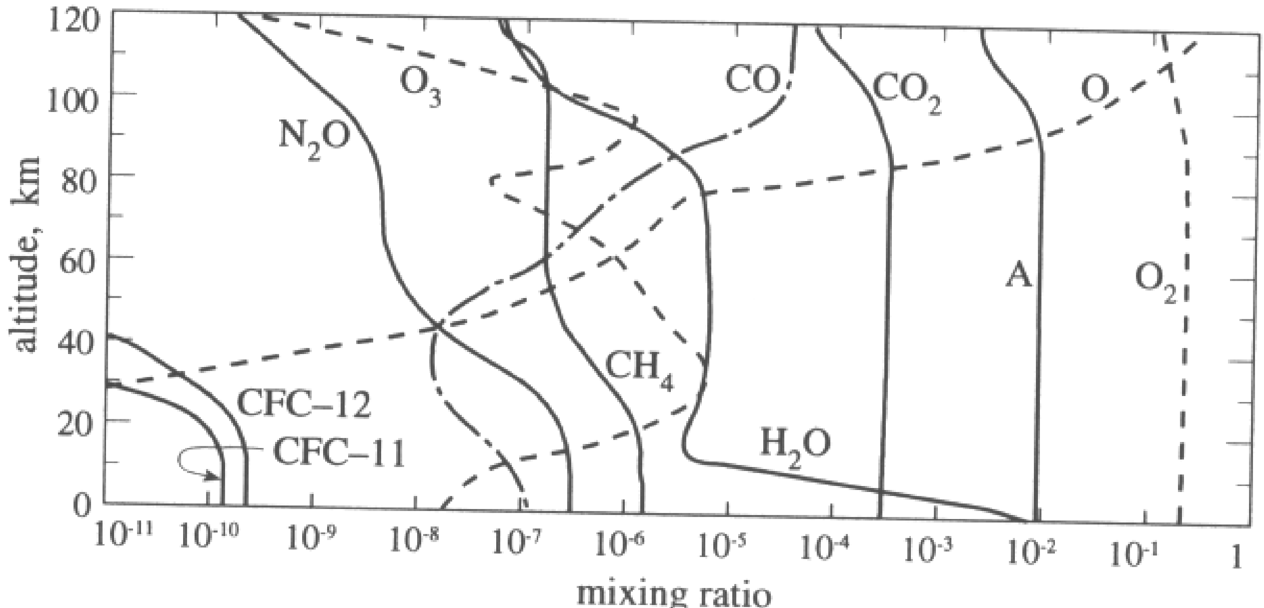

Figure 1.1 Vertical profiles of mixing ratios of selected species at an equinox. CFC-11 and CFC-12 are chlorofluorocarbons.

Bohren & Albrecht, 1999

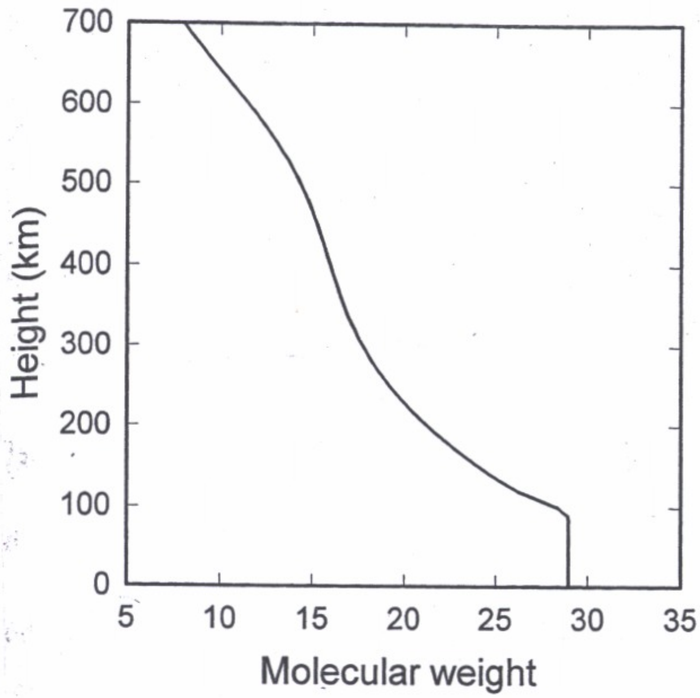

Figure 2.13 Mean molecular weight versus height for U.S. Standard Atmosphere.

