AT 621, Fall 2012

Homework #4

Due Wednesday, October 3

Problem 1.

Show that the local steady-state concentration of oxygen atoms in the Chapman mechanism is

$$[O] = \frac{j_{o_3}[o_3]}{k_2[o_2][M]}$$

And that the rates of formation and destruction of O_3 are $2R_1$ and $2R_4$ respectively (Where K_2, R_1 and R_4 correspond to reactions 1,2 and 4 of the Chapman mechanism on pages 142,143 in Seinfeld and Pandis.

Problem 2.

Estimate the lifetime of odd oxygen (i.e. ozone) at 20 km and 45 km. It may be assumed that the photolysis rates of ozone at these two altitudes are (see Figure 4.14, Seinfeld and Pandis)

j_{O3} = $7*10^{-4}$ s^{-1} at 20 km
= $6*10^{-3}$ s^{-1} at 45 km

and that O_3 concentrations at the two altitudes are (see figure 5.2, Seinfeld and Pandis)

$[O_3]$ = $2*10^{12}$ molecules cm^{-3} at 20km
= $0.2 * 10^{12}$ molecules cm^{-3} at 45km

Problem 3.

a. Write out the catalytic ozone loss cycle that is initiated by the self-reaction of CLO, which is a key cycle for loss of polar ozone.
b. The ozone abundance at 20km altitude fell from 2.0 ppm on August 23 to .8 ppm on September 22. Assuming that the self-reaction of CLO is the rate-limiting step for ozone loss at 20km, calculate the mixing ratio of CLO required to account for the observed loss of ozone. Assume T=200K and p=60mbar. Since the catalytic cycle involves a photolytic process, it occurs only during periods of daylight. Between August 23 and September 22, air in the polar vortex experiences roughly 8h of sunlight per day.

Problem 4.

Problem 5.11 in Seinfeld and Pandis text, Second Edition (parts a and b only).