KATHMANDU UNIVERSITY
End Semester Examination [C]
June 2018

Marks Scored:

Level : B.E.
Year : IV
Course : MEPP 403
Semester: I

Exam Roll No.
Time: 30 mins.
F.M. : 20

Registration No.:
Date : JUN 10 2018

SECTION "A"
[10 Q. × 1 = 10 marks]

Mark [√] for the most appropriate answer (s).

1. The relationship between COP heat pump and COP refrigerator for the same range of temperature operation is
   a) COP heat pump = COP refrigerator
   b) COP heat pump - COP refrigerator = 1
   c) COP heat pump = 2COP refrigerator
   d) COP heat pump + COP refrigerator =1

2. The cooling load temperature difference (CLTD) incorporate the effects of
   a) infiltration b) thermal storage c) ventilation d) internal loads

3. The outdoor air enters into the air-conditioning space through window cracks and through doors when opened is termed as .....
   a) leaks b) glazing c) infiltration d) penetration

4. The ratio of high temperature to low temperature for reversed Carnot refrigerator is 1.25. The COP be
   a) 2 b) 3 c) 4 d) 5

5. Vapor compression refrigeration system is used as heat pump to heat a room and also direct radiation electrical heater is used to heat similar room. For the same heating effect the former arrangement uses
   a) more electrical energy than the latter
   b) less electrical energy than the latter
   c) Same electrical energy as the latter
   d) more or less as it cannot be predicted

6. In a simple saturated vapor compression refrigeration cycle the following results were obtained. Heat rejected in condenser is 160 kJ/kg, compressor work is 32 kJ/kg. The COP refrigeration is
   a) 5 b) 4 c) 6 d) not possible to find with this data

7. Wet- bulb temperature of air whose relative humidity is 100% is
   a) greater than dry-bulb temperature
   b) equal to dry bulb temperature
   c) less than dry bulb temperature
   d) cannot be predicted

8. In summer air-conditioning system for hot and humid outdoor conditions, the required comfort conditions are obtained by employing
   a) Cooling with humidification
   b) Heating with dehumidification
   c) Cooling with dehumidification
   d) Heating with humidification

9. A good refrigerant for vapor compression cycle should have
   a) high thermal conductivity
   b) low latent heat
   c) high leak tendency
   d) high viscosity

10. When flash gas removal is used in a multistage compression, it
   a) eliminates the undesirable throttling of the vapor generated at the intermediate pressure
   b) increases the work to be done in high pressure compressor
   c) increases the size of the evaporator
   d) has no effect in the system

SECTION "B"

[10 Q. × 1 = 10 marks]

11. Room sensible heat factor is the ratio of .....
12. A ton of refrigeration is equivalent to .....kJ/s.
13. For saturated air wet bulb depression is .....
14. The cooling load temperature difference (CLTD) incorporates the effects of .....
15. The by-pass factor (BPF) of the coil ..... as the number of rows in the flow direction increase.
16. The refrigerant usually used in aero plane is .....
17. Using intercooling in multi-stage compression systems will ..... at higher stage compression.
18. When the suction pressure of vapour compression refrigeration system decreases, the COP of the system is .....
19. During sensible cooling, wet bulb temperature .....
20. An assembly of different parts of the system used to produce specified condition of air with a required space building is called .....

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F.M. : 55

SECTION "C"

Attempt *ALL* questions. Assume any suitable data if any is missing.

1.a. Explain, with necessary schematic diagram, basic absorption refrigeration system and compare it with vapor compression system. [5]
b. Write short note on 'thermodynamics of a human body' and explain briefly the factors which affect human comfort. [3]
c Explain with the help of a diagram the advantage of dry compression instead of wet compression in a vapor compression refrigeration system. [3]

2.a. What is azeotropic refrigerant? Discuss the desirable properties of refrigerants. [4]
b. A vapor compression refrigeration system based on refrigerant 22 operates between an evaporator temperature -24°C and condenser temperature of 50°C. Determine a) COP of the system, b) Work input to the compressor, c) Area of superheat horn and d) Throttling loss. (Draw TS diagram and assume isentropic compression). [7]

