Name ______________________

CM ______________________

Exam 2

Oct 9, 2012

Problem 1	______/ 30
Problem 2	______/ 36
Problem 3	______/ 34
Total	______/ 100

Show all work for full credit.

Open book, computer use for computational purposes, one 8 ½ x 11" handwritten equation sheet.

If you use tabular data from your text, do **not** interpolate values. Use the nearest value in the table(s).

Problem 1 (30 Points)

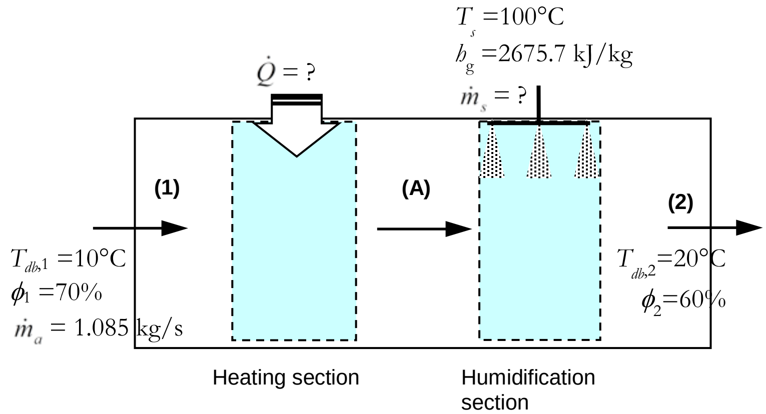
A mixture of ideal gases contains 75% N_2 (M=28.01) and 25% CO_2 (M=44.00) on a molar basis.

(a) Find the mass fraction of each component.
(b) Find the apparent (or average) molar mass of the mixture and the ideal gas constant of the mixture in kJ/(kg-K).
(c) 0.2 kmol of the mixture is contained in a **rigid vessel**. A paddle wheel does work on the gas in the amount of W_{in}=86.3 kJ, increasing the temperature from T_1=47°C to T_2=87°C. Find the heat transfer in or out of the mixture, in kJ. Assume that specific heats *are* a function of temperature.

Problem 2 (36 pts)

Air is heated and humidified in a two-step process as shown in the figure.

Moist air at a dry-bulb temperature of $T_{db,1}$=10°C and a relative humidity of ϕ_1=70% enters the heating section at (1). In the next section the air is humidified by an unknown flow rate of 100°C saturated steam (h_g=2675.7 kJ/kg) in an adiabatic process, leaving (2) at $T_{db,2}$=20°C and a relative humidity of ϕ_2=60%. The mass flow rate of *dry air* through the system is $\dot{m}_a$ =1.085 kg/s. The total pressure is constant at 1 atm.



(**Hint**: Find the requested quantities in the order given.)

(a) Find the humidity ratio ω_1 at (1), and the humidity ratio ω_2 at (2).
(b) Find the mass flow rate of saturated steam $\dot{m}_s$ in kg/s.
(c) Find the mixture enthalpy h_A, the relative humidity φ_A, and the temperature $T_{db,A}$ at (A).
(d) Calculate the rate of heat transfer required in the heating section in kW.

Problem 3 (34 Points)

(a) (3 pts) $m_i = n_i M_i$ and $\dot{m}_i = \dot{n}_i M_i$.

- o True/False: $mf_i = y_i M_i$

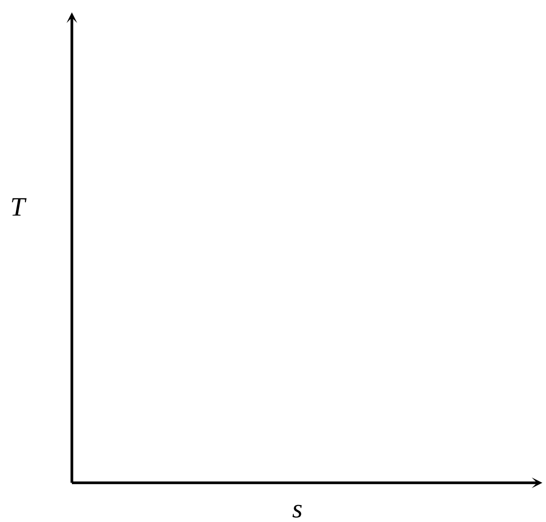
(b) (3 pts) Circle one: A volumetric analysis of an ideal gas mixture is the same as a

- o mole analysis
- o mass analysis

(c) The molar analysis of a mixture is 20% N_2 and 80% CO_2. The pressure, temperature and volume of the mixture are 100 kPa, 300 K and 1 m^3, respectively.

- o (2 pts) True/false: The temperature of the CO_2 is 300 K.
- o (2 pts) True/false: The pressure of the CO_2 is 80 kPa.
- o (2 pts) True/false: The volume of the N_2 is 0.20 m^3.
- o (2 pts) True/false: The specific volumes of the two gases are the same; i.e., $v_{CO_2} = v_{N_2}$.

(d) (8 pts) Sketch the *T-s* diagram for an ideal vapor-compression refrigeration cycle. Label all relevant points and processes appropriately.



(e) A two-chambered container initially has N_2 in one chamber and He in the other chamber. A partition between the chambers is removed so that the N_2 and the He mix together. The system is kept at constant temperature and constant pressure during the mixing.

- o (3 pts) True/false: Since the two chambers taken together make up a closed system and $s = s(T,P)$, the entropy of the system remains constant.

(f) (6 pts) A moist air mixture has a temperature of T=23°C, relative humidity of φ=0.4, and a total pressure of P=90 kPa. Find the vapor pressure.

(g) (3 pts) Consider a moist air mixture at $T_{db,1}$ and $\varphi_1 < 100\%$. The temperature is lowered to $T_{db,2} > T_{dew}$ at constant total pressure. What happens to the relative humidity?

- o It increases.
- o It remains about the same.
- o It decreases.
- o In sufficient info to determine.