國立清華大學命題紙

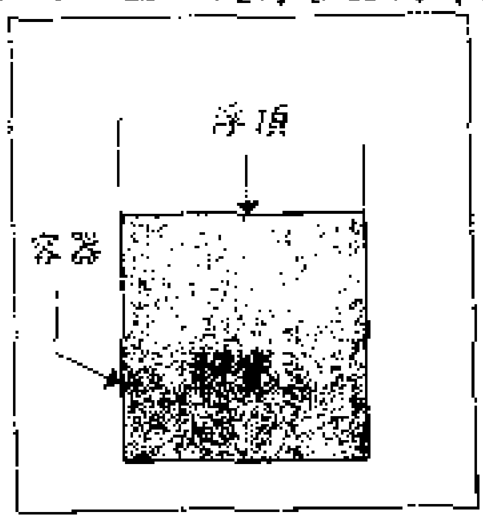
九十七學年度 化學工程學 系（所） 甲 組碩士班研究生入學考試

科目 化工熱力學及化學反應工程 科號 2302 共 4 頁第 1 頁 *請在試卷【答案卷】內作答

Problem 1 (20%)

一位才華橫逸、聰穎過人的大學生，在經過了激烈的碩士班入學考後，如願以償的考上他最嚮往的一流學府-清華大學化工系。這位前途似錦、大有為的年輕人，一見金榜題名，立刻收拾行囊，迫不及待的直奔清華大學，拜訪他心怡的教授。這位在國際享有盛名的清大教授，為了確定此年輕人確實為可造之材，當下給了這位學術界可能的明日之星一個小的測驗題。題目如下所述，也請你幫忙回答此一問題。

某一物質在50°C 與 1 atm 下為液態，承裝於一浮頂的容器中。此容器中的物質與外界有很好的熱交換，而且此蓋子會隨著此物質體積的改變而移動位置，使得容器內外的溫度與壓力得以平衡，但容器內外並無任何物質的交換。



(a) 若系統的壓力保持在1 atm，則此物質在100°C 時沸騰汽化。請畫出此物質從50°C 上昇到150°C，壓力保持在 1 atm，此物質的ΔG、ΔH、ΔS與溫度的關係圖。

(b) 當容器內的壓力為 4.5 atm 時，此液體沸騰汽化的溫度為 150°C。請畫出此物質 fugacity 與壓力的關係圖，若容器內的溫度為150°C，而壓力從 1 atm 提昇到 10 atm。

(c) 當容器內的溫度為 105°C、壓力為 2 atm 時，此物質為液態。若容器內的壓力突然間改變為 1 atm，而溫度仍保持在 105°C，則此物質會開始沸騰汽化，其所需的熱量稱為汽化熱(Heat of vaporization)。請問在這條件下(105°C，1 atm)的汽化熱，與在(100°C，1 atm)條件下的汽化熱是否相同？為什麼？

Problem 2 (20%)

