第一部分 簡答題 (20%)

1. (5%) Give the definitions of the space time and the space velocity for a flow reactor.
2. (5%) How many kinds of chemical rectors you know of. Please explain them in detail.
3. (2%) What is the second law of thermodynamics?
4. (2%) How many degrees of freedom are there for a liquid mixture containing water and oil?
5. (2%) The constant-volume heat capacity of an ideal gas should NOT be a function of temperature. (True or False?)
6. (2%) The Joule-Thomson process refers to as an isentropic process. (True or False?)
7. (2%) When phase *I* is in equilibrium with phase *II* and phase *II* is in equilibrium with phase *III*, phase *I* must be in equilibrium with phase *III*. (True or False?)

第二部分 計算題 (80%)

8. (10%) A PFR operating isothermally at 773 K is used to conduct the following elementary reaction: A→ B + C. If a feed of pure A enters at 5 atm and at a flow rate of 0.193 ft^3/s, what length of pipe with a cross-sectional area of 0.0388 ft^2 is necessary for the reaction to achieve 90% conversion? Data: $k = 7.80 \times 10^9 \exp[-19{,}200/T]$ s^{-1}.

9. (20%) The exothermic reaction A → B + C was carried out adiabatically and the following data recorded:

X (conversion)	0	0.2	0.4	0.45	0.5	0.6	0.8	0.9
$-r_A$ (mole/dm^3·min)	1.0	1.67	5.0	5.0	5.0	5.0	1.25	0.91

The entering molar flow rate of A was 300 mol/min.

a. (5%) What are the PFR and CSTR volumes necessary to achieve 40% conversion?
b. (5%) Over what range of conversion would the CSTR and PFR reactor volume be identical?
c. (5%) What is the maximum conversion that can be achieved in a 105 dm^3 CSTR?
d. (5%) What conversion can be achieved if a 72 dm^3 PFR is followed in series by a 24 dm^3 CSTR?

10. (10%) The following reactions are observed when an olefin is epoxidized with dioxygen:

$$\text{alkene} + O_2 \xrightarrow{k_1} \text{epoxide}$$

$$\text{epoxide} + O_2 \xrightarrow{k_2} CO_2 + H_2O$$

$$\text{alkene} + O_2 \xrightarrow{k_3} CO_2 + H_2O$$

If alkene is represented by A, epoxide by EP, and CO_2 by CD, and assuming an excess of dioxygen:

a. (5%) Derive the rate expressions for this mixed-parallel series-reaction network and the expression for the percent selectivity to the epoxide (EP), namely, $S_{EP} = r_{EP}/(r_{EP} + r_{CD})$.

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b. (5%) Calculate the maximum epoxide selectivity (S_{EP}^{max}) attained.

11. (20%) At high temperature, a system at 1 bar is in gas phase with three components: *A*, *B*, and *C* in a molar ratio of 2:1:2. The temperature goes down at a fixed pressure of 1 bar, and we observe that the bubble point occurs at 49 °C. The vapor pressures of the three species are the following

$$\log_{10} P_A = 4 - \frac{1170}{T - 49}$$

$$\log_{10} P_B = 4 - \frac{1070}{T - 40}$$

$$\log_{10} P_C = 5.2 - \frac{1733}{T - 40}$$

where the pressure is in a unit of bar and temperature is in a unit of K.

a. (10%) How many immiscible liquid phases are there in this system at the bubble point?
b. (10%) Please determine the mole fraction of *B* in vapor phase at the bubble point.

Note: *A*, *B*, and *C* may or may not be miscible in liquid phase. You can assume Raoult's Law applies for any homogeneous liquid mixture that may exist in this system. Your answer should be based on the calculation. A random guess will get no credit.

12. (20%) A rigid box of a volume of 1 m^3 contains 1 mole of nitrogen at $T = 300$ K. The box is connected to a high-pressure nitrogen gas line at $P = 200$ kPa and $T = 280$ K *via* a valve. The valve is opened and one mole of nitrogen flows into the box. The valve is then closed. The process mentioned above occurs in a very short time, and the temperature of the box increases during this process.

Then heat exchange occurs between the box and the surroundings (which are also at 300 K), and the temperature of the box returns to 300 K. Please calculate how much heat is exchanged between the box and the surroundings.

Note: You can assume nitrogen behaves like an ideal gas with C_p of 29 J/(mole K) under all conditions.

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