(p57) ✓ 21. If an air parcel has a temperature of 270 K and a relative humidity of 70%, what is the water vapor partial pressure over liquid water? What is the water vapor pressure over ice? Which is greater?

liquid $e_s = 6.11 \exp\left[(6808)\left(\frac{1}{273}-\frac{1}{T}\right) - 5.09 \ln\frac{T}{273}\right]$ $e = .7 e_s(270) = 4.9$ hPa

ice $e_{si} = 6.11 \exp\left[(6293)\left(\frac{1}{273}-\frac{1}{T}\right) - .56 \ln\frac{T}{T_0}\right]$ $e_i = .7 e_{si}(270) = 4.76$ hPa

$e_i < e_l$

in class 2002 22. If an air parcel has a temperature of 290 K and a relative humidity of 70%, what is the mass of water vapor in 1 m^3?

$m = \rho V$; $\rho = \frac{e}{R_v T}$; $e = .7 e_s(290)$; $m = \frac{.7 e_s(290) V}{R_v T}$

$e_s(290) = 19.4$ hPa $\Rightarrow m = \frac{(.7)(1940)(1)}{(461)(290)} \Rightarrow m = 1.0 \times 10^{-2}$ kg

in class 2002 ✓ 23. Assume that a cloud has a liquid water content (LWC) of 1 g m^{-3}. How much solar energy is required to convert all the liquid water to water vapor at a constant temperature for a stratus cloud that is 100 m thick? Consider energy per square meter.

units $\left(\frac{J}{m^2}\right)$ $\Delta E = l_v M_e = l_v \rho_e \Delta z$

$\Delta E = (2.5 \times 10^6 \text{ J kg}^{-1})(.001 \frac{kg}{m^3})(100 \text{ m}) \Rightarrow \Delta E = 2.5 \times 10^5 \frac{J}{m^2}$

in class 2002 ✓ 24. An ice cube (10 cm^3) at 0°C, when completely melted, will lower the temperature of how much water from 90° C to 10°C? $l_f M_{ice} + C_e M_{ice} \Delta T_2 C_e + C_e M_e \Delta T_1 = 0$ Conservation of energy

equate energy required to melt ice with energy required to warm water plus the water from melted ice.

$l_f M_{ice} = -\Delta T_1 C_e M_e - \Delta T_2 C_e M_{ice} \Rightarrow M_e = \frac{-(l_f + C_e \Delta T_2) M_{ice}}{C_e \Delta T_1} = \frac{(l_f + C_e \Delta T) \rho_i V_i}{C_e \Delta T}$

$M_e = \frac{-[(3.3 \times 10^5) + (4220)(10)](10^{-3})(920)}{[4220(-80)]}$ $M_e = .910$ kg $\Rightarrow V_e = 10$ cm^3

in class 2002 25. How much energy is required to evaporate a water puddle that is 1 m^2 in area and 1 cm deep? Assume no temperature change.

$E = l_v M_p = l_v \rho_e A \Delta z$

$E = (2.5 \times 10^6)(10^3 \frac{kg}{m^3})(1 \text{ m}^2)(.001 \text{ m}) \Rightarrow E = 2.5 \times 10^6$ J

(p57) 26. If the mixing ratio, w, is 0.01, and the total pressure is 850 hPa, what is the water vapor partial pressure?

$w = \rho_v / \rho_d = \frac{\epsilon e}{p - e}$ where $\epsilon = \frac{R_d}{R_v} = 0.622$

reconfigure. $w(p-e) = \epsilon e$; $wp = (w + \epsilon)e$

$e = \frac{wp}{w+\epsilon}$; $e = \frac{(.01)(850)}{.01 + .622} \Rightarrow e = 13.4$ hPa

27. If the dew point temperature is 20°C, and the air temperature is 30°C, what is the relative humidity? What is the water vapor pressure?

from the skewT, use 1000 hPa.

$w(20) = 15$ g/kg $w(30) = w_s = 27$ g/kg $RH = 100 \times \frac{w}{w_s} \Rightarrow RH = 55\%$

$e = \frac{(.015)(1000)}{(.015)+.622} \Rightarrow e = 23.6$ hPa (from skewT, $e = 24$ hPa)

✓28. What is the saturation water vapor mixing ratio, w_s, if the temperature is 280 K and the total pressure is 850 hPa?

from skewT, go to P = 850 hPa, T = 280 − 273 = 7°C.

Read off $w = w_s(280)$. $w_s = 7.5$ g/kg ($e_s = 10$ hPa ✓)

✓29. What is the water vapor mixing ratio, w, if the temperature is 280 K, the total pressure is 850 hPa, and the relative humidity is 65%?

$w = \frac{RH}{100} w_s$; $w = (.65)(7.5 \frac{g}{kg}) = 4.9 \frac{g}{kg}$

30. Consider an air parcel rising in a cloud. At cloud base, the temperature is 298 K at 900 hPa. The parcel ascends moist adiabatically up in the cloud, reaching a temperature of 283 K at 590 hPa. What is the water vapor mixing ratio at 590 hPa? What fraction of the water is in the liquid at 590 hPa?

Use skew T. Follow moist adiabat to 590 hPa.

$w_s(590) = 13.8$ g/kg

$w_s(900) = 22.5$ g/kg

$f_{liquid} = \frac{w_s(900) - w_s(590)}{w_s(900)} = \frac{22.5 - 13.8}{22.5} = 39\%$