7. What is the density of an air parcel at a pressure of 500 hPa and a temperature of 250 K?

$\rho_d = \frac{P}{R_d T}$; $\rho_d = \frac{5\times10^4}{(287)(250)} \Rightarrow \rho_d = 0.70 \frac{kg}{m^3}$

8. How does the energy of an air parcel change as it descends from 700 hPa to 900 hPa adiabatically?

It does not change; its descent is adiabatic.

in class 2002

9. Consider an air parcel at the surface that is at a pressure of 1000 hPa and a temperature of 280 K and a thickness of 100 m. If the solar heating rate is 800 watts m^{-2}, what is the isobaric temperature change in one hour?

units $\left(\frac{J}{m^2 s}\right)$

$\frac{dE}{dt} = C_{pd} M_d \frac{dT}{dt}$; $M_d = \rho_d \Delta Z = \frac{P}{R_d T}\Delta Z$ (units $\frac{kg}{m^2}$)

$\therefore \frac{\Delta E}{\Delta t} = \frac{C_{pd} P \Delta Z \Delta T}{R_d T_{initial} \Delta t} \Rightarrow \Delta T = \left(\frac{\Delta E}{\Delta t}\right) * \frac{R_d T_i \Delta t}{C_{pd} P \Delta Z} = 800 \frac{(287)(280)(3600)}{(1005)(10^5)(100)} = 23\text{ K}$

✓10. Consider the heating of an air parcel. What is the ratio of the temperature change that occurs at constant pressure to the temperature change that occurs at constant volume?

Same energy in both cases. $\Delta T_v C_v = \Delta T_p C_p \Rightarrow \frac{\Delta T_p}{\Delta T_v} = \frac{C_v}{C_p} = \frac{C_v}{C_p}$

$\frac{\Delta T_p}{\Delta T_v} = \frac{1}{\gamma} = \frac{1}{1.4} = 0.71$

11. What is the potential temperature of an air parcel that has a pressure of 200 hPa and a temperature of 200 K?

$\Theta = T\left(\frac{P_0}{P}\right)^{R/C_p} \Rightarrow \Theta = 200\left(\frac{1000}{200}\right)^{.286} \Rightarrow \Theta = 317\text{ K}$

12. What is the temperature of this air parcel as it is brought adiabatically to 500 hPa?

$T = \Theta\left(\frac{P}{P_0}\right)^{.286} \Rightarrow T = (317)\left(\frac{500}{1000}\right)^{.286} \Rightarrow T = 260\text{ K}$

✓13. What is the density of an air parcel that contains 1% water vapor at a pressure of 1000 hPa and 293 K?

We want the mean density

$\langle \rho \rangle = \frac{\sum N_i \rho_i}{\sum N_i} = \frac{N_d \rho_d}{N_d + N_v} + \frac{N_v \rho_v}{N_d + N_v} = (1-f_v)\left(\frac{P}{R_d T}\right) + (f_v)\left(\frac{P}{R_v T}\right)$

where $f_v = 0.01$

$\langle \rho \rangle = (.99)\left(\frac{10^5}{287 \cdot 293}\right) + (0.01)\left(\frac{10^5}{461 \cdot 293}\right)$ $\langle \rho \rangle = 1.19\ kg\ m^{-3}$

14. Which air parcel is most buoyant at the same pressure (1000 hPa): one with a temperature of 310 K with no water vapor or one with a temperature of 305 K and a water vapor fraction of 0.01? (That means that the water vapor pressure is 1% of the total pressure.)

$\langle\rho\rangle = \left(.99\frac{1}{287} + .01\frac{1}{461}\right)\frac{10^5}{305} = 1.14 \text{ kg m}^{-3}$;

$\rho_d = \frac{P}{R_d T} \Rightarrow \rho_d = \frac{10^5}{287 \cdot 310} \Rightarrow \rho_d = 1.12$ ∴ warmer dry air is ~~more~~ less dense.

15. What is the water vapor saturation pressure if the dry air pressure is 850 hPa and the temperature is 280 K?

Only T matters. Use $e_s = 6.11 \exp\left[(6808)\left(\frac{1}{273} - \frac{1}{T}\right) - 5.09 \ln\left(\frac{T}{273}\right)\right]$

$e_s(280) = 10.0$ hPa

in class 2000

16. If the relative humidity is 75% and the temperature is 293 K, what is the saturation vapor pressure? What is the vapor pressure?

$e_s(293) = 23.4$ hPa $\quad e = \frac{RH}{100} e_s \Rightarrow e = \frac{75}{100} 23.4 \Rightarrow e = 17.6$ hPa

17. If the dew point temperature is 275 K, what is the ~~saturation~~ vapor pressure?

$e_s(T_d) = e \qquad e = 7.1$ hPa

ps7

18. If the relative humidity is 50% and the dew point temperature is 290 K, what is the vapor pressure?

★ $e = e_s(290) = 19.4$ hPa

17°C

✓19. If an air parcel with a temperature of 290 K and a relative humidity of 70% is raised from the surface adiabatically, at what altitude is the lifting condensation level? Use skew-T

R.H. $= 100 \times \frac{w}{w_s} \sim 100 \times \frac{e}{e_s}$. assume $p = 1000$ hPa. $w_s(290) = 12 \frac{g}{kg}$

∴ $w = .7 \times 12 = 8.4$ g/kg. Take θ, w intersection $P_{LCL} = 910$ hPa (1 km)

20. If an air parcel with temperature of 290 K and a dew point temperature of 280 K is raised from the surface adiabatically, at what altitude is the lifting condensation level?

Assume $P = 1000$ hPa.

$T_d = 280 \Rightarrow w = 6.2$ g/kg

Take θ, w intersection $\quad P_{LCL} = 845$ hPa (~1.5 km)

or equation 6.19 $\quad z_{LCL} - z_0 \approx \frac{T_0 - T_{d0}}{8} \Rightarrow z_{LCL} = 1.25$ km