1) For every 100kmol of mixture,

$m_{O_2} = 30 \times 31.999 = 959.97 kg$

$m_{N_2} = 40 \times 28.013 = 1120.52 kg$

$m_{CO_2} = 10 \times 44.01 = 440.1 kg$

$m_{CH_4} = 20 \times 16.043 = 320.86 kg$

Total mass $= 959.97 + 1120.52 + 440.1 + 320.86$

$= 2841.45 kg$

$mf_{O_2} = \frac{954.97}{2841.5} = 0.337839169 5$

$mf_{N_2} = \frac{1120.52}{2841.5} = 0.3943410171$

$mf_{CO_2} = \frac{440.1}{2841.5} = 0.1548829843$

$mf_{CH_4} = \frac{320.86}{2841.5} = 0.1129192328$

$c_p = \sum mf_i c_{pi}$

$= 0.337839169 5(0.918) + 0.3943410171(1.039) +$
$0.1548829843(0.846) + 0.5182(2.2537)$

$= 1.105373754 kJ kg^{-1} K^{-1}$

$q = c_p \Delta T$

$= 1.105373754(200-20)$

$= 198.9672757 kJ kg^{-1}$

$\simeq 199 kJ kg^{-1}$

2) $n_{O_2} = \frac{1}{31.999} = 0.031250977659\,kmol$

$$PV = n_{N_2}RT$$

$$n_{N_2} = \frac{PV}{RT}$$

$$n_{N_2} = \frac{500 \times 2}{8.314(273.15+50)}$$

$$= 0.372208099\,6\,kmol$$

$$V_{O_2} = \frac{\frac{1}{31.999} \times 8.314(273.15+15)}{300}$$

$$= 0.249557704\,9\,m^3$$

a) $PV = nRT$

$$P = \frac{nRT}{V}$$

$$= \frac{\left(\frac{1}{31.999} + 0.372208099\,6\right) \times 8.314 \times (273.15+25)}{0.249557704\,9 + 2}$$

$$= 444.577199\,3\,kPa$$

$$\simeq 444.6\,kPa$$

2b) $m_{N_2} = 0.3722080966\,(28.013)$

$= 10.42666549\,kg$

$Q = m_{N_2} c_p \Delta T + m_{O_2} c_p \Delta T$

$= 10.42666549(0.743)(50-25) + 1(0.658)(15-25)$

$= 187.0953116\,kJ$

$\simeq 187.1\,kJ$

c) $nf_{O_2} = \dfrac{0.0312509765}{0.0312509765 + 0.3722080966}$

$= 0.07745761202$

$nf_{N_2} = \dfrac{0.3722080966}{0.0312509765 + 0.3722080966}$

$= 0.9225423888$

$P_{O_2} = 0.07745761202 \times 444.5771993$

$= 34.43588822$

$P_{N_2} = 0.9225423888 \times 444.5771993$

$= 410.1413111$

2c) $\Delta S_g = 10.426665 49\left[1.0391\ln\left(\frac{273.15+25}{273.15+50}\right) - 0.2968\ln\left(\frac{410.1413}{500}\right)\right]$

$+ 1\left[0.9181\ln\left(\frac{273.15+25}{273.15+15}\right) - 0.2598\ln\left(\frac{34.435886822}{300}\right)\right]$

$= 0.3344727964\ kJK^{-1}$

$\Delta S_{surr} = \frac{187.09533116}{273.15+25}$

$= 0.62752075\ kJK^{-1}$

$S_{gen} = 0.3344727964 + 0.62752075$

$= 0.9619935464$

$\approx 0.962\ kJK^{-1}$

3a) $\omega = \frac{0.17}{15}$

$= 0.0113\dot{}$

$\simeq 0.01133$

b) $\phi = \frac{\omega P}{(0.622+\omega)P_g}$

$= \frac{0.0113\dot{}(100)}{(0.622+0.0113\dot{})(4.2469)}$

$= 0.4213599765$

$\simeq 0.421$

c) $V = \frac{nRT}{P}$

$= \frac{\left(\frac{15}{28.97} + \frac{0.17}{18.015}\right) \times 8.314 (273.15 + 30)}{100}$

$= 13.28783389 m^3$

$\simeq 13.3 m^3$

4) Vapour pressure of water vapour $= \phi P_g$

$= 0.55 (3.1698)$

$= 1.74339 kPa$

Dew point temperature:

$T_{dp} = T_{sat@P_v}$

$$\frac{2.0 - 1.74339}{2.0 - 1.5} = \frac{17.50 - T_{sat@P_v}}{17.50 - 13.02}$$

$T_{sat@P_v} = 15.20077744°C$

$= 15.2°C > T_{glasses}$

∴ The glasses will fog up.

5) From the chart:

a) $\phi = 48\%$

b) $w = 11.25\ g\,kg^{-1}$

$= 0.01125$

≈ 0.0113

c) $h = 58\ kJ\,kg^{-1}$

d) $T_{dp} = 16°C$

e) $\phi = \frac{P_v}{P_g}$

$P_v = \phi P_g$

$= 0.48\, P_{sat@28°C}$

$$\frac{30-28}{30-25} = \frac{4.2469 - P_{sat@28°C}}{4.2469 - 3.1698}$$

$P_{sat} = 3.81606\ kPa$

$P_v = 0.48(3.81606)$

$= 1.8317088\ kPa$

$\approx 1.83\ kPa$