1. A mass of 2 kg water is contained in a piston-cylinder device at 100 kPa. Initially, the piston rests on the lower stop such that the volume occupied by the water is 1.2 m^3. Heat is transferred to the water and the piston starts moving. A pressure of 200 kPa is required to support the piston, and the volume enclosed by the upper stop is 1.6 m^3. Heat is added to the water until the water exists as a saturated vapor.

(a) Sketch each step on a p-v diagram. (4%)
(b) How much net work does the water do on the piston during whole process? (6%)
(c) What are the final pressure and temperature? (10%)

2. A balloon initially contains 10 m^3 of helium gas at atmospheric conditions of 100 kPa and 17°C. The balloon is connected by a valve to a large reservoir that supplies helium gas at 125 kPa and 25°C. Now the valve is opened, and helium is allowed to enter the balloon until pressure equilibrium with the helium at the supply line is reached. The material of the balloon is such that its volume increases linearly with pressure. If no heat transfer takes place during this process, determine
(a) the work done by the balloon (10%) and (b) the final mass and temperature in the balloon (10%). (C_p=5.1926 kJ/kg.K, C_v=3.1156 kJ/kg.K for helium)

3. Air at 600 kPa, 500 K and a mass flow of 200 kg/h enters a pipe. At the pipe exit, the pressure and temperature of the air are 550 kPa and 400 K, respectively. Assuming air is ideal gas and kinetic and potential energy effects can be ignored. Heat transfer between the pipe and its surroundings occurs at an average outer surface temperature of 380 K. At steady state, please determine the following. (Please state all of your assumptions.)
(a) the rate of heat transfer, in kW, for a control volume comprising the pipe and its contents (8%) and
(b) the rate of entropy production, in kW/K. (12%)

4. The equation of state for a certain substance over a certain range of temperatures and pressures.

$V = \frac{RT}{P} - \frac{c}{T^3}$, where c is a constant.

For an isothermal process of this substance, derive a simple expression for
(a) the change of enthalpy. (10%)
(b) the change of entropy. (10%)

5. Air at 30°C, 1 atm, and 70% relative humidity enters a dehumidifier operating at steady state with a mass flow rate of 1 kg/s. Saturated moist air and condensate exit in separate streams, each at 10 °C. Neglecting kinetic and potential energy effects, determine
(a) the rate of heat transfer from the moist air, in kJ/s, (10%)
(b) the rate water is condensed, in kg/s. (10%)

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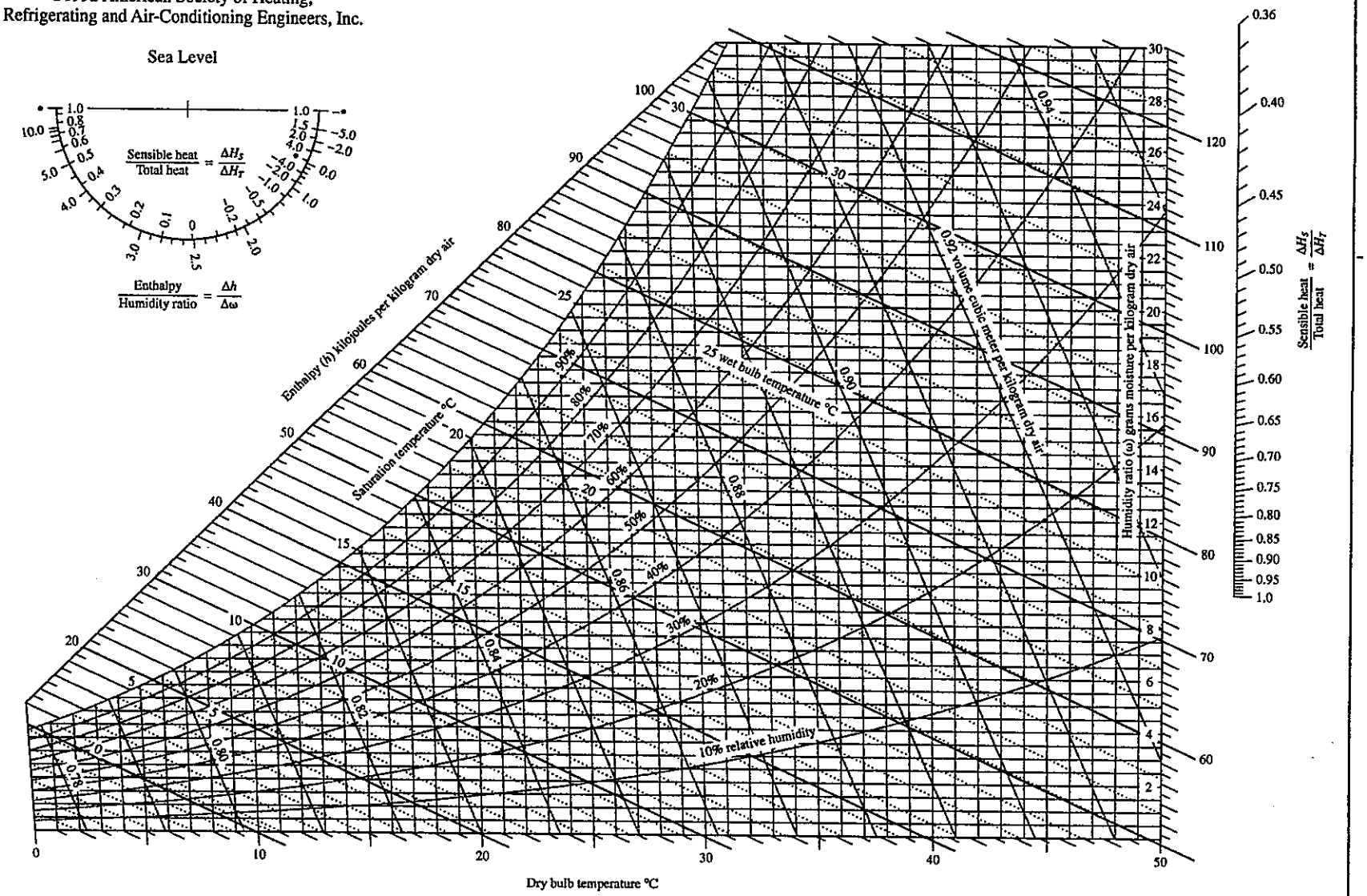
Properties of saturated water

Sat. pressure (kPa)	Sat. temp (°C)	Specific volume(m^3 /kg)		Internal energy (kJ/kg)		Enthalpy (kJ/kg)		Entropy ((kJ/kg K^{-1}))	
P	T	v_f	v_g	u_f	u_g	h_f	h_g	s_f	s_g
1.2281	10	0.001000	106.32	42.020	2388.7	42.022	2519.2	0.1511	8.8999
4.2469	30	0.001004	32.879	125.73	2415.9	125.74	2555.6	0.4368	8.4520
100	99.61	0.001043	1.6941	417.4	2505.6	417.51	2675.0	1.3028	7.3589
200	120.21	0.001061	0.88578	504.50	2529.1	504.71	2706.3	1.5302	7.1270
250	127.41	0.001067	0.71873	535.08	2536.8	535.35	2716.5	1.6072	7.0525

Psychrometric chart at 1 atm total pressure.



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