	2781.5	3036.8	9.4464	7.287	2780.9	3036.0	8.6314
	320	45.618	2843.0	3116.7	9.5859	7.815	2842.5	3116.1	8.7712
	360	48.696	2905.5	3197.7	9.7180	8.344	2905.1	3197.1	8.9034
	400	51.774	2969.0	3279.6	9.8435	8.872	2968.6	3279.2	9.0291
	440	54.851	3033.5	3362.6	9.9633	9.400	3033.2	3362.2	9.1490
	500	59.467	3132.3	3489.1	10.1336	10.192	3132.1	3488.8	9.3194
$p = 0.70 \text{ bar} = 0.07 \text{ MPa}$ ( $T_{\text{sat}} = 89.95^\circ\text{C}$ )					$p = 1.0 \text{ bar} = 0.10 \text{ MPa}$ ( $T_{\text{sat}} = 99.63^\circ\text{C}$ )				
	Sat.	2.365	2494.5	2660.0	7.4797	1.694	2506.1	2675.5	7.3594
	100	2.434	2509.7	2680.0	7.5341	1.696	2506.7	2676.2	7.3614
	120	2.571	2539.7	2719.6	7.6375	1.793	2537.3	2716.6	7.4668
	160	2.841	2599.4	2798.2	7.8279	1.984	2597.8	2796.2	7.6597
	200	3.108	2659.1	2876.7	8.0012	2.172	2658.1	2875.3	7.8343
	240	3.374	2719.3	2955.5	8.1611	2.359	2718.5	2954.5	7.9949
	280	3.640	2780.2	3035.0	8.3162	2.546	2779.6	3034.2	8.1445
	320	3.905	2842.0	3115.3	8.4504	2.732	2841.5	3114.6	8.2849
	360	4.170	2904.6	3196.5	8.5828	2.917	2904.2	3195.9	8.4175
	400	4.434	2968.2	3278.6	8.7086	3.103	2967.9	3278.2	8.5435
	440	4.698	3032.9	3361.8	8.8286	3.288	3032.6	3361.4	8.6636
	500	5.095	3131.8	3488.5	8.9991	3.565	3131.6	3488.1	8.8342
$p = 1.5 \text{ bar} = 0.15 \text{ MPa}$ ( $T_{\text{sat}} = 111.37^\circ\text{C}$ )					$p = 3.0 \text{ bar} = 0.30 \text{ MPa}$ ( $T_{\text{sat}} = 133.55^\circ\text{C}$ )				
	Sat.	1.159	2519.7	2693.6	7.2233	0.606	2543.6	2725.3	6.9919
	120	1.188	2533.3	2711.4	7.2693	0.651	2587.1	2782.3	7.1276
	160	1.317	2595.2	2792.8	7.4665	0.716	2650.7	2865.5	7.3115
	200	1.444	2656.2	2872.9	7.6433	0.781	2713.1	2947.3	7.4774
	240	1.570	2717.2	2952.7	7.8052	0.844	2775.4	3028.6	7.6299
	280	1.695	2778.6	3032.8	7.9555	0.907	2838.1	3110.1	7.7722
	320	1.819	2840.6	3113.5	8.0964	0.969	2901.4	3192.2	7.9061
	360	1.943	2903.5	3195.0	8.2293	1.032	2965.6	3275.0	8.0330
	400	2.067	2967.3	3277.4	8.3555	1.094	3030.6	3358.7	8.1538
	440	2.191	3032.1	3360.7	8.4757	1.187	3130.0	3486.0	8.3251
	500	2.376	3131.2	3487.6	8.6466	1.341	3300.8	3703.2	8.5892
	600	2.685	3301.7	3704.3	8.9101				

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【Attached B】

共 8 頁，第 6 頁

\*請在【答案卷、卡】作答

770 Tables in SI Units

TABLE A-7 Properties of Saturated Refrigerant 22 (Liquid-Vapor): Temperature Table

