

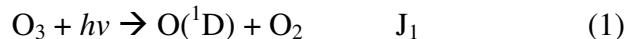
ATMO 363: Atmospheric Chemistry
Problem Set 4

- (1) In a cloud event with a liquid water content of 4.5 g m^{-3} , estimate the equilibrium distributions between the gas phase and the liquid phase for CO_2 , NH_3 , and H_2CO . Discuss how the wet deposition process can influence their atmospheric distributions.
- (2) Consider a system prepared by mixing pure air (consisting of O_2 and N_2 only) with NO_2 and exposed to the solar radiation. Assume that only the following reactions take place in the system:



Obtain an expression, with suitable approximations, for the steady-state ozone concentration $[\text{O}_3]_{\text{ss}}$, as a function of J_1 , k_3 , and initial NO_2 concentration. Compute $[\text{O}_3]_{\text{ss}}$, assuming $J_1 = 5 \times 10^{-3} \text{ s}^{-1}$, $k_3 = 1.8 \times 10^{-14} \text{ cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$, and $[\text{NO}_2]_0 = 10^{13} \text{ molecule cm}^{-3}$.

- (3) The main tropospheric source of hydroxyl radical OH is thought to be photolysis,



followed by reaction between H_2O and $\text{O}(^1\text{D})$,



$\text{O}(^1\text{D})$ can be thermalized in collision with O_2 and N_2 molecules. The following data may be used at a temperature of 288 K in the planetary boundary layer,

$$\begin{aligned} [\text{O}_3] &= 5 \times 10^{11} \text{ molecule cm}^{-3} \\ [\text{H}_2\text{O}] &= 2.5 \times 10^{16} \text{ molecule cm}^{-3} \\ [\text{N}_2] &= 1.99 \times 10^{19} \text{ molecule cm}^{-3} \\ [\text{O}_2] &= 5.33 \times 10^{18} \text{ molecule cm}^{-3} \\ J_1 &= 3 \times 10^{-4} \text{ s}^{-1} \end{aligned}$$

The Arrhenius coefficients for the relevant reactions are given,

	$A, \text{ cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$	$Ea/R, \text{ K}$
$\text{O}(^1\text{D}) + \text{H}_2\text{O} \rightarrow 2\text{OH}$	2.2×10^{-10}	0
$\text{O}(^1\text{D}) + \text{N}_2 \rightarrow \text{O}(^3\text{P}) + \text{N}_2$	1.8×10^{-11}	-110
$\text{O}(^1\text{D}) + \text{O}_2 \rightarrow \text{O}(^3\text{P}) + \text{O}_2$	3.2×10^{-11}	-70

- (i) What fraction of $\text{O}(^1\text{D})$ reacts to form hydroxyl radicals ?
- (ii) What is the concentration of $\text{O}(^1\text{D})$ at the steady state ?
What is the production rate of hydroxyl radicals, when $\text{O}(^1\text{D})$ is in the steady state?