31.8 Propane is burned with approximately 50% excess air as shown in the reaction below. What is the mass fraction of CO_2 in the combustion products?

$$C_3H_8 + 7.5O_2 + 28.2N_2 \rightarrow Combustion\ Products$$

A. 12%

B. 22%

C. 32%

D. 42%

As a starting point, refer to the table on Combustion Reactions of Common Fuel Constituents and note the stoichiometric reaction for propane and air. Note nitrogen is excluded since it does not participate in the reaction; however, it is present in both the reactants and products and should be included since its presense will influence the mass fraction of any other constituent.

The full stoichiometric reaction for propane is:

$$C_3H_8 + [5O_2 + 5\,(3.76)\,N_2] \rightarrow 3CO_2 + 4H_2O + 5\,(3.76)\,N_2$$

Increase the air by 50% on the reactance side and include oxygen on the product side. Incruduce variables coefficients to the product side of the reaction to allow for balancing.

$$C_3H_8 + 1.5\,[5O_2 + 5\,(3.76)\,N_2] \rightarrow aCO_2 + bH_2O + cO_2 + dN_2$$

$$C_3H_8 + 7.5O_2 + 28.2N_2 \rightarrow aCO_2 + bH_2O + cO_2 + dN_2$$

Balancing carbon shows that $a = 3$. Balancing hydrogen shows that $b = 4$. This is unchanged from the schoichiometric reaction.

Balancing nitrogen shows that $d = 28.2$, which makes sense since nitrogen doesn't react in the combustion process.

Balance oxygen to find c. Substitute known values for a and b.

$$(2)\,(7.5) = 2a + b + 2c$$

$$15 = 6 + 4 + 2c$$

$$c = 2.5$$

The final balance reaction for propane burned with 50% excess air is:

$$C_3H_8 + 7.5O_2 + 28.2N_2 \rightarrow 3CO_2 + 4H_2O + 2.5O_2 + 28.2N_2$$

To find the mass fraction of carbon dioxide in the reactants, use the Periodic Table to look up the atomic weights of each element as needed. Divide the mass of CO_2 by the total mass of all reactants.

$$m_{CO_2} = 3\left[12 + (16)\,(2)\right] = 132$$

$$m_{H_2O} = 4\left[(2)\,(1) + 16\right] = 72$$

$$m_{O_2} = 2.5\left[(2)\,(16)\right] = 80$$

$$m_{N_2} = 28.2\left[(2)\,(14)\right] = 789.6$$

$$\frac{m_{CO_2}}{m_{CO_2} + m_{H_2O} + m_{O_2} + m_{N_2}} = \frac{132}{132 + 72 + 80 + 789.6} = 0.12$$

Answer A