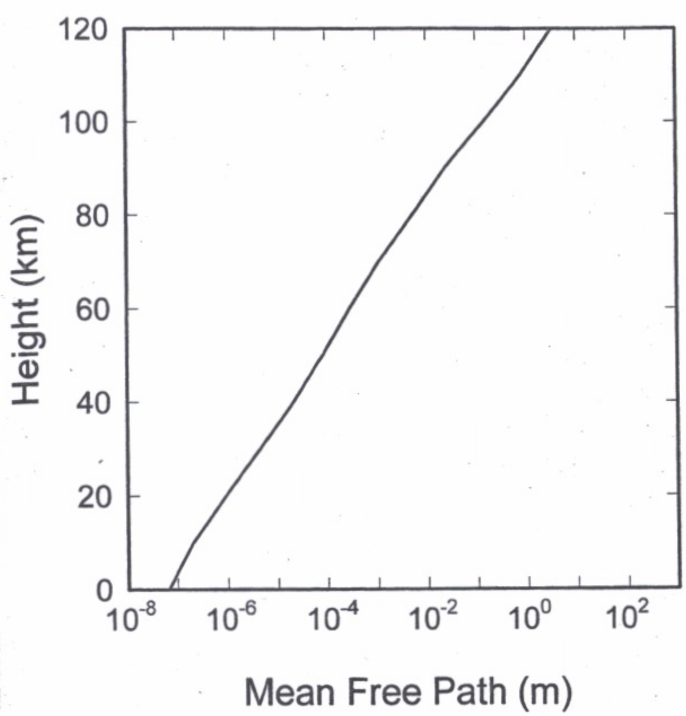

Figure 2.12 Mean free path between collisions of air molecules versus height for U.S. Standard Atmosphere.

The temperature dependence of water saturation vapor pressure, also known as the "saturation vapor curve", is given by the integrated form of the Clausius-Clapeyron Equation:

$$P_{H2O,sat}(T) = P_{H2O,sat}(T_o) \cdot exp\left(\frac{L_v \cdot M_{H2O}}{R} \cdot \left(\frac{1}{T_o} - \frac{1}{T}\right)\right)$$

T in Kelvin, T_o =273.15 K, $P_{H2O,sat}(T_o)$=610.7 Pa, L_v =2.501x10^6 J/kg

The leading term, on the right hand side, is the saturation vapor pressure at the reference temperature:

$P_{H2O,sat}(T_o)$=610.7 Pa at T_o =273.15 K

The first term in the exponent is a constant:

$$\frac{L_v \cdot M_{H2O}}{R} = \frac{2.501 \cdot 10^6 \ J/kg \cdot 0.018 \ kg/mol}{8.314 \ J/(mol \cdot K)} = 5410 \ K$$

For our application, the Clausius-Clapeyron Equation is simplified:

$$P_{H2O,sat}(T) = 610.7 \cdot exp\left(5410 \cdot \left(\frac{1}{273.15} - \frac{1}{T}\right)\right)$$

Problem 1.1 – Fog Formation. A weather station reports T=293 K, RH=50% at sunset. Assuming that the partial pressure of water vapor (P_{H2O}) remains constant, by how much must the temperature drop over the coarse of the evening in order for fog to form?

How to attack this problem?

1) Think about properties of the air that are changing during the night. The air temperature is decreasing. Why? The ground is cooling, radiatively, and the air next to the ground is cooling because of the heat it is losing to the ground by conduction.

2) Think about the properties of the air that remain constant during the night. The air pressure, which reflects the weight of air above, is constant; so P =constant. Also, the amount of water vapor in the air, when expressed as a mole fraction (aka, mixing ratio) is constant (c_{H2O} =constant).

It follows that P_{H2O} is also a constant!

3) Can you evaluate P_{H2O} ?

4) Write an equation for the temperature of the air at saturation.

5) Solve for that temperature.