Env. Chemistry - Van Loon - Chapter 4

No. 1

$$4C_7H_{13} + 41O_2 \longrightarrow 28CO_2 + 26H_2O$$

$\Rightarrow$ $\underbrace{4 \times 97.18\,g}_{388.72\,g}$ $\underbrace{41 \times 32.0\,g}_{1312\,g}$

$\Rightarrow$ To be totally combusted, 388.72 g of C_7H_{13} need 1312 g of O_2.

Air is composed of several gases of which N_2, O_2, and Ar are the most important.

Based on Table 2.1 (book p. 21), the mixing ratios of these three components are:

$N_2 \rightarrow 78.08\%$ $\quad$ $O_2 \rightarrow 20.95$

$Ar \rightarrow 0.93\%$

$\Rightarrow$ 1 mole of air contains: 0.7808 mole of N_2,
0.2095 mole of O_2,
0.0093 mole of Ar

Masses: $N_2 = 0.7808 \times 28 = 21.86\,g$
$O_2 = 0.2095 \times 32 = 6.70\,g$
$Ar = 0.0093 \times 40 = 0.37\,g$

$\Rightarrow$ Total mass = 28.93 g

$\Rightarrow$ Mass of air needed $= 1312 \times \frac{28.93}{6.70} = 5665.1\,g$

$\Rightarrow$ Air to gasoline ratio is 5665.1 : 388.72 = 14.6 : 1

No. 8

$$\text{Biomass} \longrightarrow 3\{CH_2O\} \longrightarrow C_2H_5OH + CO_2$$

3 moles → 1 mole

$\Rightarrow$ 3×30 g → 46 g

$\Rightarrow$ 90 g of biomass will produce 46 g of ethanol

$\Rightarrow$ 1000 kg (1t) of biomass will produce 511 kg of ethanol based on 100% conversion of the biomass.

$$d = \frac{m}{V} \Rightarrow V = \frac{m}{d} \Rightarrow V = \frac{511}{0.79} = 647\ L$$

$\Rightarrow$ 100% conversion of the biomass will produce 647 L of ethanol

$\Rightarrow$ The efficiency of the process is $\frac{300}{647} \times 100\% = 46\%$ as efficient on a mass basis compared to the production of ethanol from biomass.

No. 9

for Heptane : $C_7H_{16} + 11\,O_2 \longrightarrow 7\,CO_2 + 8\,H_2O$

You can solve this part similarly to No. 1

The heptane to air mass ratio will be 1 : 15

for Ethanol: $C_2H_5OH + 3\,O_2 \longrightarrow 2\,CO_2 + 3\,H_2O$

46g $\quad \underbrace{3 \times 32\,g}_{96g}$

$\Rightarrow$ Mass of air needed $= 96 \times \frac{28.93}{6.70} = 414.5\,g$

$\Rightarrow$ Ethanol to air ratio is $46 : 414.5 = 1 : 9$

No. 11

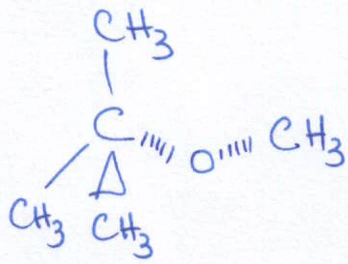
a) We assume that gasoline is pure octane (C_8H_{18})

As the oxygen content of a fuel is recommended to be 2.7%

$\Rightarrow$ 100 g of mixture require 2.7g oxygen (as O).

MTBE : $C_5H_{12}O$

M.W. 88.15 g/mol



$\Rightarrow$ the oxygen content in this molecule is:

$$\frac{16}{88.15} \times 100\% = 18.2\%.$$

As the only source of oxygen in the mixture is MTBE, so the quantity of MTBE required for this mixture is

$$\frac{2.7}{18.2} \times 100\% = 14.8\%$$

In 100g of mixture : 14.8g MTBE $\rightarrow 14.8 \times 0.182 = 2.7g$

85.2g $C_8H_{18} \rightarrow 85.2 \times 0 = 0$

100g mixture $\quad$ 2.7g O

b) A generic formula for bio diesel fuel is

C_2H_5COOR ($R = CH_3(CH_2)_n$, n typically = 14 – 18)

Let us consider n = 16 in this calculation

$\Rightarrow C_2H_5COO(CH_2)_{16}CH_3$ M.W = 312 g/mol

In this molecule, the oxygen content is

$$\frac{32}{312} \times 100\% = 10.3\%$$