注意：考試開始鈴響前，不得翻閱試題，

並不得書寫、畫記、作答。

國立清華大學 110 學年度碩士班考試入學試題

系所班組別：化學工程學系

科 目 代 碼 ：0902

考 試 科 目 ：化工熱力學及化學反應工程

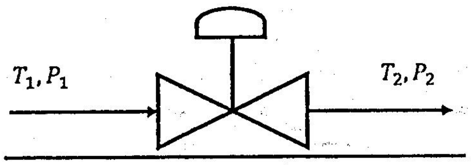
—作答注意事項—

1. 請核對答案卷（卡）上之准考證號、科目名稱是否正確。
2. 考試開始後，請於作答前先翻閱整份試題，是否有污損或試題印刷不清，得舉手請監試人員處理，但不得要求解釋題意。
3. 考生限在答案卷上標記「由此開始作答」區內作答，且不可書寫姓名、准考證號或與作答無關之其他文字或符號。
4. 答案卷用盡不得要求加頁。
5. 答案卷可用任何書寫工具作答，惟為方便閱卷辨識，請儘量使用藍色或黑色書寫；答案卡限用 2B 鉛筆畫記；如畫記不清（含未依範例畫記）致光學閱讀機無法辨識答案者，其後果一律由考生自行負責。
6. 其他應考規則、違規處理及扣分方式，請自行詳閱准考證明上「**國立清華大學試場規則及違規處理辦法**」，無法因本試題封面作答注意事項中未列明而稱未知悉。

Problem 1 (20%)

Each sub-question is 2% in score.

Consider a fluid passing through a well-insulated valve in so that $P_2 < P_1$



1. If the fluid is an incompressible liquid, which of the following statement is true?
(A) $T_2 > T_1$
(B) $T_2 < T_1$
(C) $T_2 = T_1$

2. If the fluid is an incompressible liquid, which of the following statement is true?
(A) $U_2 > U_1$
(B) $U_2 < U_1$
(C) $U_2 = U_1$

3. If the fluid is an incompressible liquid, which of the following statement is true?
(A) $H_2 > H_1$
(B) $H_2 < H_1$
(C) $H_2 = H_1$

4. If the fluid is an incompressible liquid, which of the following statement is true?
(A) $S_2 > S_1$
(B) $S_2 < S_1$
(C) $S_2 = S_1$

5. If the fluid is incompressible liquid, which of the following statement is true?
(A) The process is reversible.
(B) The process is irreversible.
(C) The reversibility cannot be determined.

6. If the fluid is an ideal gas, which of the following statement is true?
(A) $T_2 > T_1$
(B) $T_2 < T_1$
(C) $T_2 = T_1$

7. If the fluid is an ideal gas, which of the following statement is true?
(A) $U_2 > U_1$
(B) $U_2 < U_1$
(C) $U_2 = U_1$

8. If the fluid is an ideal gas, which of the following statement is true?
(A) $H_2 > H_1$
(B) $H_2 < H_1$
(C) $H_2 = H_1$

9. If the fluid is an ideal gas, which of the following statement is true?
(A) $S_2 > S_1$
(B) $S_2 < S_1$
(C) $S_2 = S_1$

10. If the fluid is an ideal gas which of the following statement is true?
(A) The process is reversible.
(B) The process is irreversible.
(C) The reversibility cannot be determined.

Problem 2 (20%)

Each sub-question is 4% in score.

11. For the liquid phase parallel reactions:

$$A \rightarrow R, r_R = k_1 C_A^2; E_1 = 80\frac{kJ}{mol}$$

$$A \rightarrow S, r_s = k_2 C_A; E_2 = 120\frac{kJ}{mol}$$

The desired product is R. The higher selectivity of R will be achieved, if. The reaction is conducted at

(A) The low temperature in an ideal continuous stirred tank reactor (CSTR)
(B) The high temperature in an ideal continuous stirred tank reactor (CSTR)
(C) The low temperature in an ideal plug flow reactor (PFR)
(D) The high temperature in an ideal plug flow reactor (PFR)