Temp. °C	Press. bar	Specific Volume m <sup>3</sup> /kg		Internal Energy kJ/kg		Enthalpy kJ/kg			Entropy kJ/kg·K		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 $s_g$	
-60	0.3749	0.6833	0.5370	-21.57	203.67	-21.55	245.35	223.81	-0.0964	1.0547	-60
-50	0.6451	0.6966	0.3239	-10.89	207.70	-10.85	239.44	228.60	-0.0474	1.0256	-50
-45	0.8290	0.7037	0.2564	-5.50	209.70	-5.44	236.39	230.95	-0.0235	1.0126	-45
-40	1.0522	0.7109	0.2052	-0.07	211.68	0.00	233.27	233.27	0.0000	1.0005	-40
-36	1.2627	0.7169	0.1730	4.29	213.25	4.38	230.71	235.09	0.0186	0.9914	-36
-32	1.5049	0.7231	0.1468	8.68	214.80	8.79	228.10	236.89	0.0369	0.9828	-32
-30	1.6389	0.7262	0.1355	10.88	215.58	11.00	226.77	237.78	0.0460	0.9787	-30
-28	1.7819	0.7294	0.1252	13.09	216.34	13.22	225.43	238.66	0.0551	0.9746	-28
-26	1.9345	0.7327	0.1159	15.31	217.11	15.45	224.08	239.53	0.0641	0.9707	-26
-22	2.2698	0.7393	0.0997	19.76	218.62	19.92	221.32	241.24	0.0819	0.9631	-22
-20	2.4534	0.7427	0.0926	21.99	219.37	22.17	219.91	242.09	0.0908	0.9595	-20
-18	2.6482	0.7462	0.0861	24.23	220.11	24.43	218.49	242.92	0.0996	0.9559	-18
-16	2.8547	0.7497	0.0802	26.48	220.85	26.69	217.05	243.74	0.1084	0.9525	-16
-14	3.0733	0.7533	0.0748	28.73	221.58	28.97	215.59	244.56	0.1171	0.9490	-14
-12	3.3044	0.7569	0.0698	31.00	222.30	31.25	214.11	245.36	0.1258	0.9457	-12
-10	3.5485	0.7606	0.0652	33.27	223.02	33.54	212.62	246.15	0.1345	0.9424	-10
-8	3.8062	0.7644	0.0610	35.54	223.73	35.83	211.10	246.93	0.1431	0.9392	-8
-6	4.0777	0.7683	0.0571	37.83	224.43	38.14	209.56	247.70	0.1517	0.9361	-6
-4	4.3638	0.7722	0.0535	40.12	225.13	40.46	208.00	248.45	0.1602	0.9330	-4
-2	4.6647	0.7762	0.0501	42.42	225.82	42.78	206.41	249.20	0.1688	0.9300	-2
0	4.9811	0.7803	0.0470	44.73	226.50	45.12	204.81	249.92	0.1773	0.9271	0
2	5.3133	0.7844	0.0442	47.04	227.17	47.46	203.18	250.64	0.1857	0.9241	2
4	5.6619	0.7887	0.0415	49.37	227.83	49.82	201.52	251.34	0.1941	0.9213	4
6	6.0275	0.7930	0.0391	51.71	228.48	52.18	199.84	252.03	0.2025	0.9184	6
8	6.4105	0.7974	0.0368	54.05	229.13	54.56	198.14	252.70	0.2109	0.9157	8
10	6.8113	0.8020	0.0346	56.40	229.76	56.95	196.40	253.35	0.2193	0.9129	10
12	7.2307	0.8066	0.0326	58.77	230.38	59.35	194.64	253.99	0.2276	0.9102	12
16	8.1268	0.8162	0.0291	63.53	231.59	64.19	191.02	255.21	0.2442	0.9048	16
20	9.1030	0.8263	0.0259	68.33	232.76	69.09	187.28	256.37	0.2607	0.8996	20
24	10.164	0.8369	0.0232	73.19	233.87	74.04	183.40	257.44	0.2772	0.8944	24
28	11.313	0.8480	0.0208	78.09	234.92	79.05	179.37	258.43	0.2936	0.8893	28
32	12.556	0.8599	0.0186	83.06	235.91	84.14	175.18	259.32	0.3101	0.8842	32
36	13.897	0.8724	0.0168	88.08	236.83	89.29	170.82	260.11	0.3265	0.8790	36
40	15.341	0.8858	0.0151	93.18	237.66	94.53	166.25	260.79	0.3429	0.8738	40
45	17.298	0.9039	0.0132	99.65	238.59	101.21	160.24	261.46	0.3635	0.8672	45
50	19.433	0.9238	0.0116	106.26	239.34	108.06	153.84	261.90	0.3842	0.8603	50
60	24.281	0.9705	0.0089	120.00	240.24	122.35	139.61	261.96	0.4264	0.8455	60

