94學年度__化學工程學___系（所）______________組碩士班入學考試

科目___化工熱力學及化學反應工程___科目代碼___1402__共___3__頁第_1_頁 *請在試卷【答案卷】作答

1. A common problem in the design of chemical processes is the steady-state compression of gases from a low pressure P_1 to a much higher pressure P_2. We can gain some insight about optimal design of this process by considering adiabatic reversible compression of ideal gases with stagewise intercooling. If the compression is to be done in two stages, first compressing the gas from P_1 to P^*, then cooling the gas at constant pressure down to the compressor inlet temperature T_1, and then compressing the gas to P_2, what should the value of the intermediate pressure be to accomplish the compression with minimum work? (20%)

2. The first practical cubic equation of state is the van der Waals equation of state: $(P+\frac{a}{V^2})(V-b)=RT$ By making use of the inflection characteristic at the critical point, please show that:

(a) $a=\frac{27R^2T_c^2}{64P_c}$ & $b=\frac{RT_c}{8P_c}$ (10%),

(b) determine the critical compressibility for van der Waals equation of state (5%),

(c) The temperature at which $\lim_{P\to 0}\left[V\left(\frac{PV}{RT}-1\right)\right]=0$ (please note as $P\to 0$, $V\to\infty$) is called the Boyle temperature. Please show that for the van der Waals fluid, $T_{Boyle}=3.375\ T_c$ (5%)

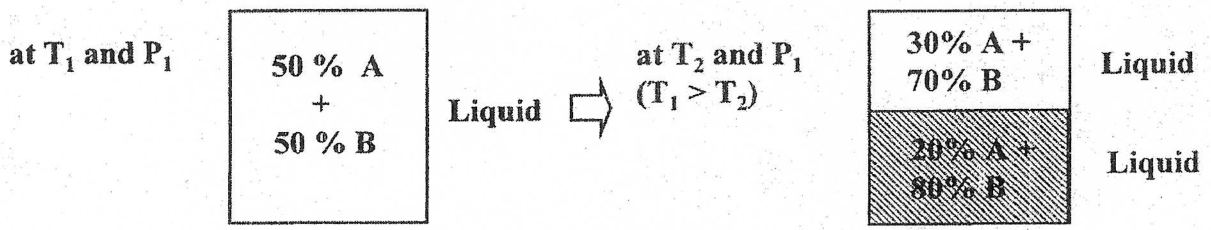
94學年度__化學工程學___系（所）______________組碩士班入學考試

科目___化工熱力學及化學反應工程___科目代碼___1402__共___3__頁第___2__頁 *請在試卷【答案卷】內作答

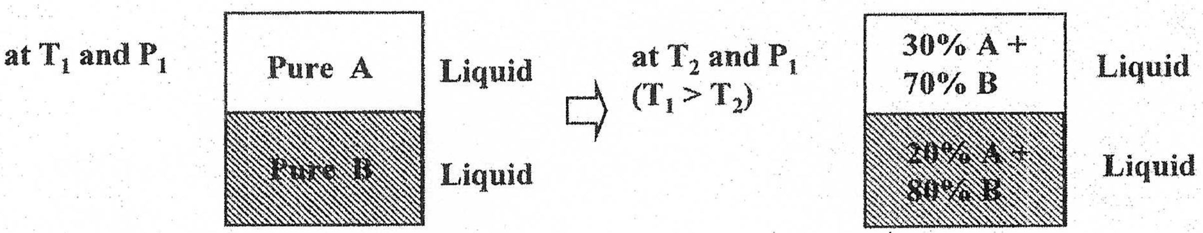
3. Please describe the behavior or rule in according to the following phase changes, and explain the observations using $\Delta G_{mix} = \Delta H_{mix} - T\Delta S_{mix}$ or $x_i \gamma_i f_i^L = y_i P$ where $x_i \gamma_i f_i^L$ and $y_i P$ are the partial molar fugacity of component i at liquid and vapor mixtures.

(20 %)

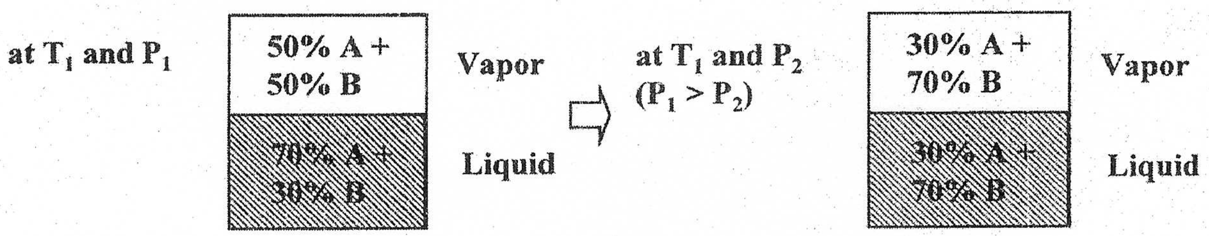
(a) 50 mole percent of A and 50 mole percent of B Mixture



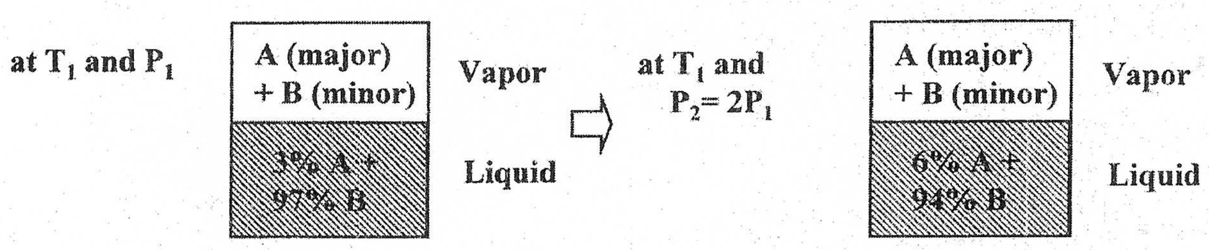
(b) 50 mole percent of A and 50 mole percent of B Mixture



(c) A and B Mixture



(d) A and B Mixture



Note that $T_1 > T_c$, critical temperature of A

94 學年度__化學工程學___系（所）______________組碩士班入學考試

科目___化工熱力學及化學反應工程___科目代碼___1402__共___3__頁第___3__頁 *請在試卷【答案卷】內作答

4. For the elementary reactions in series where k_1=k_2, find the maximum concentration of R (C_{Rmax}) and the time (t_{max}) it is reached, if C_A=C_{A0} and C_{R0}=C_{S0}=0 at time 0. (20%)

$$A \xrightarrow{k_1} R \xrightarrow{k_2} S$$

5. Consider a flow reactor system of gases of changing density. The temperature and the total pressure are constant. Derive an expression for the fraction of the reactant A converted (X_A, or called the conversion) in terms of C_{A0}, C_A, and ε_A. (20%)

Note: 1. C_A is the concentration of A and C_{A0} is C_A at X_A=0.

2. ε_A is the expansion factor which is defined as

$$\varepsilon_A = \left(V_{x_A=1} - V_{x_A=0}\right)/V_{x_A=0}$$

where V is the volume of the gases.

3. Every step of the derivation should be written down and in order. A jump to the answer will get no grade point or point deduction depending on the omitted number of steps.