Meteo 431 Sample Problems

30 November 2000

You should be able to work all of these problems using the knowledge that you have learned this semester. I expect that you will know the equations that are necessary to solve many of these problems without referring to the text. Use the constants in the Appendix in Bohren and Albrecht.

1. Consider a dry air parcel that is at a pressure of 1000 hPa and temperature of 273 K. If we reduce the volume from 2 m^3 to 1 m^3 isothermally, what is the new pressure?

$P_1V_1 = nR^*T$. Isothermal $\Rightarrow P_1V_1 = P_2V_2 \Rightarrow P_2 = P_1\frac{V_1}{V_2}$

$P_2 = 1000 * (\frac{2}{1}) = 2000$ hPa

2. If we had done the compression adiabatically, what would the temperature be?

Poisson's relations. $T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1} \Rightarrow T_2 = T_1(\frac{V_1}{V_2})^{\gamma-1}$

$\gamma = 1.4 \Rightarrow \gamma - 1 = 0.4 \Rightarrow T_2 = (273)(\frac{2}{1})^{.4} = 360$ K

3. If we had done the compression adiabatically, what would the pressure be?

Poisson's Relations. $P_1V_1^{\gamma} = P_2V_2^{\gamma} \Rightarrow P_2 = P_1(\frac{V_1}{V_2})^{\gamma}$

$\gamma = 1.4 \Rightarrow P_2 = (1000)(\frac{2}{1})^{1.4} \Rightarrow P_2 = 2640$ hPa

4. Consider a dry air parcel that is at a pressure of 1000 hPa and temperature of 273 K. Suppose that we compress this air parcel from 2 m^2 to 1 m^3 at constant pressure. What is the new temperature?

$PV = nR^*T$; P = constant $\therefore \frac{V_1}{T_1} = \frac{V_2}{T_2} \Rightarrow T_2 = T_1(\frac{V_2}{V_1})$

$T_2 = 273(\frac{1}{2}) \Rightarrow T_2 = 137$ K

5. How much work is done on the air parcel to reduce the volume at constant pressure?

$W = -\int_{V_1}^{V_2} pdV = P(V_1 - V_2)$

$W = (10^5 \text{ Pa})(2-1)\text{m}^3 \Rightarrow W = 10^5$ J

6. What is the mass of dry air in 10 m^3 at a pressure of 950 hPa and temperature of 300 K?

$P = \rho_d R_d T$; $\Rightarrow \rho_d = \frac{P}{R_d T}$; $\rho_d = \frac{m_d}{V} \Rightarrow m_d = \frac{PV}{R_d T}$

$m_d = \frac{(9.5 \times 10^4 \text{ Pa})(10 \text{ m}^3)}{(287 \text{ J kg}^{-1}\text{K}^{-1})(300 \text{ K})} \Rightarrow m_d = 11$ kg