PART 1 - A

Equations

$$\text{function}\ \ getenthalpy(S\$,\ T) \tag{1}$$

This function uses the NASA external procedure to return the enthalpy of species S$ at T.

$$\text{call}\ \ NASA(S\$,\ T : cp,\ geTenthalpy,\ s) \tag{2}$$

$$\text{end}\ \ getenthalpy \tag{3}$$

Considering that for this segment, the equilibrium equations are not given to us, we assume the only tool in our disposal for figuring out the mole fractions in the products in conservation of mass.

0.9 CH_4 + a_1 (O_2 + 3.76 N_2) $\longleftrightarrow$ b_1 CO_2 + c_1 H_2O + d_1 N_2 + e_1 O_2 + f_1 C_2H_6
0.1 C_2H_6 + a_2 (O_2 + 3.76 N_2) $\longleftrightarrow$ b_2 CO_2 + c_2 H_2O + d_2 N_2 + e_2 O_2 + f_2 C_2H_6
this form of the equation too is sufficiently good enough if we use HR_1 + HR_2 = HP_1 + HP_2, but if we change our energy equation to HR_1 = HP_1 & HR_2 = HP_2 meaning we assume that the two combustion reactions are completely isolated from eachother (there is no heat exchange between them). here we are finally able to solve for our mole fractions only after removing O2 from out products. I did not opt for this solution however as it seemed to make one asumption too many
Thus we arrive to the solution I found the most satisfying:

0.9 CH_4 + 0.1 C_2H_6 + a (O_2 + 3.76 N_2) $\longleftrightarrow$ b CO_2 + c H_2O + d N_2 + e O_2 + $>>>$f CH_4 + g $C_2H_6$$<<<$
OR
$C_{1.1}H_{4.2}$ + a (O_2 + 3.76 N_2) $\longleftrightarrow$ b CO_2 + c H_2O + d N_2 + e O_2 + $>>>$f $C_{1.1}H_{4.2}$$<<<$
by combining the CH4 and the C2H6 fuels into a hybrid C1.1H4.2 (just as how we did it for natual gas) our equation is finally solveable. the only downside is that we cannot determine that in our unbernt fuel what percentage is CH4 and what amount of it belongs to C2H6, but since our problem only is only concerend with input air, I found this to be an acceptable compromise

$$T_{air} = 460\ \text{[K]} \tag{4}$$

$$T_{fuel} = 430\ \text{[K]} \tag{5}$$

$$T_{final,1} = 1700\ \text{[K]} \tag{6}$$

$$T_{final,2} = 1600\ \text{[K]} \tag{7}$$

$$T_{final,3} = 1300\ \text{[K]} \tag{8}$$

$$h_{N2,inlet} = getenthalpy(\text{'N2'}\ ,\ T_{air}) \tag{9}$$

$$h_{O2,inlet} = getenthalpy(\text{'O2'}\ ,\ T_{air}) \tag{10}$$

$$h_{CH4,inlet} = getenthalpy(\text{'CH4'}\ ,\ T_{fuel}) \tag{11}$$

$$h_{C2H6,inlet} = getenthalpy(\text{'C2H6'}\ ,\ T_{fuel}) \tag{12}$$

$$h_{fuel,inlet} = 0.9 \cdot h_{CH4,inlet} + 0.1 \cdot h_{C2H6,inlet} \tag{13}$$

Stoichiometry for a basis of 1 kmol of fuel

$$1.1 = b \qquad \text{Carbon balance} \tag{14}$$

$$4.2 = 2 \cdot c \qquad \text{Hydrogen balance} \tag{15}$$

duplicate $i = 1,\ 3$ (16)

Stoichiometry for a basis of 1 kmol of fuel - Continued

$$2 \cdot a_i = 2 \cdot b + c + 2 \cdot e_i \quad \text{Oxygen balance} \tag{17}$$

$$3.76 \cdot 2 \cdot a_i = 2 \cdot d_i \quad \text{Nitrogen balance} \tag{18}$$

The following equations provide the enthalpy for each chemical species at the inlet tempretures and T_{final} and the reference pressure of 10 bar. The NASA external procedure is used in the Function getenthalpy to calculate h at the equilibrium temperature, which is determined from an energy balance.

$$h_{CO2,i} = getenthalpy(\text{'CO2'}\ ,\ T_{final,i}) \tag{19}$$

$$h_{H2O,i} = getenthalpy(\text{'H2O'}\ ,\ T_{final,i}) \tag{20}$$

$$h_{N2,i} = getenthalpy(\text{'N2'}\ ,\ T_{final,i}) \tag{21}$$

$$h_{O2,i} = getenthalpy(\text{'O2'}\ ,\ T_{final,i}) \tag{22}$$

$h_{CH4,i}$ = getenthalpy('CH4',$T_{final,i}$)
$h_{C2H6,i}$ = getenthalpy('C2H6',$T_{final,i}$)
$h_{fuel,i}$ = 0.9 * $h_{CH4,i}$ + 0.1 * $h_{C2H6,ionly}$ truly accurate if our fuels burn at a rate proportional to their initial molar fraction, but is servisable enough as an estimate
Find the enthalpy of the reactants

$$HR_i = h_{fuel,inlet} + a_i \cdot h_{O2,inlet} + 3.76 \cdot a_i \cdot h_{N2,inlet} \tag{23}$$

Find the enthalpy of products

$$HP_i = b \cdot h_{CO2,i} + c \cdot h_{H2O,i} + d_i \cdot h_{N2,i} + e_i \cdot h_{O2,i} \tag{24}$$

Apply an adiabatic energy balance to determine the product temperature

$$HR_i = HP_i \tag{25}$$

end (26)

1 kmol of fuel weighs the same as 0.9 kmol of CH4 and 0.1 kmol of C2H6, = 0.9 * 16.043 + 0.1 * 30.07 = 17.4457 kg/kmol, so 0.07 kg/s fuel equals to 0.0040124501 kmol/s of fuel.
and as 1 kmol of air weighs 28.97 kg/kmol, then a kmols of air per 1 kmol of fuels equals [0.0040124501*28.97]*a = 0.1162406782*a kg/s of air for 0.07 kg/s fuel

$$\dot{m}_1 = (1 + 3.76) \cdot a_1 \cdot 0.1162406782\ \text{[kg/s]} \tag{27}$$

$$\dot{m}_1 + \dot{m}_2 = (1 + 3.76) \cdot a_2 \cdot 0.1162406782\ \text{[kg/s]} \tag{28}$$

$$\dot{m}_1 + \dot{m}_2 + \dot{m}_3 = (1 + 3.76) \cdot a_3 \cdot 0.1162406782\ \text{[kg/s]} \tag{29}$$