Source: Tables A-7 through A-9 are calculated based on equations from A. Kamei and S. W. Beyerlein, "A Fundamental Equation for Chlorodifluoromethane (R-22)," *Fluid Phase Equilibria*, Vol. 80, No. 11, 1992, pp. 71-86.



# 國立清華大學 100 學年度碩士班入學考試試題

系所班組別：工程與系統科學系乙組

考試科目（代碼）：熱力學(2902)

**【Attached B】** 共 8 頁，第 7 頁 \*請在【答案卷、卡】作答

Tables in SI Units 773

TABLE A-9 (Continued)

$T$ °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
$p = 2.5 \text{ bar} = 0.25 \text{ MPa}$ ( $T_{\text{sat}} = -19.51^\circ\text{C}$ )								
Sat.	0.09097	219.55	242.29	0.9586	0.07651	221.34	244.29	0.9502
-15	0.09303	222.03	245.29	0.9703				
-10	0.09528	224.79	248.61	0.9831	0.07833	223.96	247.46	0.9623
-5	0.09751	227.55	251.93	0.9956	0.08025	226.78	250.86	0.9751
0	0.09971	230.33	255.26	1.0078	0.08214	229.61	254.25	0.9876
5	0.10189	233.12	258.59	1.0199	0.08400	232.44	257.64	0.9999
10	0.10405	235.92	261.93	1.0318	0.08585	235.28	261.04	1.0120
15	0.10619	238.74	265.29	1.0436	0.08767	238.14	264.44	1.0239
20	0.10831	241.58	268.66	1.0552	0.08949	241.01	267.85	1.0357
25	0.11043	244.44	272.04	1.0666	0.09128	243.89	271.28	1.0472
30	0.11253	247.31	275.44	1.0779	0.09307	246.80	274.72	1.0587
35	0.11461	250.21	278.86	1.0891	0.09484	249.72	278.17	1.0700
40	0.11669	253.13	282.30	1.1002	0.09660	252.66	281.64	1.0811
$p = 3.0 \text{ bar} = 0.30 \text{ MPa}$ ( $T_{\text{sat}} = -14.66^\circ\text{C}$ )								
$p = 3.5 \text{ bar} = 0.35 \text{ MPa}$ ( $T_{\text{sat}} = -10.39^\circ\text{C}$ )								
Sat.	0.06605	222.88	246.00	0.9431	0.05812	224.24	247.48	0.9370
-10	0.06619	223.10	246.27	0.9441				
-5	0.06789	225.99	249.75	0.9572	0.05860	225.16	248.60	0.9411
0	0.06956	228.86	253.21	0.9700	0.06011	228.09	252.14	0.9542
5	0.07121	231.74	256.67	0.9825	0.06160	231.02	255.66	0.9670
