AOSC 620 Homework #3

Complete 1 and either 2 or 3

1. A sample of moist air has a temperature of -5 °C, a pressure of 80 kPa, and a relative humidity of 65%. Solve for the following properties of the sample by calculations, using approximations where convenient. Confirm the answers with a tephigram wherever possible:
   (a) potential temperature;
   (b) mixing ratio;
   (c) dew point;
   (d) isentropic condensation temperature;
   (e) wet-bulb temperature;
   (f) web-bulb potential temperature;
   (g) equivalent temperature;
   (h) virtual temperature;
   (i) density.

2. A pseudoadiabatic process is not a polytropic process but it may be approximated as such over a limited range of pressure and temperature. Show that in a pseudoadiabatic process at 270 K and 80 kPa, pressure and specific volume are related by $p\alpha^n = const.$, where n has the value 1.23. Show further that n deviates only 5% from this value as the temperature changes by ± 10 K about 270 K and the pressure changes by ± 10 kPa about 80 kPa.

3. Using $L(T) = L_0 - (c - c_{pv})(T - T_0)$, where c is the specific heat capacity for liquid water and c_{pv} is the specific heat of water vapor at constant pressure, for the dependence of latent heat of vaporization on temperature, integrate $\frac{de_s}{dT} = \frac{Le_s}{R_v T^2}$ obtaining an expression for e_s(T) (e_{s0} = 611.21 Pa at T_0 = 0 °C). (This result is sometimes called the Magnus equation or Kiefer's formula.) Over the range -30°C ≤ T ≤ 30°C, compare e_s(T) from this equation with the simpler approximation $e_s = Ae^{\frac{-B}{T}}$ where A = 2.53x10^8 kPa and B = 5.42x10^3 K and T is in Kelvin, with Bolton's empirical formula $e_s(T) = 6.112e^{\frac{17.67T}{T+243.5}}$ where T in in °C and e_s is in mb, and with the data in the table below.

T(°C)	e_s (Pa)	e_i (Pa)	L (J/g)	L_s (J/g)
-40	19.05	12.85	2603	2839
-35	31.54	22.36		
-30	51.06	38.02	2575	2839
-25	80.90	63.30		
-20	125.63	103.28	2549	2838
-15	191.44	165.32		
-10	286.57	259.92	2525	2837
-05	421.84	401.78		
00	611.21	611.15	2501	2834
05	872.47		2489	
10	1227.94		2477	
15	1705.32		2466	
20	2338.54		2453	
25	3168.74		2442	
30	4245.20		2430	
35	5626.45		2418	
40	7381.27		2406	