第一部分單選題(1~14)，每題 4 分，**選擇最接近正確之答案，答對得 4 分，答錯倒扣 1 分，請務必使用試卷第一頁[選擇題作答區]作答**

1. Two reactions occur in the reactor. Please qualitatively suggest, what reactors and conditions would you use in order to maximize the selectivity of the desired product (D) for the following parallel reactions:
   A + C → D, the rate equation based on mole of D produced, $r_D = 15e^{-(273/T)}C_A^{0.5}C_C$
   A + C → U, the rate equation based on mole of U produced, $r_U = 200e^{-(2000/T)}C_AC_C$
   where D is the desired product, U is the undesired product, T is the reaction temperature, and C_A and C_C are concentrations of compounds A and C.
   (a) PFR with lower temperature (b) PFR with higher temperature (c) CSTR with lower temperature (d) CSTR with higher temperature.

For the following gas-phase reaction (of compound A decomposed to compounds B and C), A → 2 B + C. The experiment was carried out in an ideal batch reactor at 30 ^{0}C. The followings are the experimental data of total pressure versus reaction time, and only A existed at the beginning of the reaction:

Time (min)	0.0	2.5	5.0	10.0	15.0	20.0
Total Pressure (mmHg)	7.5	10.5	12.5	15.8	17.9	19.4

2. What is the concentration (M) of reactant A at the 10 minutes reaction time.
   (a) 1.8×10^{-4} (b) 1.2×10^{-6} (c) 1.5×10^{-3} (d) 1.2×10^{-2}.
3. What is the reaction rate (M/min) of A at the 10 minutes reaction time.
   (a) 0.9×10^{-3} (b) 3.0×10^{-4} (c) 2.5×10^{-7} (d) 1.4×10^{-5}

4. What is the necessary condition for a reaction to occur in a reactor to have multiple steady states?
   (a) adiabatic reactor (b) isothermal reactor (c) exothermic reaction (d) endothermic reaction.

5. Which method may be better used for preventing the possible multiple steady state in a reactor?
   (a) large heat transfer area for heat exchange (b) maintaining high temperature operation (c) maintaining low temperature operation (d) maintaining low conversion of the reaction.

6. For a gas phase reaction A + B → C + D at 500 K and 5 atm, the change in Gibbs free energy for the reaction is **-500 cal/mol**. For an equal molar feed of A and B, what is the equilibrium conversion?

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(a) 0.2 (b) 0.4 (c) 0.6 (d) 0.8

7. For a 1st order irreversible isomerization reaction (A → B) occuring in a plug flow reactor, the rate constant of the reaction is 0.2 $(min)^{-1}$. What is the space time when the conversion of the ractant is at 60%?
(a) 2 min (b) 3 min (c) 4 min (d) 5 min

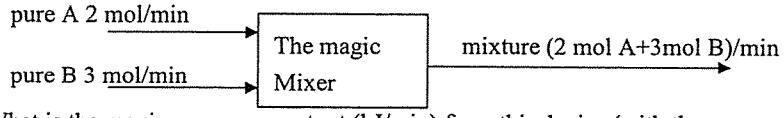
One mole of air is to be compressed isothermally from 1 bar to 10 bar at 25°C

8. What is the minimum work (kJ) needed to complete the process?
(a) 5 (b) 10 (c) 50 (d) 100 (e) 150
9. What is the work (kJ) applied if the compression is done with an external pressure of 20 bar?
(a) 5 (b) 10 (c) 50 (d) 100 (e) 150

The vapor pressure of a chemical species was measured at two temperatures:
$P^{vap}(T=300\ K)=5$ bar and $P^{vap}(T=400\ K)=10$ bar.

10. What is the heat of vaporization (kJ/mol) of the chemical?
(a) 1 (b) 3 (c) 5 (d) 7 (e) 9
11. What is the state of aggregation of the chemical species at 350 K and 7 bar?
(a) vapor (b) liquid (c) solid (d) vapor+liquid (e) cannot be determined

A chemical engineer claimed to have invented a magic device (illustrated below) that can extract work from the process of mixing two fluids. Suppose the two chemicals A and B form an ideal mixture, answer the following questions.



12. What is the maximum power output (kJ/min) from this device (with the stream flowrates shown in the figure above) at steady state if the process proceeds isothermally at 300 K.
(a) 0 (b) 4 (c) 8 (d) 12 (e) not possible
13. What is the maximum power output (kJ/min) from this device (with the stream flowrates shown in the figure above) at steady state if the process proceeds adiabatically
(a) 0 (b) 4 (c) 8 (d) 12 (e) not possible

14. What is the degree of freedom of coca cola in the aluminum cans, assuming that the ingredients contain only water, CO2, sugar, and flavor (i.e., 4 components)
(a) 0 (b) 1 (c) 2 (d) 3 (e) 4

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第二部分計算題(15~22)，題分註明於問題後方括弧內。

A liquid phase homogeneous reaction, A + 2B → 2C + D, occurs in an isothermal ideal batch reactor. The rate equation based on mole of A consumed in the reaction is $(-r_A) = kC_AC_B$, k = 0.2 (liter)(mol)$^{-1}$(min)$^{-1}$. The reaction volume is 100 liter solution, which contains 2 (mol)(liter)$^{-1}$ of A and 4 (mol)(liter)$^{-1}$ of B at the beginning of the reaction.

15. How many moles of C is present in the reactor after one hour reaction? [5 pts]
16. How long would it take for the conversion of reactant A being at 80%? [5 pts]
17. Under the same reaction conditions and reactant concentrations, if we want to produce 300 moles of product C at 80% reactant conversion and if the reaction volume is four fifth (4/5) of the reactor volume, what is the reactor size? [6 pts]
18. If the reaction occurs in an isothermal PFR at steady state, and the same reaction conditions as those in the previous batch reactor are used. At the reactor inlet, the concentrations are also 2 (mol)(liter)$^{-1}$ of A and 4 (mol)(liter)$^{-1}$ of B. At the reactor outlet, the conversion of reactant A is also at 80%. If the total volumetric flow rate is 240 liter per hour, what is the reactor volume of this PFR. [6 pts]

The CPU in a modern computer consumes electricity and generates heat. Suppose the voltage drop across the CPU is V and the current through it is I. The total heat capacity of the resistor is C_p, and heat is dissipated to the surrounding air according to $\dot{Q} = -h(T - T_{am})$ where T_{am} is the ambient air temperature, T is the temperature of the CPU, and h is the heat transfer coefficient.

19. What is the steady state temperature of the CPU? (i.e., express T in terms of V, I, C_p, h, and/or T_{am}) [4 pts]
20. What is the rate of entropy generation from the CPU at steady state? [4 pts]
21. You are asked to develop a magic device that can recover work from the waste heat of the CPU. Suppose the device does not change the steady state temperature of the CPU, determine the maximum amount of power (work per unit time) you may obtain. [4 pts]

22. In order to reduce CO_2 emissions from coal-fired power plants, we wish to capture 90% of the CO_2 in the flue gas, which contains 10% CO_2 at 1 bar and 300 K. In other words, only 10% of the CO2 produced from the power plants are allowed to emit to the atmosphere. Estimate the minimum work (kJ/mol CO_2 captured) required to capture CO_2 in the flue gas with a steady-flow process operating at constant temperature of 300 K and pressure at 1 bar. [10 pts]

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