3.a. Explain multi stage compression refrigeration system and working principle of flash gas chamber with the help of schematic and TS diagram. [6]
b. The simple LiBr-water absorption refrigeration cycle is operating at the following temperatures: generator, 100°C; condenser, 40 °C; evaporator, 10 °C; and absorber 30°C. Compute the rate flow rate of refrigerant through the condenser and evaporator in the cycle if the pump delivers 0.6 kg/s. (Draw a schematic diagram and level all components with temperature). [5]

4.a. A small office of 30 person capacity is to be air conditioned when the outdoor conditions are 35°C DBT, 27 °CWBT and required conditions for the office are 23°C DBT and 55% RH. If the amount of air circulation is 0.35 m^3/min/person and sensible and latent heat load in the room are 121500 kJ/h and 41300 kJ/h, respectively, find the sensible heat factor of the plant. [8]
(Sketch the process in a Psychometric chart and leave the chart along with your answer copy)
b. Write short notes on Air Handling Unit (AHU). [3]

5.a. Explain briefly the simple aircraft refrigeration systems with the help of suitable diagram. [6]
b. Saturated air leaving the cooling section of an air-conditioning system at 14°C at a rate of 50 m^3/min is mixed adiabatically with the outside air at 32°C and 60 percent relative humidity at a rate of 20 m3/min. Assuming that the mixing process occurs at a pressure of 1 atm, determine the specific humidity, the relative humidity, the dry-bulb temperature, and the volume flow rate of the mixture. [5]

MEPP-403 Table

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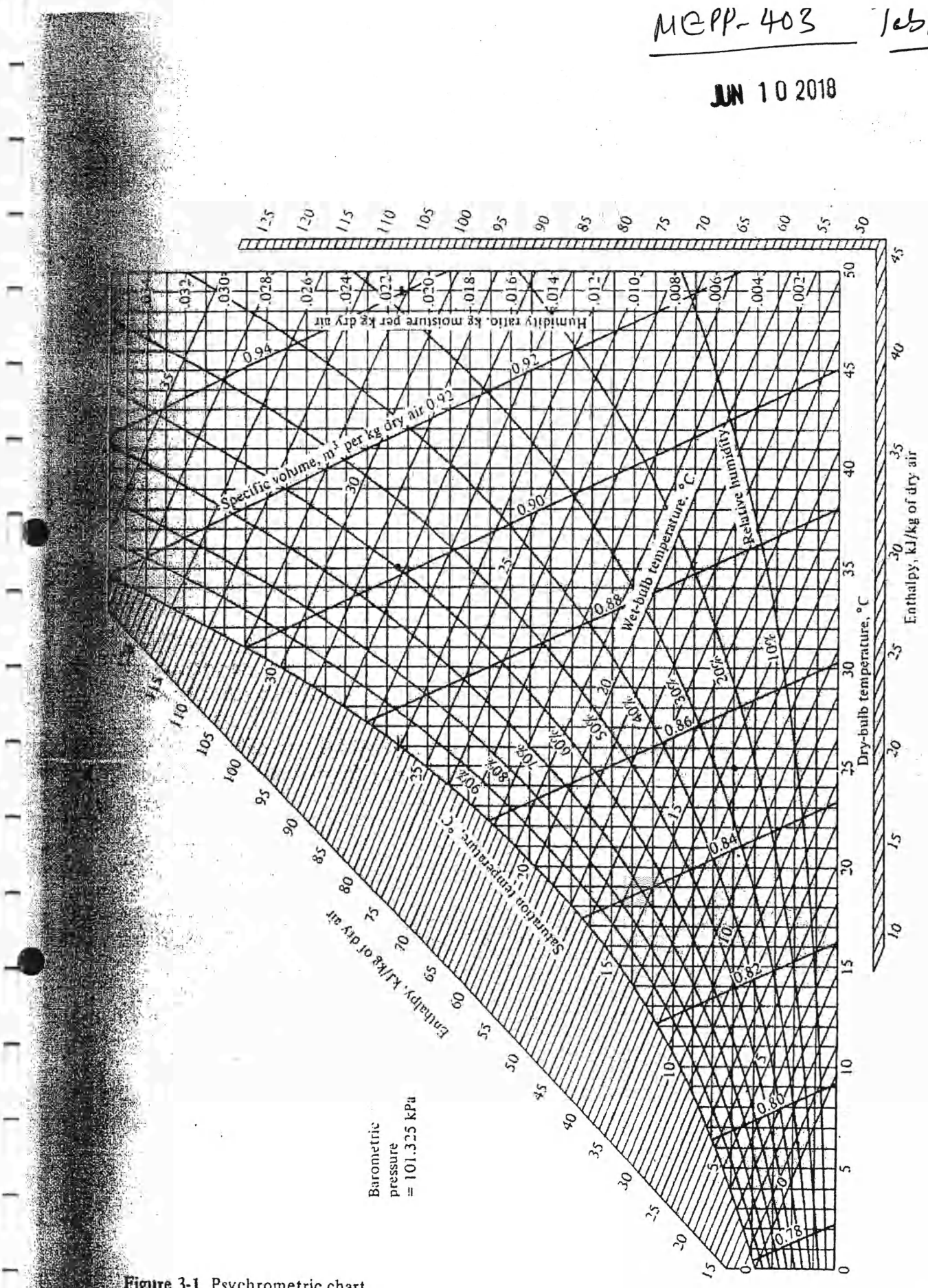