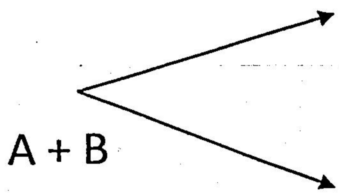
12. The desired liquid-phase reaction $D + E \xrightarrow{k_1} F, \frac{dC_F}{dt} = k_1 C_D C_E^{0.3}$, is accompanied by the side reaction $D + E \xrightarrow{k_2} G, \frac{dC_G}{dt} = k_2 C_D^{0.5} C_E^{1.8}$, from the standpoint of favourable product distribution, the most desirable contacting scheme is

(A) An ideal plug flow reactor (PFR) with the mainstream of "D" and "E"
(B) An ideal plug flow reactor (PFR) with the mainstream of "D" and side stream of "E"
(C) An ideal plug flow reactor (PFR) with the mainstream of "E" and side stream of "D"
(D) An ideal mixed flow reactor (MFR) with the mainstream of "D" and "E"

13. For the uni-molecular type elementary reactions $A \overset{k_1}{\rightarrow} B \overset{k_2}{\rightarrow} C$, the fractional yield of B in MFR for the given conversion of A

(A) remains constant with increase in k_2/k_1
(B) increases with the increase in k_2/k_1
(C) decreases with the increase in k_2/k_1
(D) increase linearly with increase in k_2/k_1

14. Consider the liquid phase reactions shown in the schematic below carried out in a flow reactor at steady state.



$$R(desired),\ r_R = kC_A^{1.5}C_B^{0.8}$$

$$S(Undesired),\ r_S = kC_A^{0.5}C_B^{1.7}$$

Keeping the reaction system isothermal, the yield of the desired product can be maximized by maintaining

(A) Low concentration of A and high concentration of B
(B) The high concentration of A and high concentration of B
(C) Low concentration of B and low concentration of B
(D) The high concentration of A and low concentration of B

15. For the irreversible elementary reaction in parallel is

$A \overset{k_1}{\rightarrow} R; A \overset{k_2}{\rightarrow} S,$ the rate of disappearance of reactant A is given by

(A) $(k_1-k_2)C_A$
(B) $(k_1+k_2)C_A$
(C) $0.5(k_1+k_2)C_A$
(D) k_1C_A

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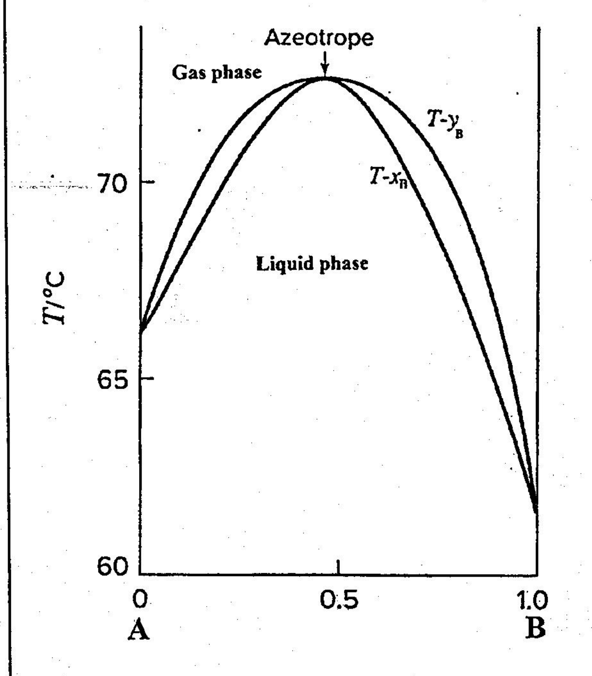
　　*請在【答案卷】作答

Problem 3 (10%)

(a) (8) A vessel, divided into two parts by a partition, contains 4 mol of *A* gas at 350K and 30 bar on one side and 3 mol of *B* gas at 350K and 20 bar on the other. If the partition is removed and the gases mix completely to form a gas mixture also at 350K, what are the changes in enthalpy, entropy and Gibbs free energy? Assume both *A* and *B* gases are ideal gases with $C_V = 2.5R$. $R = 8.314 \frac{J}{mol \cdot K}$. (b) (2) The enthalpy of a *C-D* binary system at fixed *T* and *P* is represented by the equation: $H = 600x_C + 400x_D + x_C x_D(40x_C + 20x_D)$. Is this binary system an ideal solution? Why or why not?

