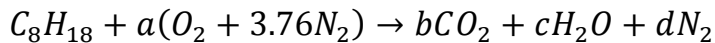


Example (3.2) Determine the air–fuel ratio on both a molar and mass basis for the complete combustion of octane, C_8H_{18} , with (a) the theoretical amount of air, (b) 150% theoretical air (50% excess air).

Solution

(a) For complete combustion of C_8H_{18} with the theoretical amount of air, the products contain carbon dioxide, water, and nitrogen only. That is



Applying the conservation of mass principle to carbon, hydrogen, oxygen, and nitrogen:

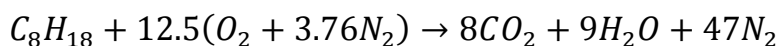
$$C: b = 8$$

$$H: 2c = 18 \rightarrow c = 9$$

$$O: 2b + c = 2a \rightarrow a = 12.5$$

$$N: d = 3.76a \rightarrow d = 47$$

Then the balanced chemical equation is:



The air-fuel ratio on molar basis is;

$$\overline{AF} = \frac{12.5(1+3.76)}{1} = 59.5 \text{ kmol air/kmol fuel}$$

The air-fuel ratio on mass basis is;

$$AF = \frac{m_{air}}{m_{fuel}} = \frac{(NM)_{air}}{(NM)_{fuel}} = \frac{(NM)_{air}}{(NM)_C + (NM)_{H_2}}$$

$$AF = \frac{(12.5 \times 4.76 \text{ kmol}) \times (29 \text{ kg/kmol})}{(8 \text{ kmol}) \times (12 \text{ kg/kmol}) + (9 \text{ kmol}) \times (2 \text{ kg/kmol})}$$

$$AF = 15.1 \text{ kg air/kg fuel}$$

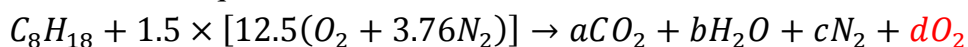
(b) For 150% theoretical air,

$$\overline{AF}_{150\%} = 1.5 \times 59.5 = 89.25 \text{ kmol air/kmol fuel}$$

$$AF_{150\%} = 1.5 \times 15.1 = 22.65 \text{ kg air/kg fuel}$$

OR,

the chemical equation for combustion takes the form;



Applying the conservation of mass;

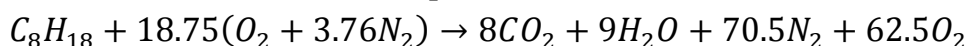
$$C: a = 8$$

$$H: 2b = 18 \rightarrow b = 9$$

$$O: 2a + b + 2d = 1.5 \times 12.5 \times 2 \rightarrow d = 6.25$$

$$N: c = 1.5 \times 12.5 \times 3.76 \rightarrow c = 70.5$$

Then the balanced chemical equation for 150% theoretical air is:



The air-fuel ratio on molar basis is;

$$\overline{AF}_{150\%} = \frac{18.75(1+3.76)}{1} = 89.25 \text{ kmol air/kmol fuel}$$

The air-fuel ratio on mass basis is;

$$AF_{150\%} = \frac{m_{air}}{m_{fuel}} = \frac{(NM)_{air}}{(NM)_{fuel}} = \frac{(NM)_{air}}{(NM)_C + (NM)_{H_2}}$$

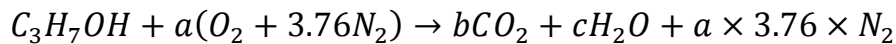
$$AF_{150\%} = \frac{(18.75 \times 4.76 \text{ kmol}) \times (29 \text{ kg/kmol})}{(8 \text{ kmol}) \times (12 \text{ kg/kmol}) + (9 \text{ kmol}) \times (2 \text{ kg/kmol})}$$

$$AF_{150\%} = 22.7 \text{ kg air/kg fuel}$$

Example (3.3) Propyl alcohol (C_3H_7OH) is burned with 50 percent excess air. Write the balanced reaction equation for complete combustion and determine the air-to-fuel ratio.

