Chemical Principles of Environmental Science 11:375:202

Homework 2: Tropospheric chemistry

BE SURE TO SHOW ALL WORK NEATLY ON A SEPARATE PAGE
Due: September 30, 2009

1. The rate limiting step leading to the production of formaldehyde (H_2CO) in the troposphere is the oxidation of methane:

$$CH_4 + OH\cdot \xrightarrow{k_1} CH_3\cdot + H_2O \qquad k_1 = 7.7 \times 10^{-15}\ cm^3\ molecule^{-1}\ s^{-1}\ (25°C)$$

Formaldehyde loss depends on the photolysis of H_2CO:

$$H_2CO \xrightarrow{k_2} H\cdot + HCO \qquad k_2 = 4.5 \times 10^{-5}\ s^{-1}\ (25°C)$$

a.(1) Write an expression for the steady-state concentration of H_2CO in the troposphere.

b.(2) Assuming a temperature of 25°C and a pressure of 1 atm, calculate the steady-state **number density** of H_2CO based on chemical reactions in the troposphere given that the concentration of CH_4 is 1.5 ppm and that of $OH\cdot$ is 10^6 molecules cm^{-3}.

c.(1) In addition to the oxidation of methane in the troposphere, there are a number of sources and sinks of H_2CO in urban environments including dry deposition to surfaces, vertical mixing, and emissions from synthetic materials and industry. Using $R_{sources}$ and R_{sinks} to represent the urban sources and sinks of H_2CO, modify your answer to 1.a. and write a new equation for the steady-state concentration of H_2CO.

d.(2) The average **measured** summertime concentration of H_2CO in some urban areas is 6 ppb. Based on this observation and your answer to 1.b., are urban areas ***net*** sources or sinks of H_2CO?

2. The net reaction for the oxidation of ethene is:

$$H_2C{=}CH_2 + 3OH\cdot + 8O_2 + NO\cdot \rightarrow 2CO_2 + 7HOO\cdot + NO_2\cdot$$

a.(1) What are the oxidation states of C, N, and O in each reactant and product of this reaction?
b.(1) How many electrons are lost or gained by **all** C atoms in this reaction?
c.(1) How many electrons are lost or gained by **all** N atoms in this reaction?
d.(1) How many electrons are lost or gained by **all** O atoms in this reaction?