Assignment 6: CHM221A
Topic: Critical points and colligative properties

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To students: These assignments are designed to strengthen your understanding in the lessons taught in class as well as develop your problem solving skills. If you copy from other sources without understanding, those purposes will be defeated and you will receive no benefits. **If you cannot solve them, *try* and bring your problems to the instructor. He will definitely help. Also, there may be some typo - discuss with me if you think there are any.**

1. A system's free energy depends on an order parameter ϕ as

$$G(T, P, \phi) = G_0(T, P) + a_2(T - T_0)\phi^2 - a_3\phi^3 + a_4\phi^4$$

   where a_2, a_3 and a_4 are all positive constants.

   (a) Show that this system will undergo a phase transition.

   (b) What would be the order of that phase transition?

   (c) What will be the temperature at which phase transition will occur? (**Hint:***It is not T_0!*)

   (d) Plot ϕ as a function of temperature around the phase transition temperature.

2. Choose the correct option: For a van der Waals gas isotherm (ie. pressure vs volume curve), at critical temperature there is

   (a) a maximum

   (b) a minimum

   (c) a saddle point

   (d) a horse.

3. Using the information above, find out the critical temperature T_{cr}, critical pressure P_{cr}, critical molar volume v_{cr} in terms of van der Waals parameters a and b.

4. Using the informations below, find out the critical exponent γ and β. (**Hint:***See Callen Ch. 10*)

5. Consider a reaction
$$2A + 3B \to \nu C$$
where ν is the Stoichiometric number. At 300 K, the heat of reaction is 50 KJ/mol. The concentration of C at equilibrium depends on temperature as
$$C(T) = C_0(1 + T^2)$$
where $C_0 = 0.2mol/L$ for 1 mol/L concentration of both A and B. Find out ν.

6. Consider an ideal solution of two volatile liquid is in equilibrium with their vapours. The gas mole fraction of the first component is 0.2 while the vapour pressures of **pure components** are 1 Pa and 2 Pa respectively. Find out the liquid mole fraction of the second component and total pressure of the vapour phase for this mixture.

7. Two chambers **A** and **B** are connected by a semi-permeable membrane. Both chamber contained 1 L of water. We added 0.02 mole of sugar in the chamber **A**. Find out the change of osmotic pressure across the membrane.