14.25

initial state: 1 kmole CO
4.76 kmole dry air

final state: unknown amounts of CO_2, CO, O_2, N_2

(equilibrium) $T = 3000\,K$, $p = 1$ atm

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initial → 1 CO + 1(3.76 N_2 + O_2) → final $\alpha\,CO_2 + \beta\,CO + \gamma\,O_2 + \delta\,N_2$

↑ kmoles

atomic mass balance requires

C: $1 = \alpha + \beta$ ⟶ $\beta = 1 - \alpha$

O: $1 + 2 = 2\alpha + \beta + 2\gamma \Rightarrow 3 = 2\alpha + 1 - \alpha + 2\gamma$ $\gamma = \frac{2-\alpha}{2}$

N: $\delta = 3.76$

$$1\,CO + 3.76\,N_2 + O_2 \rightarrow \alpha\,CO_2 + (1-\alpha)\,CO + \frac{2-\alpha}{2}\,O_2 + 3.76\,N_2$$

N_2 plays no chemical role (although it plays a role in determining mole fractions).

The Reaction involves CO, O_2, CO_2

A-27 ⇨ $CO_2 \rightleftharpoons CO + \frac{1}{2}O_2$

↳ $\log_{10} K(3000K) = -0.485$ $\underline{K = 0.327}$

$$K = \frac{y_{CO}\, y_{O_2}^{1/2}}{y_{CO_2}} \left(\frac{1}{1}\right)^{1+\frac{1}{2}-1}$$

$$n_{TOT} = \alpha + 1 - \alpha + \frac{2-\alpha}{2} + 3.76 = 5.76 - \frac{\alpha}{2}$$

$$y_{CO} = \frac{1-\alpha}{5.76 - \frac{\alpha}{2}} \qquad y_{CO_2} = \frac{\alpha}{5.76 - \frac{\alpha}{2}} \qquad y_{O_2} = \frac{\frac{2-\alpha}{2}}{5.76 - \frac{\alpha}{2}}$$

↳

$$.327 = \frac{\left(\frac{1-\alpha}{5.76-\frac{\alpha}{2}}\right)\left(\frac{\frac{2-\alpha}{2}}{5.76-\frac{\alpha}{2}}\right)^{1/2}}{\frac{\alpha}{5.76-\frac{\alpha}{2}}} = \left(\frac{1-\alpha}{\alpha}\right)\sqrt{\frac{2-\alpha}{11.52-\alpha}}$$

$$.327 = \frac{1-\alpha}{\alpha}\sqrt{\frac{2-\alpha}{11.52-\alpha}}$$

solve iteratively $\Rightarrow$ $\alpha = 0.528$

Hence final composition is

CO_2	:	0.528 kmoles
CO	:	0.472 kmoles
O_2	:	0.736 kmoles
N_2	:	3.76 kmoles

4.25 continued