Chemistry 410B **Exam 6** **Spring 2008**

NAME:

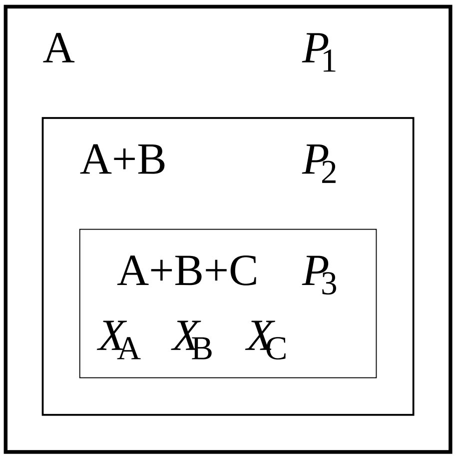
Instructions:

1. Keep this exam closed until instructed to begin. Please write your name on this page but not on any other page.
2. Please silence any noisy electronic devices you have.
3. Attached sheet(s) provide potentially useful constants and equations. You may detach these from the exam if you prefer.
4. To receive full credit for your work, please
   (a) show all your work, using the back of this sheet if necessary,
   (b) specify the correct units, if any, for your final answers,
   (c) stop writing and close your exam immediately when time is called.

Other notes:

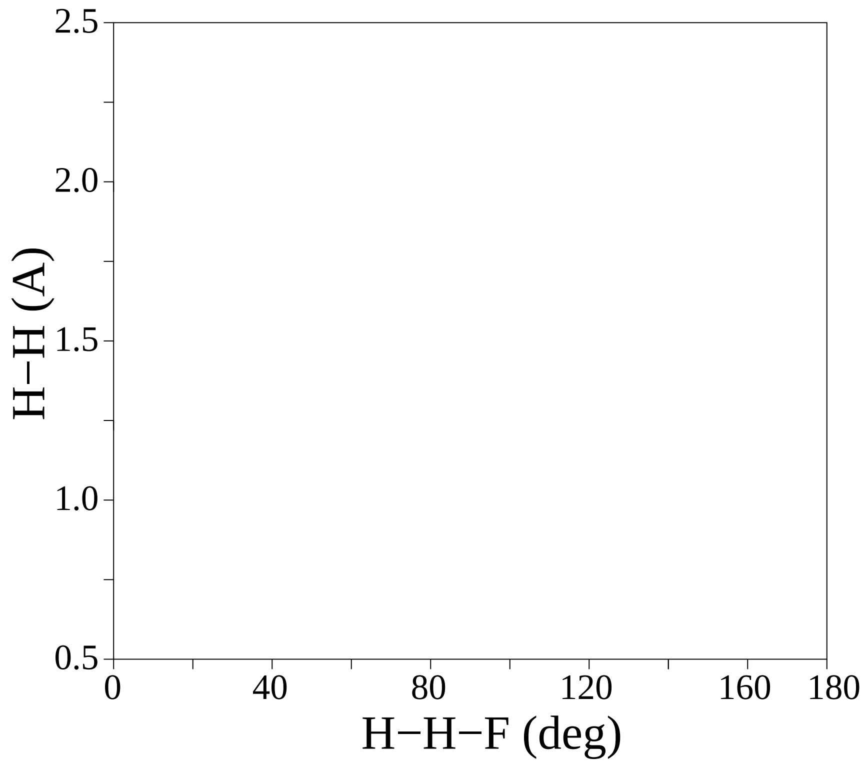
- **Your 4 best scores of the 5 problems will constitute your total score.**
- Partial credit is available for all problems, so try each problem and do not erase any of your work.
- Each question is worth 25 points, but they are not intended to be equally easy.

1. Consider the osmotic cell-within-a-cell design sketched below. The membrane between 1 and 2 is permeable only to solvent A, and the membrane between 2 and 3 is permeable to both A and B but not C. Find an expression for the *total pressure* P_3 in terms of P_1 and the molarities [B] and [C] in cell 3. Assume that X_A is much greater than X_B and X_C and that the solution is incompressible.



2. Find an equation for the slope of the phase boundary of a two-component liquid as it approaches the eutectic point on a T vs. X_B phase diagram, in terms of the temperature and the solvent enthalpy of fusion.

3. In the space below, sketch the contours to complete a **qualitative** version of the $H_2 + F$ reaction surface, this time as a function of the H-H distance and the **H-H-F angle**. Lightly shade in the lower energy regions. Do not worry about making the surface quantitatively correct, but be sure to show any major features.



4. A sample of 0.500 mol H_2S gas reacts with O_2 gas completely to yield H_2O and SO_3, both in the gas phase. If the reactants start at 298 K and the final temperature is 458 K, what is the total change in entropy for this sample?

5. Identify the number of degrees of freedom for each reactant and product in the two following reactions, and indicate whether the overall $\Delta_{\mathrm{rxn}}S$ is likely to be positive or negative:

	$2O_2(g)$	$\longrightarrow$	$O_3(g)$	+	$O(g)$
translational					
rotational					
vibrational					
$\Delta_{\mathrm{rxn}}S$ + or −					

	$GeH_4(g)$	+	$2O_2(g)$	$\longrightarrow$	$GeO_2(s)$	+	$2H_2O(g)$
translational							
rotational							
vibrational							
$\Delta_{\mathrm{rxn}}S$ + or −							

$$
\begin{aligned}
\text{thermo derivatives:} \quad dE &= TdS \;-\; PdV \;+\; \mu_1 dn_\cdot \;+\; ... \\
dH &= TdS \;+\; VdP \;+\; \mu_1 dn_\cdot \;+\; ... \\
dF &= -SdT \;-\; PdV \;+\; \mu_1 dn_\cdot \;+\; ... \\
dG &= -SdT \;+\; VdP \;+\; \mu_1 dn_\cdot \;+\; ...
\end{aligned}
$$

$$
\begin{aligned}
\text{entropy:} \quad \Delta S &= nR\ln\left(\frac{V_f}{V_i}\right) \qquad \Delta S \;=\; nC_{Pm}\ln\left(\frac{T_f}{T_i}\right) \\
\Delta S_{\text{mix}} &= -R(n_A \ln X_A \;+\; n_B \ln X_B) \\
\Delta G_{\text{mix}} &= RT(n_A \ln X_A \;+\; n_B \ln X_B)
\end{aligned}
$$

$$
\begin{aligned}
\text{activities:} \quad \frac{\partial \ln a_{\text{A}}}{\partial T} &= \frac{\Delta_{\text{fus}} H^{\bullet}_{\text{A}m}}{RT^2} \\
\Delta T_f &= -\frac{RT^{\bullet 2}_f X_B}{\Delta_{\text{fus}} H} \\
\Pi &= \frac{RTX_2}{V_m} \;=\; RTx_2
\end{aligned}
$$

$$
\begin{aligned}
\text{reactions:} \quad T_{\text{ad}} &= T_1 \;-\; \frac{\Delta H_{,\text{rxn}}(T_1)}{C_P(\text{products})} \\
\Delta_{\text{rxn}} G &= \Delta_{\text{rxn}} G^{\ominus} \;+\; RT\ln\Xi
\end{aligned}
$$