Figure 3-1 Psychrometric chart.

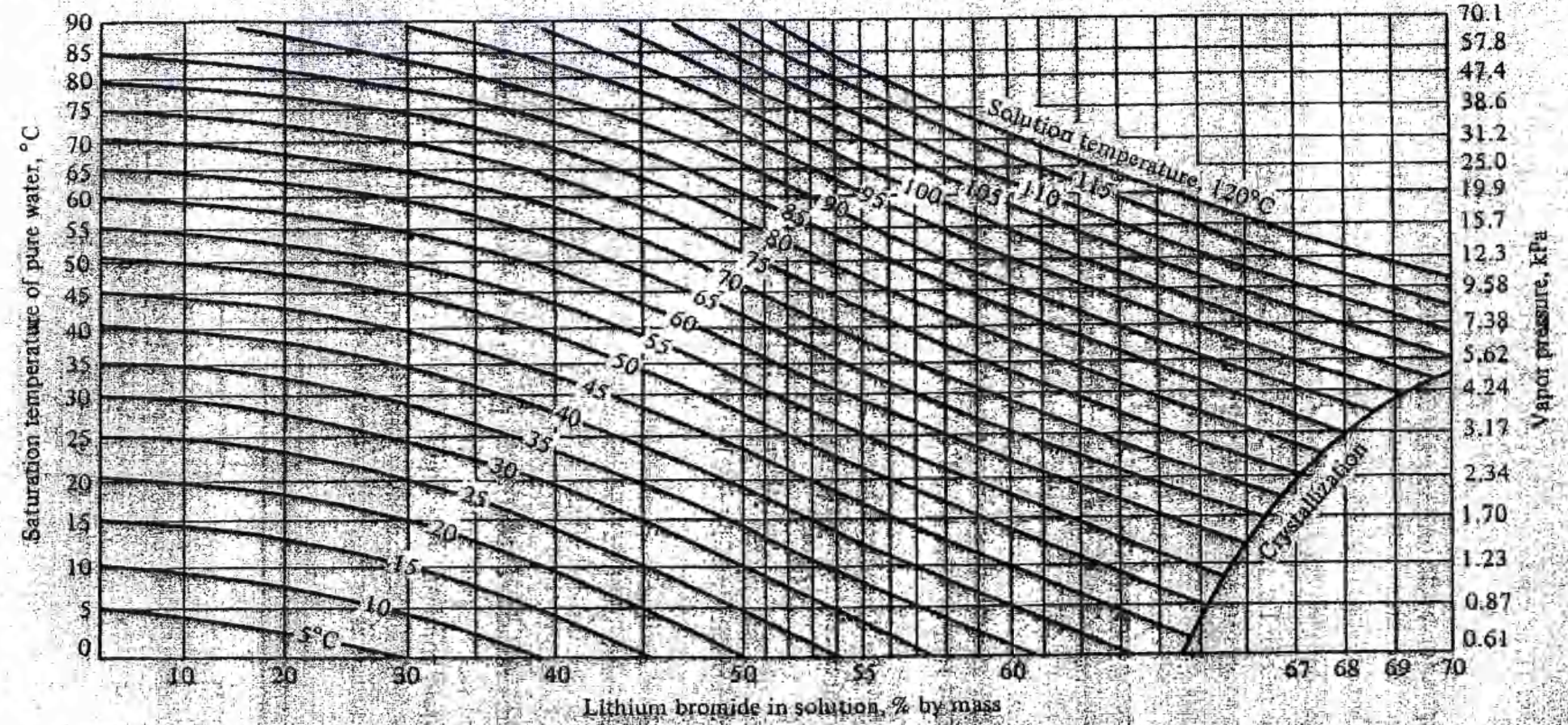

Figure 17-5 Temperature-pressure-concentration diagram of saturated LiBr-water solutions, developed from data in Ref. 1.