10	0.07284	234.63	260.12	0.9948	0.06306	233.95	259.18	0.9795
15	0.07444	237.52	263.57	1.0069	0.06450	236.89	262.69	0.9918
20	0.07603	240.42	267.03	1.0188	0.06592	239.83	266.19	1.0039
25	0.07760	243.34	270.50	1.0305	0.06733	242.77	269.71	1.0158
30	0.07916	246.27	273.97	1.0421	0.06872	245.73	273.22	1.0274
35	0.08070	249.22	277.46	1.0535	0.07010	248.71	276.75	1.0390
40	0.08224	252.18	280.97	1.0648	0.07146	251.70	280.28	1.0504
45	0.08376	255.17	284.48	1.0759	0.07282	254.70	283.83	1.0616
$p = 4.0 \text{ bar} = 0.40 \text{ MPa}$ ( $T_{\text{sat}} = -6.56^\circ\text{C}$ )								
$p = 4.5 \text{ bar} = 0.45 \text{ MPa}$ ( $T_{\text{sat}} = -3.08^\circ\text{C}$ )								
Sat.	0.05189	225.45	248.80	0.9316	0.04686	226.54	249.97	0.9269
0	0.05275	227.29	251.03	0.9399				
5	0.05411	230.28	254.63	0.9529	0.04810	229.52	253.57	0.9399
10	0.05545	233.26	258.21	0.9657	0.04934	232.55	257.22	0.9530
15	0.05676	236.24	261.78	0.9782	0.05056	235.57	260.85	0.9657
20	0.05805	239.22	265.34	0.9904	0.05175	238.59	264.47	0.9781
25	0.05933	242.20	268.90	1.0025	0.05293	241.61	268.07	0.9903
30	0.06059	245.19	272.46	1.0143	0.05409	244.63	271.68	1.0023
35	0.06184	248.19	276.02	1.0259	0.05523	247.66	275.28	1.0141
40	0.06308	251.20	279.59	1.0374	0.05636	250.70	278.89	1.0257
45	0.06430	254.23	283.17	1.0488	0.05748	253.76	282.50	1.0371
50	0.06552	257.28	286.76	1.0600	0.05859	256.82	286.12	1.0484
55	0.06672	260.34	290.36	1.0710	0.05969	259.90	289.75	1.0595
$p = 5.0 \text{ bar} = 0.50 \text{ MPa}$ ( $T_{\text{sat}} = 0.12^\circ\text{C}$ )								

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# 國立清華大學 100 學年度碩士班入學考試試題

系所班組別：工程與系統科學系乙組

考試科目（代碼）：熱力學(2902)

**【Attached B】** 共 8 頁，第 8 頁 \*請在【答案卷、卡】作答

TABLE A-9 (Continued)

