Exercises

A. What defines the location of the tropopause? What is the altitude of the tropopause under the conditions shown in *DeMore, et al* (Chemical Kinetics and Photochemical Data for Use in Stratospheric Modelling #12)?

B.1. Use data from *DeMore** to determine the ratio of [Cl] (Figure 11) to [O_3] (Figure 9) at 40 km. Use the spacing of the tick marks in Figure 11 to read Figure 9 correctly.

B.2. Determine the value of [N_2] and [O_2] at 20 km.

C. Use the ideal gas law to convert gas pressure of 0.500 bar at 230. K to molecules/cm^3.

D. The Air Quality Standard for O_3 in the United States is now 75 ppbv. Convert this value to bar, to molecules/cm^3 and to μg/m^3, assuming P_{total}= 1.0 atm and T = 285 K.

E. Determine the equilibrium constant at 298 K for the reaction: $N_{2\,(g)} + O_{2\,(g)} \leftrightarrows 2\,NO_{(g)}$ from values of $\Delta G_f°$ from a textbook or other reference.*

F.1 Use calculations to determine whether the reaction: $N_{2\,(g)} + O_{2\,(g)} \leftrightarrows 2\,NO_{(g)}$ at equilibrium in air at ground level for ambient [NO] concentrations of 10^{-3} ppbv?

F.2 Which way would this reaction need to shift to move towards equilibrium? EXPLAIN!

G. Is the graph at right consistent with the idea that CF_2Cl_2 is "well-mixed" in the atmosphere below about 17 km?

Is the vertical profile of atomic chlorine (Cl) from DeMore consistent with Cl being well-mixed over some range of altitudes?

"well-mixed" = mole fraction is independent of altitude

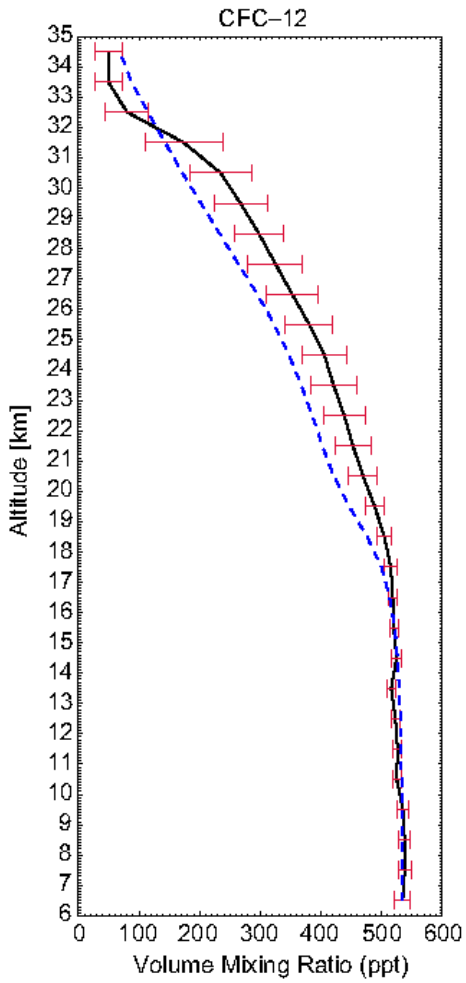

Figure Caption: Average vertical profile of CFC-12 (CF_2Cl_2) in pptv between 30°N and 30°S from 2004 to 2010 from ACE (black) and SLIMCAT (blue). The error bars represent one standard deviation of the ACE data. From *Journal of Quantitative Spectroscopy & Radiative Transfer* 112 (**2011**) 2552–2566.

* In the future, when you need data that can be found in *DeMore*, *Burkholder* or textbooks, it will generally be your responsibility to find it without being prompted.

Problems

On all Homework, EXPLAIN your answers if you want any credit

1. Consider the answer to Exercise B. If atomic chlorine destroyed ozone stoichiometrically but not catalytically, would ozone destruction by atomic chlorine be a concern?

2. Find the two errors in the following ideal gas law calculation of the number density (N/V in molecule cm^{-3}) of 1 atm of gas at 25 ºC.

$PV = nRT = (N/N_A)RT \Rightarrow N/V = PN_A/RT$ (N_A is Avogadro's number)

$N/V = 1\ atm \times (6.022 \times 10^{23}\ /\ mole)\ /\ (8.314\ Joules/(mole\ K) \times 298\ K)$

$= 2.43 \times 10^{20}$ molecules / cm^3

3. Given: Downward force of air = $m_A \times g$ (m_A = mass of the atmosphere, g = 9.8 m/sec^2)
Radius of Earth = 6380 km
Average atmospheric pressure = 0.984 bar
Definition of pressure from Physics 1

3.A. What is the mass of the atmosphere?

3.B. I did not lecture about the topic of this question, so one might argue that it is not a fair question. But I want you to present an argument for why it **is** a fair question.

4. Given: Figure 12 in *DeMore*.

Question: Do calculations to determine if CF_2Cl_2 well-mixed between 10 and 15 km.

When answering this question, think about the difference in the concentration units of Figure 12 versus the figure associated with Exercise G!