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H_2O

Saturated water - Temperature table

Temp., T °C	Sat. press., P_{sat} kPa	*Specific volume*, m³/kg: Sat. liquid, v_f	Sat. vapor, v_g	*Internal energy*, kJ/kg: Sat. liquid, u_f	Evap., u_{fg}	Sat. vapor, u_g	*Enthalpy*, kJ/kg: Sat. liquid, h_f	Evap., h_{fg}	Sat. vapor, h_g	*Entropy*, kJ/kg · K: Sat. liquid, s_f	Evap., s_{fg}	Sat. vapor, s_g
0.01	0.6113	0.001000	206.14	0.0	2375.3	2375.3	0.01	2501.3	2501.4	0.000	9.1562	9.1562
5	0.8721	0.001000	147.12	20.97	2361.3	2382.3	20.98	2489.6	2510.6	0.0761	8.9496	9.0257
10	1.2276	0.001000	106.38	42.00	2347.2	2389.2	42.01	2477.7	2519.8	0.1510	8.7498	8.9008
15	1.7051	0.001001	77.93	62.99	2333.1	2396.1	62.99	2465.9	2528.9	0.2245	8.5569	8.7814
20	2.339	0.001002	57.79	83.95	2319.0	2402.9	83.96	2454.1	2538.1	0.2966	8.3706	8.6672
25	3.169	0.001003	43.36	104.88	2304.9	2409.8	104.89	2442.3	2547.2	0.3674	8.1905	8.5580
30	4.246	0.001004	32.89	125.78	2290.8	2416.6	125.79	2430.5	2556.3	0.4369	8.0164	8.4533
35	5.628	0.001006	25.22	146.67	2276.7	2423.4	146.68	2418.6	2565.3	0.5053	7.8478	8.3531
40	7.384	0.001008	19.52	167.56	2262.6	2430.1	167.57	2406.7	2574.3	0.5725	7.6845	8.2570
45	9.593	0.001010	15.26	188.44	2248.4	2436.8	188.45	2394.8	2583.2	0.6387	7.5261	8.1648
50	12.349	0.001012	12.03	209.32	2234.2	2443.5	209.33	2382.7	2592.1	0.7038	7.3725	8.0763
55	15.758	0.001015	9.568	230.21	2219.9	2450.1	230.23	2370.7	2600.9	0.7679	7.2234	7.9913
60	19.940	0.001017	7.671	251.11	2205.5	2456.6	251.13	2358.5	2609.6	0.8312	7.0784	7.9096
65	25.03	0.001020	6.197	272.02	2191.1	2463.1	272.06	2346.2	2618.3	0.8935	6.9375	7.8310
70	31.19	0.001023	5.042	292.95	2176.6	2469.6	292.98	2333.8	2626.8	0.9549	6.8004	7.7553
75	38.58	0.001026	4.131	313.90	2162.0	2475.9	313.93	2321.4	2635.3	1.0155	6.6669	7.6824
80	47.39	0.001029	3.407	334.86	2147.4	2482.2	334.91	2308.8	2643.7	1.0753	6.5369	7.6122
85	57.83	0.001033	2.828	355.84	2132.6	2488.4	355.90	2296.0	2651.9	1.1343	6.4102	7.5445
90	70.14	0.001036	2.361	376.85	2117.7	2494.5	376.92	2283.2	2660.1	1.1925	6.2866	7.4791