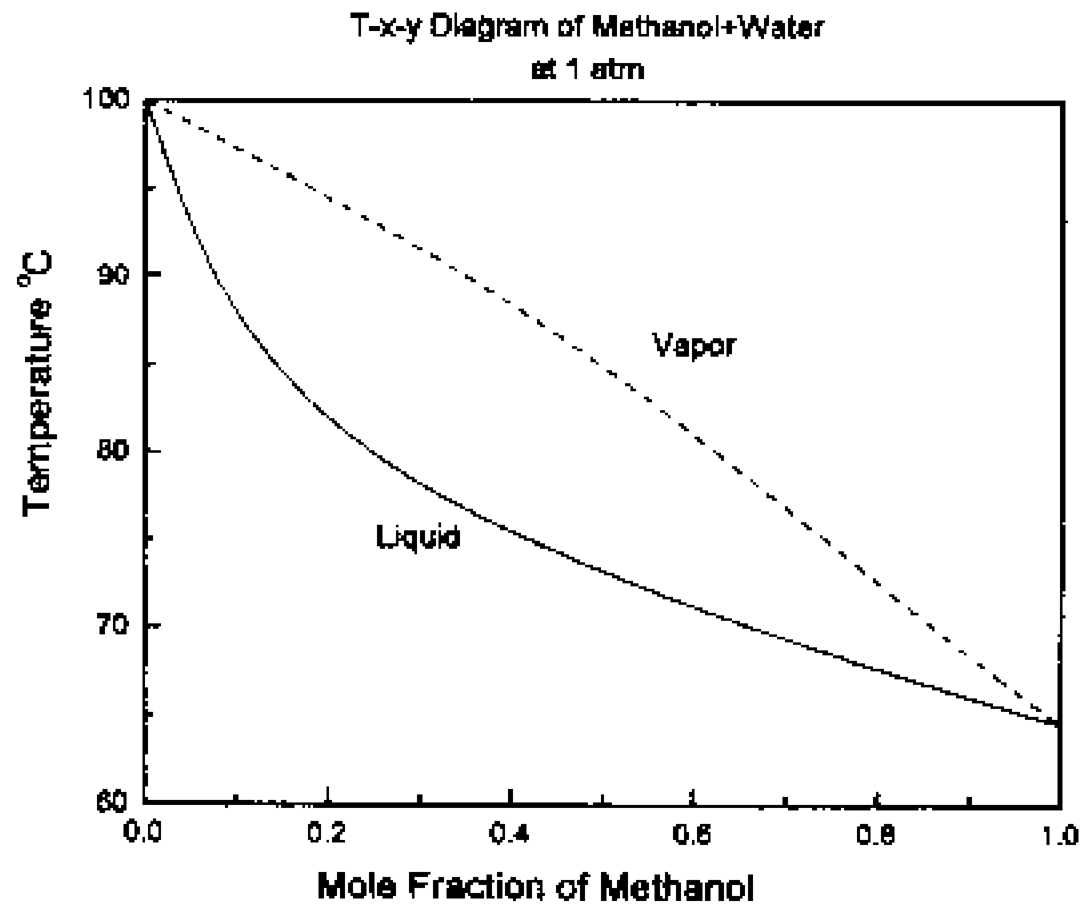
For fires to occur, a minimum concentration of fuel must exit in atmosphere. This minimum concentration is known as "Lower Flammable Limit"(LFL). The "flash point" of liquid is the temperature at which the mole fraction of a flammable component in open atmosphere above the liquid exceeds LFL.

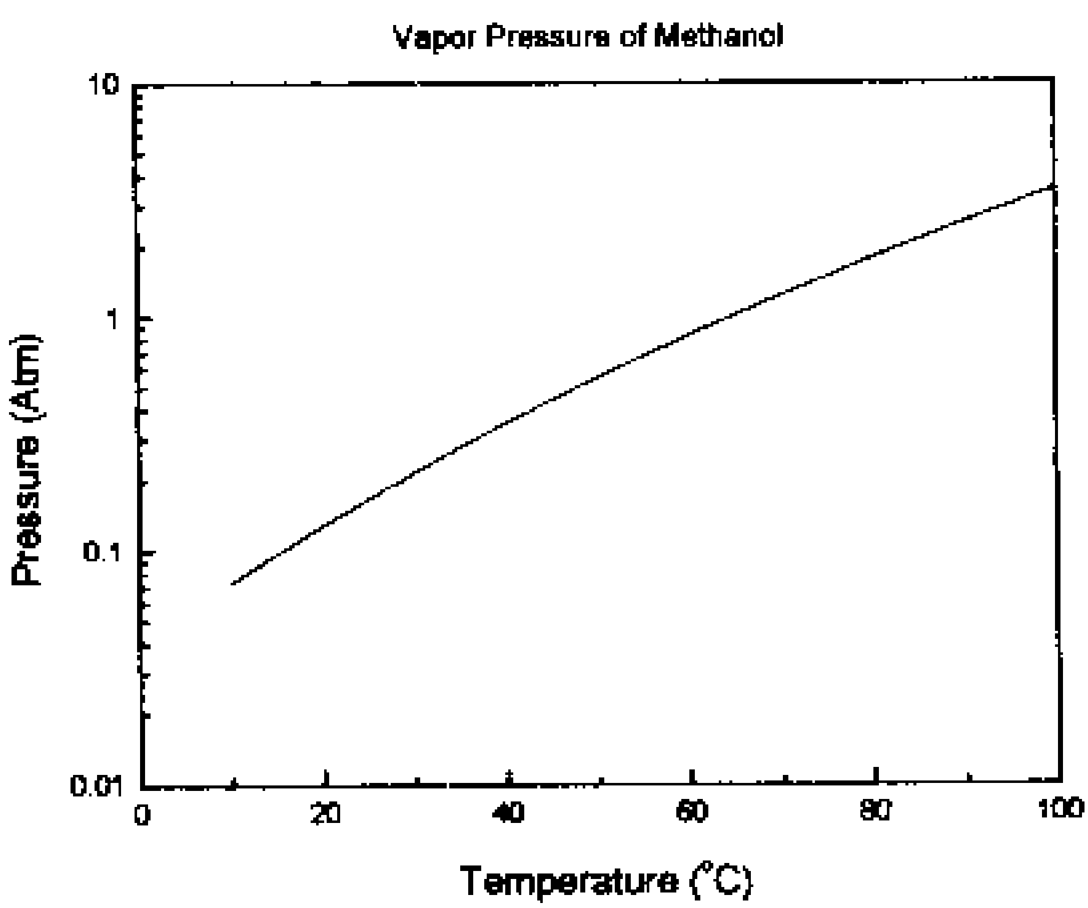
The LFL of methanol is 0.067.

