

CHEM 3410: Physical Chemistry I — Fall 2009

Exam 2

Due: Monday, November 9, 2009 — 12:45 PM

At the beginning of class

Name: _____

Read all of the following information before starting the exam:

- This is a take-home exam.
- You may use any books or notes you would like to complete the problems. If you consult a book (including the text), please cite the source.
- You must work individually and may not consult other students or faculty.
- Show all work, clearly and in order, if you want to get full credit.
- Please do your work in the space provided. If you need more space attach additional sheets to the exam.
- Please keep your written answers brief; be clear and to the point. I will take points off for rambling and for incorrect or irrelevant statements.
- Late exams will not be accepted under any circumstances.
- Justify your answers. Clearly state any assumptions you make.
- Good luck!

Question	Score	Total
1		15
2		15
3		20
4		15
5		16
Total		81

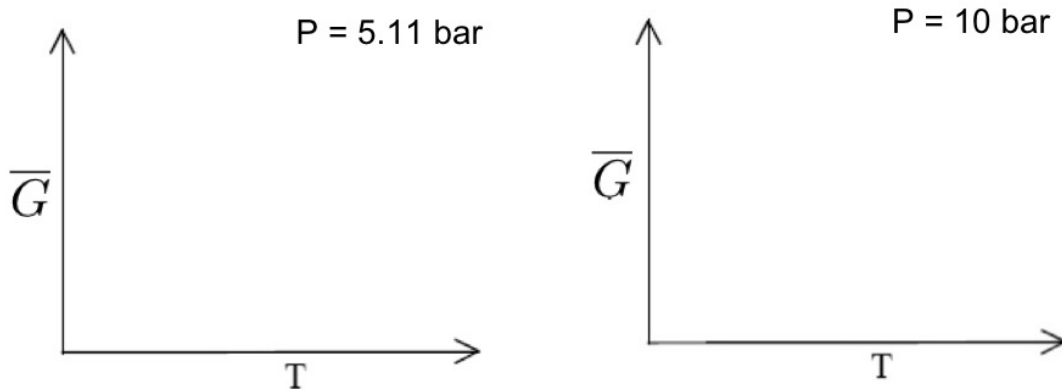
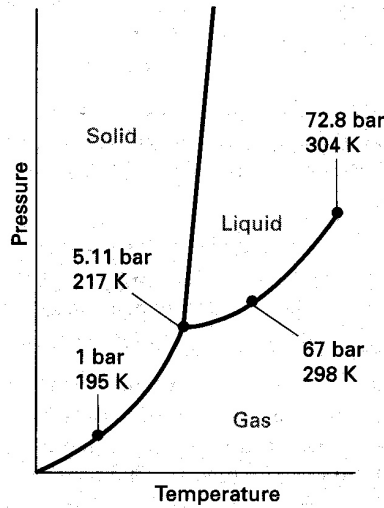
1. (15 points) For the isomeric conversion reaction n-butane \rightleftharpoons iso-butane, the equilibrium constant K_p is 0.858 at 550 K and 0.686 at 600 K.

(a) Without doing any computations, do you expect this reaction to be exothermic or endothermic? Briefly explain your answer. (8)

(b) Use this data to calculate the enthalpy of this reaction. State any assumptions you make to solve this problem. (7)

2. (15 points) Consider the single component system consisting of carbon dioxide as shown in the phase diagram below. The triple point of CO₂ is $T_{tp} = 217$ K, $P_{tp} = 5.11$ bar.

- (a) Sketch qualitatively reasonable \bar{G} vs. T diagrams for CO₂ at $P = 5.11$ bar and $P = 10$ bar. The $P = 5.11$ bar diagram should contain a feature qualitatively consistent with a triple point and the $P = 10$ bar diagram should show the usual solid \rightarrow liquid \rightarrow gas sequence of phase transformations as T increases. (10)



- (b) Using data from the phase diagram and the Clausius–Clapeyron equation, estimate the enthalpy of vaporization of CO₂. What assumptions are you making when you use this relationship? (5)

3. (20 points) Please identify each of the following statements as true or false. Give a brief justification for each answer.

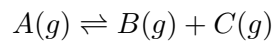
(a) When the temperature of an ice and water mixture at 0°C and 1 atm is suddenly raised by 1°C , the chemical potential of the ice then exceeds that of the water. (5)

(b) When two ideal gases are mixed together in a container at constant pressure, the entropy of the universe is constant for this process ($\Delta S_{universe} = 0$). (5)

(c) If an A–B system exhibits positive deviation from ideality (i.e. if the activity of A in an A–B solution is greater than the concentration, $a_A > X_A$) then A & B have attractive interactions. (5)

(d) For a single component system ($C = 1$), it is impossible to have 3 phases in equilibrium. (5)

4. (15 points) Consider the reaction:



The equilibrium constant for this gas phase reaction at 300 K is $K_p = 2.49$. Assume that all gases involved in this reaction behave ideally.

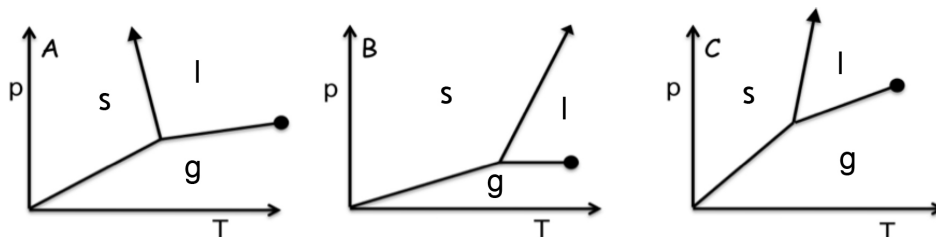
- (a) One mole of A is initially placed in a container maintained at 10 bar and 300 K until the reaction reaches equilibrium. Determine the partial pressures of all the gases at equilibrium at 300 K in this container maintained at a total pressure of 10 bar.

(10)

- (b) If you wish to increase the fraction of gas A that has decomposed at 300 K should the pressure be increased or decreased? Be sure to justify your answer.

(5)

5. (16 points) The following phase diagrams concern three different substances (A, B and C). All three gases have the same molar volume (\bar{V}_g) and all three solids have the same molar volume (\bar{V}_s).



Using the phase diagrams, identify the substance (A, B, or C) with:

(a) the smallest liquid molar volume. (4)

(b) the largest $\Delta S_{sublimation}$. (4)

(c) the highest critical point temperature. (4)

(d) the highest triple point pressure. (4)

In each case be sure to *briefly* justify your answer.