95	84.55	0.001040	1.982	397.88	2102.7	2500.6	397.96	2270.2	2668.1	1.2500	6.1659	7.4159
	Sat. press., MPa											
100	0.10135	0.001044	1.6729	418.94	2087.6	2506.5	419.04	2257.0	2676.1	1.3069	6.0480	7.3549
105	0.12082	0.001048	1.4194	440.02	2072.3	2512.4	440.15	2243.7	2683.8	1.3630	5.9328	7.2958
110	0.14327	0.001052	1.2102	461.14	2057.0	2518.1	461.30	2230.2	2691.5	1.4185	5.8202	7.2387
115	0.16906	0.001056	1.0366	482.30	2041.4	2523.7	482.48	2216.5	2699.0	1.4734	5.7100	7.1833
120	0.19853	0.001060	0.8919	503.50	2025.8	2529.3	503.71	2202.6	2706.3	1.5276	5.6020	7.1296
125	0.2321	0.001065	0.7706	524.74	2009.9	2534.6	524.99	2188.5	2713.5	1.5813	5.4962	7.0775
130	0.2701	0.001070	0.6685	546.02	1993.9	2539.9	546.31	2174.2	2720.5	1.6344	5.3925	7.0269
135	0.3130	0.001075	0.5822	567.35	1977.7	2545.0	567.69	2159.6	2727.3	1.6870	5.2907	6.9777
140	0.3613	0.001080	0.5089	588.74	1961.3	2550.0	589.13	2144.7	2733.9	1.7391	5.1908	6.9299
145	0.4154	0.001085	0.4463	610.18	1944.7	2554.9	610.63	2129.6	2740.3	1.7907	5.0926	6.8833
150	0.4758	0.001091	0.3928	631.68	1927.9	2559.5	632.20	2114.3	2746.5	1.8418	4.9960	6.8379
155	0.5431	0.001096	0.3468	653.24	1910.8	2564.1	653.84	2098.6	2752.4	1.8925	4.9010	6.7935
160	0.6178	0.001102	0.3071	674.87	1893.5	2568.4	675.55	2082.6	2758.1	1.9427	4.8075	6.7502
165	0.7005	0.001108	0.2727	696.56	1876.0	2572.5	697.34	2066.2	2763.5	1.9925	4.7153	6.7078
170	0.7917	0.001114	0.2428	718.33	1858.1	2576.5	719.21	2049.5	2768.7	2.0419	4.6244	6.6663
175	0.8920	0.001121	0.2168	740.17	1840.0	2580.2	741.17	2032.4	2773.6	2.0909	4.5347	6.6256
180	1.0021	0.001127	0.19405	762.09	1821.6	2583.7	763.22	2015.0	2778.2	2.1396	4.4461	6.5857
185	1.1227	0.001134	0.17409	784.10	1802.9	2587.0	785.37	1997.1	2782.4	2.1879	4.3586	6.5465
190	1.2544	0.001141	0.15654	806.19	1783.8	2590.0	807.62	1978.8	2786.4	2.2359	4.2720	6.5079
195	1.3978	0.001149	0.14105	828.37	1764.4	2592.8	829.98	1960.0	2790.0	2.2835	4.1863	6.4698

Table A-6 Refrigerant 22: properties of liquid and saturated vapor[6]