Solution:

For complete combustion of C_3H_7OH with the theoretical amount of air, the products contain carbon dioxide, water, and nitrogen only. That is



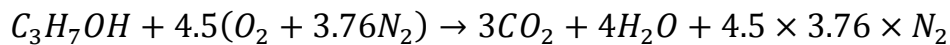
Applying the conservation of mass;

$$C: 3 = b$$

$$H: 8 = 2c \rightarrow c = 4$$

$$O: 1 + 2a = 2b + c = 6 + 4 = 10 \rightarrow a = \frac{9}{2} = 4.5$$

Then the balanced chemical equation for 150% theoretical air is:

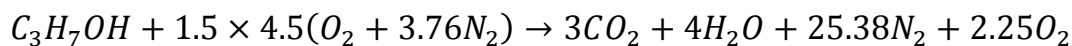


$$AF = \frac{m_{air}}{m_{fuel}} = \frac{(NM)_{air}}{(NM)_{fuel}} = \frac{(NM)_{air}}{(NM)_C + (NM)_{H_2} + (NM)_{O_2}}$$

$$AF = \frac{(4.5 \times 4.76 \text{ kmol}) \times (29 \text{ kg/kmol})}{(3 \text{ kmol}) \times (12 \text{ kg/kmol}) + (8 \text{ kmol}) \times (1 \text{ kg/kmol}) + (1 \text{ kmol}) \times (16 \text{ kg/kmol})}$$

$$AF = \frac{621.18}{60} = 10.353 \text{ kg air/kg fuel}$$

Then the balanced chemical equation for 150% theoretical air is:



$$AF_{150\%} = \frac{(6.75 \times 4.76 \text{ kmol}) \times (29 \text{ kg/kmol})}{(3 \text{ kmol}) \times (12 \text{ kg/kmol}) + (8 \text{ kmol}) \times (1 \text{ kg/kmol}) + (1 \text{ kmol}) \times (16 \text{ kg/kmol})}$$

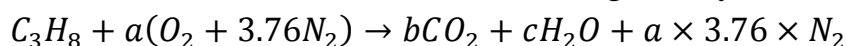
$$AF_{150\%} = \frac{931.77}{60} = 15.53 \text{ kg air/kg fuel}$$

$$\text{Or } AF_{150\%} = 1.5 \times 10.353 = 15.53 \text{ kg air/kg fuel}$$

Example (3.4) Propane (C_3H_8) is burned with 75 % excess air during a combustion process. Assuming complete combustion, determine the air–fuel ratio.

Solution:

For complete combustion of C_3H_8 with the theoretical amount of air, the products contain carbon dioxide, water, and nitrogen only, that is:



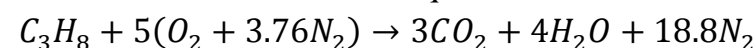
Applying the conservation of mass;

$$C: 3 = b$$

$$H: 8 = 2c \rightarrow c = 4$$

$$O: 2a = 2b + c = 6 + 4 = 10 \rightarrow a = \frac{10}{2} = 5$$

Then the balanced chemical equation for 100% theoretical air is:



$$AF_{100\%} = \frac{m_{air}}{m_{fuel}} = \frac{(NM)_{air}}{(NM)_{fuel}} = \frac{(NM)_{air}}{(NM)_C + (NM)_{H_2}}$$

$$AF_{100\%} = \frac{(5 \times 4.76 \text{ kmol}) \times (29 \text{ kg/kmol})}{(3 \text{ kmol}) \times (12 \text{ kg/kmol}) + (8 \text{ kmol}) \times (1 \text{ kg/kmol})}$$

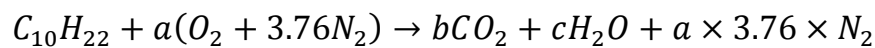
$$AF_{100\%} = \frac{690.2}{44} = 15.69 \text{ kg air/kg fuel}$$

$$AF_{175\%} = 1.75 \times 15.69 = 27.46 \text{ kg air/kg fuel}$$

Example (5.5) A certain fuel oil has the composition $C_{10}H_{22}$. If this fuel is burned with 150% theoretical air, what is the composition of the products of combustion?

Solution:

For complete combustion of $C_{10}H_{22}$ with the theoretical amount of air, the products contain carbon dioxide, water, and nitrogen only. That is

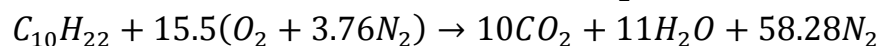


Applying the conservation of mass;

$$C: 10 = b$$

$$H: 22 = 2c \rightarrow c = 11$$

$$O: 2a = 2b + c = 20 + 11 = 31 \rightarrow a = \frac{31}{2} = 15.5$$



Then the balanced chemical equation for 150% theoretical air is:



Or