Problem 4 (10%)

Attached is the phase diagram of a binary *A-B* system at 101.3 kPa. (a) What is the degree of freedom of azeotrope according to phase rule? (b) If the gas phase is an ideal solution, is the liquid phase an ideal solution as well? Why or why not? (c) Draw the curves of Gibb free energy vs. composition for both gas and liquid phases at 75°C. (d) Draw the curves of Gibb free energy vs. composition for both gas and liquid phases at 70°C. (e) Draw the curves of Gibb free energy vs. composition for both gas and liquid phases at 65°C.



Temperature-composition phase diagram

Problem 5 (10%)

A gas-phase, reversible reaction, $A \xleftrightarrow{k_1/k_2} B$, with both rate constants obeying the Arrhenius Law. Please show that the difference of activation energy between forward (k_1) and backward (k_2) rate constants is equal to the reaction enthalpy; i.e., $E_{a1} - E_{a2} = \Delta H$ where E_{a1} and E_{a2} indicate the activation energy of the forward and backward rate constants, respectively.

Problem 6 (10%)

A liquid-phase irreversible reaction: P + Q → R + S follows the elementary reaction rate law. This reaction is carried out in a series of three, equal volume CSTRs at the same reaction temperature. The concentrations of P and Q in the feed to the first reactor are the same ($C_{P,0} = C_{Q,0} = 1.2$ mol/L). If the rate constant (k) for this reaction is 3.50 L/mol-h at the operation temperature. The final conversion is 0.75. If the total volume of these three reactors is 9300 L, what is the volume flow rate (in L/h) to the first reactor? What are the conversions in reactors 1 and 2?

Problem 7 (10%)

The elementary irreversible gas phase catalytic reaction A→B is carried out isothermally in a batch reactor with rate constant of 0.2 dm^3/kgcat*min at 300K. The catalyst deactivation follows a first order decay law (with decay rate constant of 0.1 min^{-1} at 300K) and is independent of the concentrations of both A and B. Calculate the conversion in the reactor after 10 minutes at 300 K.

Additional Information:

Initial concentration of A (C_{A0}) = 1 mol/dm^3

Batch reactor volume (V_0) = 1 dm^3

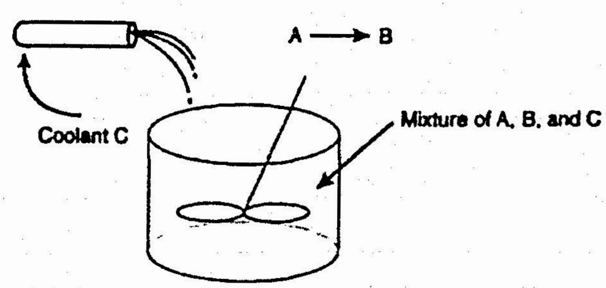
Catalyst weight (W) = 1 kg

Problem 8 (10%)

You are operating a batch reactor and the reaction is first-order, liquid phase and exothermic. An inert coolant is added to the reaction mixture to control the temperature as shown below. The energy balance of this reactor scheme is:

$$\frac{dT}{dt}=\frac{\sum F_iC_{pi}(T-T_{i0})+(-H^0_{Rx})(-r_AV)}{\sum N_iC_{pi}}=0$$

Where F is molar flow rate, the temperature is kept constant by varying the flow rate of the coolant. Calculate the flow rate of the coolant 2 hours after the start of the reaction. Note that initially the reactor contains A only (no B and coolant present).



Additional Data:

Initial temperature of reaction: 100°F

Rate constant, k at 100°F: $1.2*10^{-4}$ s^{-1}

Temperature of coolant: 80°F

Heat capacity of all components: 0.5 Btu/lb°F

Density of all components: 50 lb/ft^3

ΔH^o_{Rx}: -25000 Btu/lbmol

Reactor volume: 50 ft^3

C_{A0}: 0.5lbmol/ft^3