		Enthalpy, kJ/kg		Entropy, kJ/kg · K		Specific volume, L/kg	
t, °C	P, kPa	h_f	h_g	s_f	s_g	v_f	v_g
−60	37.48	134.763	379.114	0.73254	1.87886	0.68208	537.152
−55	49.47	139.830	381.529	0.75599	1.86389	0.68856	414.827
−50	64.39	144.959	383.921	0.77919	1.85000	0.69526	324.557
−45	82.71	150.153	386.282	0.80216	1.83708	0.70219	256.990
−40	104.95	155.414	388.609	0.82490	1.82504	0.70936	205.745
−35	131.68	160.742	390.896	0.84743	1.81380	0.71680	166.400
−30	163.48	166.140	393.138	0.86976	1.80329	0.72452	135.844
−28	177.76	168.318	394.021	0.87864	1.79927	0.72769	125.563
−26	192.99	170.507	394.896	0.88748	1.79535	0.73092	116.214
−24	209.22	172.708	395.762	0.89630	1.79152	0.73420	107.701
−22	226.48	174.919	396.619	0.90509	1.78779	0.73753	99.9362
−20	244.83	177.142	397.467	0.91386	1.78415	0.74091	92.8432
−18	264.29	179.376	398.305	0.92259	1.78059	0.74436	86.3546
−16	284.93	181.622	399.133	0.93129	1.77711	0.74786	80.4103
−14	306.78	183.878	399.951	0.93997	1.77371	0.75143	74.9572
−12	329.89	186.147	400.759	0.94862	1.77039	0.75506	69.9478
−10	354.30	188.426	401.555	0.95725	1.76713	0.75876	65.3399
−9	367.01	189.571	401.949	0.96155	1.76553	0.76063	63.1746
−8	380.06	190.718	402.341	0.06585	1.76394	0.76253	61.0958
−7	393.47	191.868	402.729	0.97014	1.76237	0.76444	59.0996
−6	407.23	193.021	403.114	0.97442	1.76082	0.76636	57.1820
−5	421.35	194.176	403.496	0.97870	1.75928	0.76831	55.3394
−4	435.84	195.335	403.876	0.98297	1.75775	0.77028	53.5682
−3	450.70	196.497	404.252	0.98724	1.75624	0.77226	51.8653
−2	465.94	197.662	404.626	0.99150	1.75475	0.77427	50.2274
−1	481.57	198.828	404.994	0.99575	1.75326	0.77629	48.6517
0	497.59	200.000	405.361	1.00000	1.75279	0.77834	47.1354
1	514.01	201.174	405.724	1.00424	1.75034	0.78041	45.6757
2	530.83	202.351	406.084	1.00848	1.74889	0.78249	44.2702
3	548.06	203.530	406.440	1.01271	1.74746	0.78460	42.9166
4	565.71	204.713	406.793	1.01694	1.74604	0.78673	41.6124
5	583.78	205.899	407.143	1.02116	1.74463	0.78889	40.3556
6	602.28	207.089	407.489	1.02537	1.74324	0.79107	39.1441
7	621.22	208.281	407.831	1.02958	1.74185	0.79327	37.9759
8	640.59	209.477	408.169	1.03379	1.74047	0.79549	36.8493
9	660.42	210.675	408.504	1.03799	1.73911	0.79775	35.7624
10	680.70	211.877	408.835	1.04218	1.73775	0.80002	34.7136
11	701.44	213.083	409.162	1.04637	1.73640	0.80232	33.7013
12	722.65	214.291	409.485	1.05056	1.73506	0.80465	32.7239
13	744.33	215.503	409.804	1.05474	1.73373	0.80701	31.7801
14	766.50	216.719	410.119	1.05892	1.73241	0.80939	30.8683
15	789.15	217.937	410.430	1.06309	1.73109	0.81180	29.9874
16	812.29	219.160	410.736	1.06726	1.72978	0.81424	29.1361
17	835.93	220.386	411.038	1.07142	1.72848	0.81671	28.3131
18	860.08	221.615	411.336	1.07559	1.72719	0.81922	27.5173
19	884.75	222.848	411.629	1.07974	1.72590	0.82175	26.7477
20	909.91	224.084	411.918	1.08390	1.72462	0.82431	26.0032

Table A-6 (continued)

