Chemistry 2290, Winter 2011, Dr. H. Georg Schreckenbach

Second Midterm Examination March 11, 2011

This exam has **4** (four) pages. *READ the question carefully*! Answer **ALL** questions, except possibly question 2, which is a bonus question that may earn you one extra mark. The questions may have *multiple* parts. Note that the questions aren't necessarily ordered by difficulty or by any other criteria. If you use *pencil*, your exam will not be remarked! For numerical problems, all mathematical steps must be shown. Please answer all questions *on* the question sheets. Use *reverse* side or extra paper if needed. On any extra sheet, indicate name and student ID number, please.

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1. Free energy calculation **5 marks**

(a) Calculate ΔG for 1.00 mole of liquid water as the external pressure is increased from 1.00 bar to 2.00 bar at a constant temperature of 298.0K. *You may need some or all of the following information: molar mass of water: 18.015 g mol^{-1}; density at 25.0°C: 997.05 kg m^{-3}.*

(b) Calculate ΔG for 1.00 mole of an ideal gas as the external pressure is increased from 1.00 bar to 2.00 bar at a constant temperature of 298.0K.

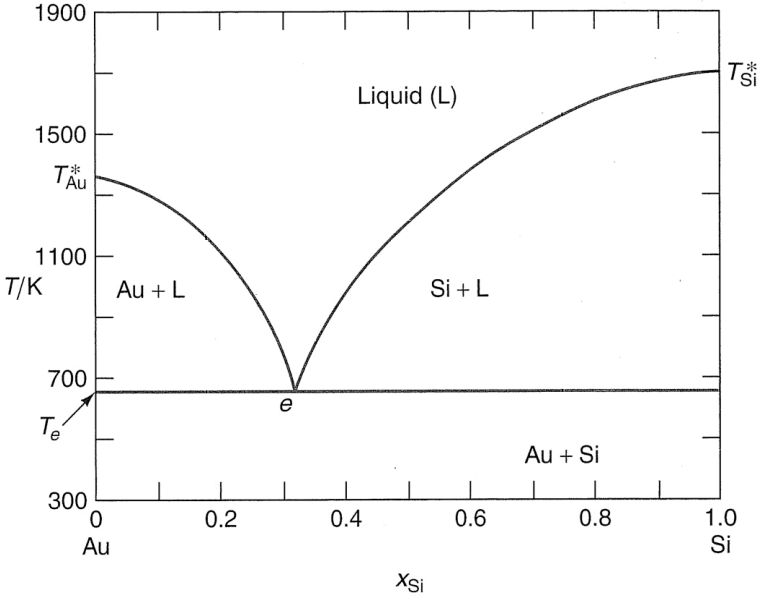
2. Helmholtz free energy **1 bonus mark**

Provide a molecular-level interpretation of the Helmholtz free energy. Justify your comments. Please be concise, though!

3. Phase change **4 marks**

Calculate the boiling point of water at 98.7kPa *(a typical barometric pressure at 275m altitude)*? *You may need some or all of the following information:* At standard conditions (373.15K; 1.00 atm), the heat of vaporization is 2258Jg^{-1} (that's Joule per gram); the molar volume of liquid water is 18.78 cm^3 mol^{-1}, and the molar volume of water vapor is 30.199 dm^3 mol^{-1}. The molar mass of water is 18.015 g mol^{-1}.

4. Phase diagram **6 marks**



Consider the following phase diagram *(*Au–Si; *figure adapted from Laidler/ Meiser/ Sanctuary, Physical Chemistry, 4th edition).*

(a) Using the phase rule, determine the number of thermodynamic degrees of freedom at the point marked "e".

(b) What are "thermodynamic degrees of freedom" (definition)?

(c) Consider a Au/Si mixture at 1100K with a mole fraction $x_{Si} = 0.60$.

(i) Determine the number of number of thermodynamic degrees of freedom present under these conditions; **(ii)** determine the composition(s) of the phase(s) present; **(iii)** if there is more than one phase present, determine the relative amounts in these phases.