

CHEM 243 – Physical Chemistry

Class Test

Wednesday 9 September 2009

Time Allowed: 60 minutes

Instructions: Answer **all four questions**, each of which carries equal marks.

1. The Clapeyron Equation for **any** phase change may be written as

$$\frac{dP}{dT} = \frac{\Delta_{\text{trs}}S}{\Delta_{\text{trs}}V}$$

where $\Delta_{\text{trs}}S$ is the molar entropy change for the phase change and $\Delta_{\text{trs}}V$ is the molar volume change for the same transition.

- (a) **Show** how this equation may be modified in the special case where the phase change is the vaporisation of a liquid to give the Clausius-Clapeyron Equation which may be expressed as either

$$\frac{dP}{dT} = \frac{P\Delta_{\text{vap}}H}{RT^2}$$

or

$$\frac{d(\ln P)}{d\left(\frac{1}{T}\right)} = \frac{-\Delta_{\text{vap}}H}{R}$$

- (b) Estimate the *normal boiling point* (i.e., at a pressure of 101.3 kPa) for methanol (CH_3OH) given that the vapour pressure of methanol is 193.7 kPa at 85 °C and 9.046 kPa at 15 °C.

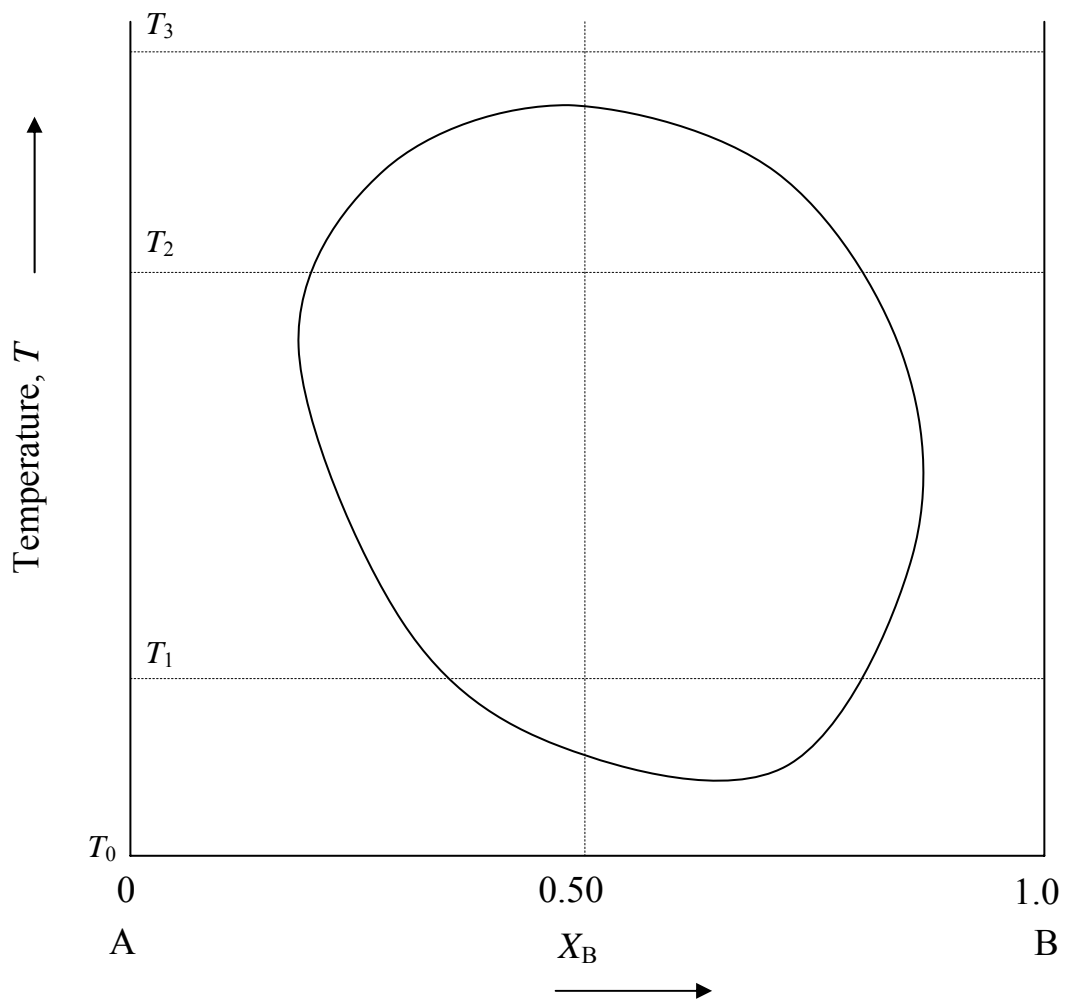
[Data: 0 °C = 273 K]

2. A binary solution of liquids A and B is prepared by mixing 3.50 moles of A and 2.00 moles of B. The temperature is then raised to 80 °C. At 80 °C the vapour pressures of pure A and B are 125.4 and 52.9 kPa, respectively. It may be assumed that A and B are sufficiently similar in their chemical natures that they form an **ideal solution**.
- (i) What are the partial pressures of A and of B, and what is the total vapour pressure above the solution at 80 °C?
- (ii) Calculate the mole fraction of A present in the vapour which is at equilibrium with the above the solution.

3. (a) The figure below shows the general form of the phase diagram for the two partially miscible liquids water (A) and nicotine (B) at temperatures below the appearance of a vapour phase. Describe what will be observed when a mixture of composition $X_B = 0.50$ is heated from temperature T_0 .

For *each* of the temperatures T_1 , T_2 and T_3 determine the **number**, **composition** and **relative amounts** of the phases present at equilibrium.

- (b) Sketch the general shape of, and label as appropriate, the boiling-point (T - X) diagram that you might expect for the A/B system if the temperature were to be raised high enough.



4. The figure on the answer sheet represents the T - X phase diagram for the liquid-solid region of mixtures of A and B. Label the **six** regions of the diagram stating **clearly** which substances will exist at equilibrium in each region. (If compound(s) are present give the formula(e).) Indicate the nature of the phase (i.e. solid or liquid).

On the right of the answer sheet, sketch cooling curves for molten liquid samples having compositions which commence at the points a, b, c and d in the diagram. Label your cooling curves to indicate which phase(s) is/are present.

