- Trans-Atlantic aircraft often fly at 37,000 ft. Are they flying in the troposphere or stratosphere?

1000 ft = 0.305 km ⇒ $h = 37{,}000\,ft\left(.305\,\frac{km}{1{,}000\,ft}\right)$

$h = 11.3$ km Stratosphere.

- What is the outside air temperature at 37,000 ft?

From Fig 1.8, $T_{11km} \sim 217\,K = -56\,°C$

4. The average tropopause height is 17 km in the tropics.

- Using the hydrostatic equation, what is the approximate pressure at the tropical tropopause?

$p = 1000 \exp(-17/7) = 88$ hPa

- How far below the tropopause do trans-oceanic flights fly in the tropics?

$17 - 11 = 6$ km

- What is the typical air temperature at the tropical tropopause?

from Figure 1.10, about 200 K (−70°C)

5. Assume an average global tropopause of 14 km and that the temperature is constant with altitude (i.e, use a constant scale height of 7 km.). Obtain a mathematical expression for the fraction of air density that is in the troposphere. What is the actual numerical fraction?

Consider the column density only. Column density ≡ $D = \int_0^z \rho(z)\,dz$

$D = \int_0^z \rho_0 \exp(-z/H)\,dz = -H\rho_0 \exp(-z/H)\Big|_0^z = H\rho_0(1-\exp(z/H))$

For the whole column, $z = \infty$; for the trop $z = z_t \sim 14$ km

∴ fraction $= H\rho_0(1-\exp(z_t/H))/H\rho_0 = 1-\exp(z_t/H) = 1-\exp(\frac{-14}{7}) = 86\%$

6. In class, we found that the atmospheric mass is approximately 5 x 10^{18} kg.

- What is the approximate number of moles in the atmosphere?

Mass per mole = 0.029 kg/mole ∴ #moles $= \frac{5\times10^{18}\,kg}{0.029\,kg/mole} = 1.7\times10^{20}$ moles

- What is the approximate number of molecules in the atmosphere?

By Avagadro's number, each mole has 6.02×10^{23} molecules

molecules $= 1.7\times10^{20} \times 6.02\times10^{23} \approx 10^{44}$ molecules.