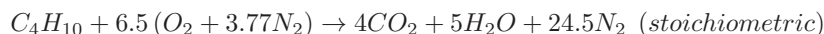


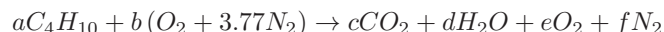
34.10 A dry product analysis of the flue gas after butane is burned in air shows that the products contain 5.6% O_2 and 10.2% CO_2 . How much excess air was in the reaction?

- A. 8%
- B. 26%
- C. 34%
- D. 40%

Start by writing the stoichiometric reaction for butane burned in air. The formula shown in the table **Combustion Reactions of Common Fuel Constituents** omits nitrogen because it does not participate in the combustion process, however nitrogen does appear in the dry product analysis. Water is not included in the dry product analysis. Include 3.77 molecules of nitrogen for every molecule of oxygen as this is the naturally occurring ratio in atmospheric air. Note the air to fuel ratio on a volume or molar basis is 6.5 when there is no excess air.



Write another reaction for the excess air scenario and initially include variables before each product or reactant to account for unknown values. Also include an oxygen product since excess O_2 will be provided and remain unburned.



Consider the products, ignoring water as it is omitted from the dry product analysis, and use the percentages given as the number of moles of each product. Since the dry products must add to 100%, calculate the moles of nitrogen.

$$c = 10.2$$

$$e = 5.6$$

$$c + e + f = 100$$

$$f = 100 - c - e = 100 - 10.2 - 5.6 = 84.2$$

Balance the carbon.

$$4a = c$$

$$a = \frac{c}{4} = \frac{10.2}{4} = 2.55$$

Balance the hydrogen.

$$10a = 2d$$

$$d = 5a = 5(2.55) = 12.75$$

Balance the oxygen.

$$2b = 2c + d + 2e$$

$$b = \frac{2c + d + 2e}{2} = \frac{2(10.2) + 12.75 + 2(5.6)}{2} = 22.2$$

Check the nitrogen balance. Expect a small amount of error due to rounding.

$$2(3.77)b = 2f$$

$$2(3.77)(22.2) = 2(84.2)$$

$$167.4 \approx 168.4 \checkmark$$

Find the air to fuel ratio on a molar basis for the reaction with excess air.

$$\frac{air}{fuel} = \frac{b}{a} = \frac{22.2}{2.55} = 8.71$$

Compare the air to fuel ratio obtained with the original stoichiometric reaction and calculate the excess as a percentage.

$$excess\ air = \frac{8.71 - 6.5}{6.5} = 34\%$$

Answer C