PROBLEM 13.24

KNOWN: Carbon burns with 80% theoretical air yielding CO_2, CO, and N_2 only.

FIND: Determine (a) the balanced reaction equation, (b) AF, (c) the analysis of the products on a molar basis.

ASSUMPTIONS: 3.76 moles of N_2 accompany each mole of O_2 in the air, and N_2 is inert.

ANALYSIS: (a) Complete combustion of C with the theoretical amount of air is described by

$$C + (O_2 + 3.76 N_2) \rightarrow CO_2 + 3.76 N_2$$

Thus, combustion with 80% theoretical air to produce CO_2, CO, and N_2 is

$$C + 0.80(O_2 + 3.76 N_2) \rightarrow a\, CO_2 + b\, CO + (0.80)(3.76) N_2$$

C: $1 = a + b \Rightarrow b = 1 - a$

O: $(.80)(2) = 2a + b \Rightarrow 1.6 = 2a + (1-a) \Rightarrow a = 0.6,\ b = 0.4$

Accordingly, the balanced reaction equation is

$$C + 0.80(O_2 + 3.76 N_2) \rightarrow 0.6\, CO_2 + 0.4\, CO + 3.008\, N_2 \quad \text{(a)}$$

(b) The air fuel ratio is

$$\overline{AF} = 0.80(4.76)/1 = 3.808 \text{ kmol(air)/kmol(fuel)}$$

Then with Eq. 13-2

$$AF = \overline{AF}\left(\frac{M_{air}}{M_{fuel}}\right) = (3.808)\left(\frac{28.97}{12.01}\right) = 9.19 \frac{\text{kg(air)}}{\text{kg(fuel)}} \quad \text{(b)}$$

(c) The molar analysis of the products is

$$\%\, CO_2 = \left(\frac{0.6}{4.008}\right)(100) = 15\%,\ \%\, CO = \frac{0.4}{4.008} = 10\%,\ \%\, N_2 = 75\% \quad \text{(c)}$$

PROBLEM 13.25

KNOWN: C_3H_8 reacts with 80% of theoretical air yielding CO_2, CO, H_2O and N_2 only.

FIND: Determine (a) the balanced reaction equation, (b) AF, (c) the analysis of the products on a dry molar basis.

ASSUMPTIONS: 3.76 moles of N_2 accompany each mole of O_2 in the air, and N_2 is inert.

ANALYSIS: (a) Complete combustion of C_3H_8 with the theoretical amount of air is described by

$$C_3H_8 + 5(O_2 + 3.76 N_2) \rightarrow 3 CO_2 + 4 H_2O + 18.8 N_2$$

Combustion with 80% of theoretical air is then

$$C_3H_8 + 4(O_2 + 3.76 N_2) \rightarrow x\, CO_2 + y\, CO + z\, H_2O + 15.04 N_2$$

C: $3 = x + y \Rightarrow y = 3 - x$

H: $8 = 2z \Rightarrow z = 4$

O: $8 = 2x + y + 4 \Rightarrow 4 = 2x + (3-x) \Rightarrow x = 1,\ y = 2$

Accordingly

$$C_3H_8 + 4(O_2 + 3.76 N_2) \rightarrow CO_2 + 2\, CO + 4\, H_2O + 15.04 N_2 \quad \text{(a)}$$

(b) $$AF = \overline{AF}\left(\frac{M_{air}}{M_{fuel}}\right) = (4)(4.76)\left[\frac{28.97}{44.09}\right] = 12.51 \frac{\text{kg(air)}}{\text{kg(fuel)}} \quad \text{(b)}$$

(c) The amount of dry products per mole of fuel is $n_{dry} = 1 + 2 + 15.04 = 18.04$. Thus, the analysis of the products on a dry basis is (c)

$$y_{CO_2} = \frac{1}{18.04} = 0.0554\ (5.54\%),\ y_{CO} = \frac{2}{18.04} = 0.1109\ (11.09\%),\ y_{N_2} = \frac{15.04}{18.04} = 0.8337\ (83.37\%)$$