$T$ °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
$p = 12.0 \text{ bar} = 1.20 \text{ MPa}$ ( $T_{\text{sat}} = 30.25^\circ\text{C}$ )								
Sat.	0.01955	235.48	258.94	0.8864	0.01662	236.89	260.16	0.8786
40	0.02083	242.63	267.62	0.9146	0.01708	239.78	263.70	0.8900
50	0.02204	249.69	276.14	0.9413	0.01823	247.29	272.81	0.9186
60	0.02319	256.60	284.43	0.9666	0.01929	254.52	281.53	0.9452
70	0.02428	263.44	292.58	0.9907	0.02029	261.60	290.01	0.9703
80	0.02534	270.25	300.66	1.0139	0.02125	268.60	298.34	0.9942
90	0.02636	277.07	308.70	1.0363	0.02217	275.56	306.60	1.0172
100	0.02736	283.90	316.73	1.0582	0.02306	282.52	314.80	1.0395
110	0.02834	290.77	324.78	1.0794	0.02393	289.49	323.00	1.0612
120	0.02930	297.69	332.85	1.1002	0.02478	296.50	331.19	1.0823
130	0.03024	304.65	340.95	1.1205	0.02562	303.55	339.41	1.1029
140	0.03118	311.68	349.09	1.1405	0.02644	310.64	347.65	1.1231
150	0.03210	318.77	357.29	1.1601	0.02725	317.79	355.94	1.1429
160	0.03301	325.92	365.54	1.1793	0.02805	324.99	364.26	1.1624
170	0.03392	333.14	373.84	1.1983	0.02884	332.26	372.64	1.1815
$p = 14.0 \text{ bar} = 1.40 \text{ MPa}$ ( $T_{\text{sat}} = 36.29^\circ\text{C}$ )								
$p = 16.0 \text{ bar} = 1.60 \text{ MPa}$ ( $T_{\text{sat}} = 41.73^\circ\text{C}$ )								
Sat.	0.01440	238.00	261.04	0.8715	0.01265	238.86	261.64	0.8649
50	0.01533	244.66	269.18	0.8971	0.01301	241.72	265.14	0.8758
60	0.01634	252.29	278.43	0.9252	0.01401	249.86	275.09	0.9061
70	0.01728	259.65	287.30	0.9515	0.01492	257.57	284.43	0.9337
80	0.01817	266.86	295.93	0.9762	0.01576	265.04	293.40	0.9595
90	0.01901	274.00	304.42	0.9999	0.01655	272.37	302.16	0.9839
100	0.01983	281.09	312.82	1.0228	0.01731	279.62	310.77	1.0073
110	0.02062	288.18	321.17	1.0448	0.01804	286.83	319.30	1.0299
120	0.02139	295.28	329.51	1.0663	0.01874	294.04	327.78	1.0517
130	0.02214	302.41	337.84	1.0872	0.01943	301.26	336.24	1.0730
140	0.02288	309.58	346.19	1.1077	0.02011	308.50	344.70	1.0937
150	0.02361	316.79	354.56	1.1277	0.02077	315.78	353.17	1.1139
160	0.02432	324.05	362.97	1.1473	0.02142	323.10	361.66	1.1338
170	0.02503	331.37	371.42	1.1666	0.02207	330.47	370.19	1.1532
$p = 18.0 \text{ bar} = 1.80 \text{ MPa}$ ( $T_{\text{sat}} = 46.69^\circ\text{C}$ )								
$p = 20.0 \text{ bar} = 2.00 \text{ MPa}$ ( $T_{\text{sat}} = 51.26^\circ\text{C}$ )								
Sat.	0.01124	239.51	261.98	0.8586	0.00907	240.22	261.99	0.8463
60	0.01212	247.20	271.43	0.8873	0.00913	240.78	262.68	0.8484
70	0.01300	255.35	281.36	0.9167	0.01006	250.30	274.43	0.8831
80	0.01381	263.12	290.74	0.9436	0.01085	258.89	284.93	0.9133
90	0.01457	270.67	299.80	0.9689	0.01156	267.01	294.75	0.9407
100	0.01528	278.09	308.65	0.9929	0.01222	274.85	304.18	0.9663
110	0.01596	285.44	317.37	1.0160	0.01284	282.53	313.35	0.9906
120	0.01663	292.76	326.01	1.0383	0.01343	290.11	322.35	1.0137
130	0.01727	300.08	334.61	1.0598	0.01400	297.64	331.25	1.0361
140	0.01789	307.40	343.19	1.0808	0.01456	305.14	340.08	1.0577
150	0.01850	314.75	351.76	1.1013	0.01509	312.64	348.87	1.0787
160	0.01910	322.14	360.34	1.1214	0.01562	320.16	357.64	1.0992
170	0.01969	329.56	368.95	1.1410	0.01613	327.70	366.41	1.1192
180	0.02027	337.03	377.58	1.1603	0.01663	335.27	375.20	1.1388
$p = 24.0 \text{ bar} = 2.4 \text{ MPa}$ ( $T_{\text{sat}} = 59.46^\circ\text{C}$ )								

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