

Solution for Problem T14

(a) Conservation of atoms :

Carbon : $A = C$	$C = A$	(1)
Hydrogen : $1.95A = 2D$	$D = \frac{1.95A}{2}$	(2)
Oxygen : $2B = 2C + D + 2E$	$E = B - A - \frac{1.95A}{4}$	(3)
Nitrogen : $3.76 \times 2B = 2F$	$F = 3.76B$	(4)

Impose 1 kg of reactants :

$$13.95A + \underbrace{(32 + 3.76 \times 28)}_{137.3} B = 1000 \quad (5)$$

Impose $f = 0.03$:

$$\frac{13.95A}{(32 + 3.76 \times 28)B} = 0.03 \quad (6)$$

Combine (6) and (5) : $13.95 \left(1 + \frac{1}{0.03}\right) = 1000$

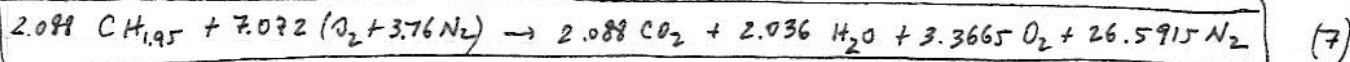
$A = 2.088 \frac{\text{mols Kero.}}{\text{kg}}$

and then

$$B = \frac{13.95 \times 2.088}{0.03 \times 137.3}$$

$B = 7.072 \frac{\text{mols air}}{\text{kg}}$

The other coefficients follow from (1)-(4), with the result



(b) For a first approximation, $\dot{m}_f h = \dot{m}_a c_p (T - T_{in})$, or

$$T = T_{in} + f \frac{h}{c_p} \quad (8)$$

Using $h = 43 \times 10^6 \text{ J/kg fuel}$, $c_p = 1005 \text{ J/kg/K}$ (as pure air), we find

$$T = 600 + 0.03 \frac{43 \times 10^6}{1005} \quad \boxed{T = 1884 \text{ K}}$$

A more realistic estimate of c_p would be that for heated air, for which $\gamma = 1.3$ is sometimes assumed. This means

$$c_p = \frac{1.3}{0.3} \frac{8.314}{0.0288} = 1249 \text{ J/kg/K}. \text{ With this } c_p, \underline{\underline{T = 1632 \text{ K}}}$$