MCG2131 Midterm 12 February 2009

1. (a) Volume fraction = mol fraction, convert to mass:

Mean molecular mass M = 13.4 kg/kmol, $Y_{CH4} = 0.418$, $Y_{H2} = 0.060$, $Y_{N2} = 0.522$.

(b) use gas law for whole mixture, with $R = \mathscr{R}/M = 0.6204$, get m = 1.10 kg.

2. (a) Psych. chart shows line moving horizontally left to dew point, then down saturation line to state 2. Reheat is line extending horizontally right from 2 to final state.

(b) $p_V = \phi\ P_{SAT}$ @ 40°C = 5.169 kPa, then $\omega = 0.0339$.

With $h_g = 2574.3$, $T_{REF} = -20°C$, $h_A = 147.5$ kJ/kg.

$T_{DP} = T_{SAT}$ @ $p_V = 33.3°C$ by interpolation in the steam table.

(c) Use perfect gas law with $p_a = P - p_V$ and R_a, get mass flow rate = 1.759 kg/s dry air.

(d) Temperature after cooling found by tracing constant ω line from final state back to saturation line, which gives $T_2 = 14°C$. From chart read $\omega_2 = 0.0098$ kg/kg dry, $h_{A2} = 58.5$ kJ/kg dry.

Water balance gives water removal rate as 0.0424 kg/s.
Energy balance: assume enthalpy of liquid leaving = h_f @ $T_2 = 58.8$ kJ/kg, then Q = - 154 kW.

3. (a) Stoichiometric combustion: for 1 kg wood

(0.5/12 C + 0.06/1 H + 0.44/16 O) + 0.0429 (O_2 + 3.76 N_2) → 0.0417 CO_2 + 0.03 H_2O + 0.1614 N_2

(b) Actual combustion: assume 100 kmol dry products (i.e. $CO_2 + O_2 + N_2$) = 100. Equation balances to

120 kg (0.5/12 C + 0.06/1 H + 0.44/16 O) + 21.04 (O_2 + 3.76 N_2) →

5 CO_2 + 3.6 H_2O + 0 CO + 15.89 O_2 + 79.11 N_2

Actual O_2 for 1 kg fuel = 21.04/120 = 0.1753

XS air = 0.1753/0.0429 - 1 = **309%.**