Problem: 12-11

Given: Air composed of O_2, O, N_2, N, and NO at 1000 K and 1 atm.
Only N_2 and O_2 are present at room temperature in a ratio of 3.76:1

Find: Equilibrium composition

There are 5 unknowns $\Rightarrow X_{O_2}, X_O, X_{N_2}, X_N, X_{NO}$. Therefore we need 5 equations.

1. We know that $\sum X_i = 1$. Therefore

$$X_{O_2} + X_O + X_{N_2} + X_N + X_{NO} = 1$$

2. At room temperature, only N_2 and O_2 are present in a ratio of 3.76 N_2 to 1 O_2. These dissociate to O, N, and NO at higher temperatures but the number of N and O atoms must be conserved. Therefore

$$\frac{\sum N_{atoms}}{\sum O_{atoms}} = 3.76$$

or

$$\frac{2X_{N_2} + X_N + X_{NO}}{2X_{O_2} + X_O + X_{NO}} = 3.76$$

The other 3 equations are K-equations from Table B.14

$$O_2 \rightleftharpoons 2O \qquad \frac{X_O^2}{X_{O_2}} = 10^{-19.44} = 3.63 \times 10^{-20}$$

$$N_2 \rightleftharpoons 2N \qquad \frac{X_N^2}{X_{N_2}} = 10^{-31.084} = 8.24 \times 10^{-32}$$

$$\frac{1}{2}O_2 + \frac{1}{2}N_2 \rightleftharpoons NO \qquad \frac{X_{NO}}{X_{O_2}^{1/2} X_{N_2}^{1/2}} = 10^{-4.068} = 8.55 \times 10^{-5}$$

Now solve for the 5 unknowns using the 5 equations (this is not easily accomplished)

$$
\begin{aligned}
X_{O_2} &= \boxed{0.201} \\
X_O &= \boxed{8.733 \times 10^{-11}} \\
X_{N_2} &= \boxed{0.7899} \\
X_N &= \boxed{2.5514 \times 10^{-16}} \\
X_{NO} &= \boxed{3.4831 \times 10^{-5}}
\end{aligned}
$$