The T-x-y diagram of methanol and water is given below. Vapor pressure of methanol is also given.

(a) Estimate the activity coefficient of methanol in a 40 mol% methanol solution using T-x-y diagram at 1 atm.

(b) Assume that the activity coefficient is independent of pressure and temperature, estimate the flash point of this 40 mol% methanol solution. (Hint: estimate the temperature at which the partial pressure of methanol over this solution exceeds 0.067 atm).





Problem 3 (20%)

For an aqueous reversible reaction:

$$A + B \Leftrightarrow P + W$$

Where the production rate of P is given by following kinetic equation:

$$dP / dt = kC_A C_B - k' C_p C_w$$

The values of reaction rate constants at specified condition are:

$$k = 3 \times 10^{-4}\ m^3 / kmol - min$$

$$k' = 1 \times 10^{-4}\ m^3 / kmol - min$$

(a) If the aqueous solution contains initially 5 kmol/m^3 of A, 10 kmol/m^3 of B and 15 kmol/m^3 of W, please calculate how much of A will be reacted at equilibrium. (8 points)

(b) If a continuous flow tank reactor is used for the reaction, determine the size of the reactor needed to produce 16 kmol/hr of P for 40% conversion of A. The feed stream in this case also contains 5 kmol/m^3 of A, 10 kmol/m^3 of B and 15 kmol/m^3 of W. (12 points)

Your will get 70% of points if the appropriate equations and procedures to solve them are given in your answers. The rest 30% will be given when correct answers are obtained.

Problem 4 (20%)

Derive a rate law for the enzyme-catalyzed reaction sequence

$$E + S \underset{k_2}{\overset{k_1}{\rightleftharpoons}} E \cdot S \underset{k_4}{\overset{k_3}{\rightleftharpoons}} P + E$$

in terms of the substrate (S) concentration, the total enzyme (E) concentration, the product (P) concentration, and the specific reaction rates k_1, k_2, k_3 and k_4.

Problem 5 (20%)

Consider the following reaction:

$$A + B \longrightarrow C + B$$

in which

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$$r_A = -kC_AC_B$$

The reaction is taking place in a semibatch reactor, in which 100 ℓ of a solution containing 2 mol/ℓ of A is initially present. No B is present initially. Starting at time t=0, 5 ℓ/min of a solution containing 0.5 mol/ℓ of B is fed into the reactor. The reactor is isothermal, and $k = 0.2\ \ell/mol \cdot \text{min}$ Find the moles of C in the reactor as a function of reaction time.