34.15 A fuel composed of 40% methane, 49% propane, and 11% nitrogen is burned in air. A dry gas analysis shows the product gas to contain 7% carbon dioxide, 4% carbone monoxide, 5% oxygen, and 84% nitrogen. What is the air-to-fuel ratio?

A. $13 \frac{lb_{air}}{lb_{fuel}}$

B. $15 \frac{lb_{air}}{lb_{fuel}}$

C. $17 \frac{lb_{air}}{lb_{fuel}}$

D. $19 \frac{lb_{air}}{lb_{fuel}}$

Since two hydrocarbons are being mixed, the blended fuel is not a Common Fuel Constituent. Write the unbalanced reaction using the percentages as coefficients for each reactant or product. Assign an arbitrary constant, a, to the quantity of air since the air to fuel ratio is unknown. Use a ratio of 3.77 nitrogren molecules per oxygen molecule in air. Assign a second constant, b, to the entire set of dry products. Assign a third constant, c, to water vapor, which is a product of any combustion reaction but is omitted from dry analysis.

$$40CH_4 + 49C_3H_8 + 11N_2 + a\left(O_2 + 3.77N_2\right) \rightarrow b\left(7CO_2 + 4CO + 5O_2 + 84N_2\right) + cH_2O$$

Balance the carbon. Refer to the Periodic Table to gather molar mass values as needed.

$$40 + 3\left(49\right) = b\left(7 + 4\right)$$

$$b = 17$$

Balance the hydrogen.

$$4\left(40\right) + 8\left(49\right) = 2c$$

$$c = 276$$

Balance the oxygen.

$$2a = 17\left[2\left(7\right) + 4 + 2\left(5\right)\right] + 276$$

$$a = 376$$

Perform an optional check of the nitrogen balance if time allows. Inconsistencies at this stage may point to mistakes earlier in the solution.

$$2\left(11\right) + 2\left(3.77\right)\left(376\right) = 2\left(84\right)\left(17\right)$$

$$2857 \approx 2856 \checkmark$$

Calculate the air-to-fuel ratio by dividing the mass of air by the mass of fuel, both from the product side of the reaction.

$$\frac{A}{F} = \frac{m_{air}}{m_{fuel}} = \frac{376\left[2\left(16\right) + 3.77\left(2\right)\left(14\right)\right]}{40\left[12 + 4\right] + 49\left[3\left(12\right) + 8\right] + 11\left[14\left(2\right)\right]} = 16.7\frac{lb_{air}}{lb_{fuel}}$$

Answer C