		Enthalpy, kJ/kg		Entropy, kJ/kg · K		Specific volume, L/kg	
t, °C	P, kPa	h_f	h_g	s_f	s_g	v_f	v_g
21	935.64	225.324	412.202	1.08805	1.72334	0.82691	25.2829
22	961.89	226.568	412.481	1.09220	1.72206	0.82954	24.5857
23	988.67	227.816	412.755	1.09634	1.72080	0.83221	23.9107
24	1016.0	229.068	413.025	1.10048	1.71953	0.83491	23.2572
25	1043.9	230.324	413.289	1.10462	1.71827	0.83765	22.6242
26	1072.3	231.583	413.548	1.10876	1.71701	0.84043	22.0111
27	1101.4	232.847	413.802	1.11290	1.71576	0.84324	21.4169
28	1130.9	234.115	414.050	1.11703	1.71450	0.84610	20.8411
29	1161.1	235.387	414.293	1.12116	1.71325	0.84899	20.2829
30	1191.9	236.664	414.530	1.12530	1.71200	0.85193	19.7417
31	1223.2	237.944	414.762	1.12943	1.71075	0.85491	19.2168
32	1255.2	239.230	414.987	1.13355	1.70950	0.85793	18.7076
33	1287.8	240.520	415.207	1.13768	1.70826	0.86101	18.2135
34	1321.0	241.814	415.420	1.14181	1.70701	0.86412	17.7341
35	1354.8	243.114	415.627	1.14594	1.70576	0.86729	17.2686
36	1389.2	244.418	415.828	1.15007	1.70450	0.87051	16.8168
37	1424.3	245.727	416.021	1.15420	1.70325	0.87378	16.3779
38	1460.1	247.041	416.208	1.15833	1.70199	0.87710	15.9517
39	1496.5	248.361	416.388	1.16246	1.70073	0.88048	15.5375
40	1533.5	249.686	416.561	1.16659	1.69946	0.88392	15.1351
41	1571.2	251.016	416.726	1.17073	1.69819	0.88741	14.7439
42	1609.6	252.352	416.883	1.17486	1.69692	0.89097	14.3636
43	1648.7	253.694	417.033	1.17900	1.69564	0.89459	13.9938
44	1688.5	255.042	417.174	1.18315	1.69435	0.89828	13.6341
45	1729.0	256.396	417.308	1.18730	1.69305	0.90203	13.2841
46	1770.2	257.756	417.432	1.19145	1.69174	0.90586	12.9436
47	1812.1	259.123	417.548	1.19560	1.69043	0.90976	12.6122
48	1854.8	260.497	417.655	1.19977	1.68911	0.91374	12.2895
49	1898.2	261.877	417.752	1.20393	1.68777	0.91779	11.9753
50	1942.3	263.264	417.838	1.20811	1.68643	0.92193	11.6693
52	2032.8	266.062	417.983	1.21648	1.68370	0.93047	11.0806
54	2126.5	268.891	418.083	1.22489	1.68091	0.93939	10.5214
56	2223.2	271.754	418.137	1.23333	1.67805	0.94872	9.98952
58	2323.2	274.654	418.141	1.24183	1.67511	0.95850	9.48319
60	2426.6	277.594	418.089	1.25038	1.67208	0.96878	9.00062
62	2533.3	280.577	417.978	1.25899	1.66895	0.97960	8.54016
64	2643.5	283.607	417.802	1.26768	1.66570	0.99104	8.10023
66	2757.3	286.690	417.553	1.27647	1.66231	1.00317	7.67934
68	2874.7	289.832	417.226	1.28535	1.65876	1.01608	7.27605
70	2995.9	293.038	416.809	1.29436	1.65504	1.02987	6.88899
75	3316.1	301.399	415.299	1.31758	1.64472	1.06916	5.98334
80	3662.3	310.424	412.898	1.34223	1.63239	1.11810	5.14862
85	4036.8	320.505	409.101	1.36936	1.61673	1.18328	4.35815
90	4442.5	332.616	402.653	1.40155	1.59440	1.28230	3.56440
95	4883.5	351.767	386.708	1.45222	1.54712	1.52064	2.55133

