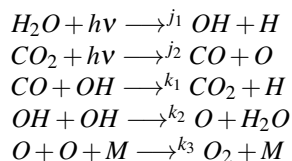


## Unit 15 ATM401, ATM601 and CHEM601

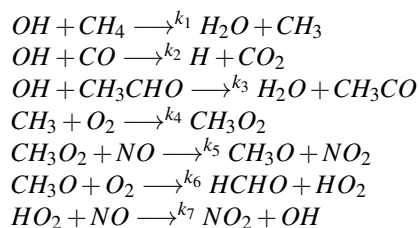
### Application, analysis, and evaluation

1. All students: In the United States, the total sulfur dioxide and nitrogen oxide emissions amount to  $19.9 \cdot 10^6 t$  and  $21.3 \cdot 10^6 t$ , respectively. Transport accounts for 3.3% of the sulfur dioxide total and 44.5 % of the nitrogen oxide total. Determine the ratio of the total amount of nitrogen oxide generated by transport to the total amount of sulfur dioxide produced by transport.
2. Undergraduate students: Ammonia ( $NH_3$ ) makes up a partial fractions of  $10^{-8}$  % of the atmosphere, which has a mass of about  $5 \cdot 10^{18} kg$ . About  $5 \cdot 10^{10} kg/y$  of  $NH_3$  escape to space. Determine the residence time of  $NH_3$ .
3. Undergraduate students: Water and  $CO_2$  can be photolysed. The combined photolytic reaction chain of water and  $CO_2$  reads



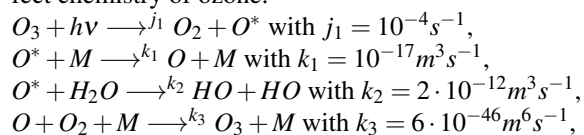
Determine the net balanced reaction, the change in  $CO_2$  and comment on whether the inclusion of  $CO_2$  alters the net reaction of the photolysis series of  $H_2O$  alone. How many water molecules are required to form one  $O_2$  molecule?

4. Graduate students: In an urban atmosphere, the following reactions may occur:

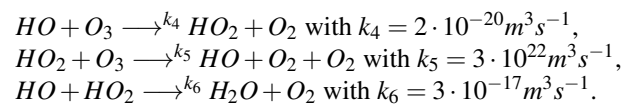


Determine the net balanced reaction. How many  $NO_2$  molecules result from two  $CH_4$  molecules? What would happen if  $CH_4$  oxidized  $NO$  and  $NO_2$  without consuming  $O_3$ ?

5. Graduate students: In the stratosphere, the following reactions significantly affect chemistry of ozone:



2



Here again  $O^*$  is an electronically excited metastable state of atomic oxygen.

At that height assume that the molecular density, the molecular fraction of water vapor, ozone, and oxygen are equal to  $5 \cdot 10^{23} m^{-3}$ ,  $2 \cdot 10^{-6}$ ,  $2 \cdot 10^{-6}$ , and 0.2, respectively. Determine the steady state molecular fraction of  $O^*$ ,  $HO$ , and  $HO_2$ .