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Table A-7 Refrigerant 22: properties of superheated vapor[6]

t, °C	v, L/kg	h, kJ/kg	s, kJ/kg · K	v, L/kg	h, kJ/kg	s, kJ/kg · K	v, L/kg	h, kJ/kg	s, kJ/kg · K
	Saturation temperature, −20°C			Saturation temperature, −10°C			Saturation temperature, 0°C		
−20	92.8432	397.467	1.7841						
−15	95.1474	400.737	1.7969						
−10	97.4256	404.017	1.8095	65.3399	401.555	1.7671			
−5	99.6808	407.307	1.8219	67.0081	404.983	1.7800			
0	101.915	410.610	1.8341	68.6524	408.412	1.7927	47.1354	405.361	1.7518
5	104.130	413.926	1.8461	70.2751	411.845	1.8052	48.3899	408.969	1.7649
10	106.328	417.258	1.8580	71.8785	415.283	1.8174	49.6215	412.567	1.7777
15	108.510	420.606	1.8697	73.4644	418.730	1.8295	50.8328	416.159	1.7903
20	110.678	423.970	1.8813	75.0346	422.186	1.8414	52.0259	419.649	1.8026
25	112.832	426.353	1.8928	76.5904	425.653	1.8531	53.2028	423.339	1.8148
	Saturation temperature, 5°C			Saturation temperature, 10°C			Saturation temperature, 15°C		
5	40.3556	407.143	1.7446						
10	41.4580	410.851	1.7578						
15	42.5379	414.542	1.7708	34.7136	408.835	1.7377			
20	43.5979	418.222	1.7834	35.6907	412.651	1.7511	29.9874	410.430	1.7311
25	44.6401	421.894	1.7958	36.6454	416.442	1.7642	30.8606	414.362	1.7556
30	45.6665	425.562	1.8080	37.5804	420.215	1.7769	31.7114	418.260	1.7578
35	46.6786	429.229	1.8200	38.4981	423.974	1.7894	32.5427	422.133	1.7707
40	47.6779	432.897	1.8319	39.4002	427.724	1.8017	33.3568	425.985	1.7833
45	48.6656	436.569	1.8435	40.2884	431.469	1.8137	34.1556	429.823	1.7956
50	49.6427	440.247	1.8550	41.1642	435.211	1.8256	34.9409	433.650	1.8078
				42.0286	438.954	1.8373	35.7139	437.470	1.8197

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Table A-7 (continued)

	Saturation temperature, 20°C			Saturation temperature, 25°C			Saturation temperature, 30°C		
20	26.0032	411.918	1.7246						
25	26.7900	415.977	1.7383	22.6242	413.289	1.7183			
30	27.5542	419.991	1.7517	23.3389	417.487	1.7322	19.7417	414.530	1.7120
35	28.2989	423.970	1.7646	24.0306	421.627	1.7458	20.3962	418.881	1.7262
40	29.0264	427.922	1.7774	24.7027	425.721	1.7590	21.0272	423.159	1.7400
45	29.7389	431.852	1.7899	25.3575	429.779	1.7718	21.6381	427.378	1.7534
50	30.4379	435.766	1.8021	25.9974	433.807	1.7844	22.2316	431.549	1.7664
55	31.1250	439.668	1.8141	26.6239	437.813	1.7967	22.8101	435.683	1.7791
60	31.8012	443.561	1.8258	27.2386	441.801	1.8087	23.3733	439.787	1.7915
65	32.4678	447.450	1.8374	27.8427	445.777	1.8206	23.9288	443.867	1.8036
	Saturation temperature, 32°C			Saturation temperature, 34°C			Saturation temperature, 36°C		
35	19.0907	417.648	1.7182						
40	19.7093	422.014	1.7322	17.8590	416.325	1.7099			
45	20.3062	426.310	1.7458	18.4675	420.792	1.7243	17.2953	419.483	1.7162
50	20.8847	430.549	1.7591	19.0526	425.174	1.7382	17.8708	423.961	1.7304
55	21.4471	434.743	1.7719	19.6178	429.487	1.7517	18.4247	428.358	1.7442
60	21.9956	438.900	1.7845	20.1660	433.747	1.7647	18.9603	432.690	1.7575
65	22.5318	443.028	1.7968	20.6994	437.963	1.7775	19.4802	436.970	1.7704
70	23.0571	447.133	1.8089	21.2199	442.143	1.7899	19.9865	441.207	1.7830
75	23.5726	451.219	1.8207	21.7289	446.294	1.8021	20.4807	445.410	1.7954
80	24.0794	455.292	1.8323	22.2278	450.424	1.8141	20.9643	449.586	1.8074
				22.7176	454.535	1.8258	21.4385	453.739	1.8193