試題　共 5 頁

注意：a. 本試題共　題，每題　分，共 100 分。

　　　b. 作答時不必抄題。

　　　c. 考生作答前請詳閱答案卷之考生注意事項。

化工熱力學

1. The following questions only need to be answered in a <u>simple way</u>. Detail descriptions are not necessary.

   (a) On what condition(s) can the unit internal energy (U) of a gas be independent of pressure (P) ? (5%)

   (b) What factor(s) can alter the unit entropy of an <u>ideal gas</u> ? (5%)

   (c) The 2nd law of thermodynamics states: *No process is possible which consists solely in the transfer of heat from one temperature level to a higher one.* What would happen to a refrigerator if it can be operated <u>against</u> the 2nd law of thermodynamics?

(Hint : Does it need power if 2nd law is violated?) (10%)

(d) Why does the saturated pressure of water in a <u>closed system</u> depend <u>only</u> on temperature? (Water is not fully evaporated at these temperatures) (5%)

2 Propane is used for drying stored grain. Propane gas at room temperature (25℃) is burned with enough air (contains 21% of oxygen and 79% of nitrogen in mole) so that combustion is complete and gases leave the burner at 1400 K . The combustion gas is then mixed with sufficient air so that the resulting gas mixture for drying is at 600 K. How many moles of air are available for drying per mole of propane burned if it is considered as an adiabatic process? (25%)

$$C_3H_8 \text{ (g)} + 5O_2 \text{ (g)} => 3CO_2 \text{ (g)} + 4H_2O\text{(g)}.$$

(Molar heat capacities, Cp , of all species are considered constant from 298 to 1400K ; $\Delta H_{f,298}^o$ is heat of formation at 298K and 1 bar)

	Cp (J/mole/K)	$\Delta H_{f,298}^o$ (kJ/mole)
Propane (C_3H_8)	---	-103.9
Carbon Dioxide (CO_2)	39.15	-393.8
H_2O(g)	33.80	-242
Oxygen (O_2)	29.63	---
Nitrogen(N_2)	29.10	---

化工動力學

下列一至三題中的化學反應各有 4 項關於其反應動力的敘述，請指出各敘述正確或不正確 (每對 1 項 3 分，每錯一項倒扣 3 分，最高全對 12 分，最低 0 分)。
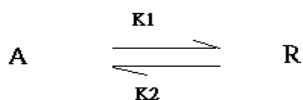
(gas law constant R = 8.314 J mol^{-1} K^{-1})。

一. 25 °C 下，均勻性液態反應 A → P，在攪拌反應器(mixed flow reactor)中進行反應，反應速率 r_A = – 3.5 C_A,M min^{-1} ，活化能 Ea = 100 KJ mol^{-1}，

1. 反應物 A 濃度由 1.0 M 增為 2.0 M 時，反應速率增為原來的 2 倍；

2. 相同溫度和濃度下，若增大反應器，反應物體積由 10 增為 20 liter，則反應速率增為原來的 2 倍；

3. 攪拌轉速由 100 改為 200 rpm 時，反應速率增為原來的 2 倍；
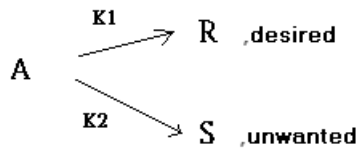
4. 反應溫度由 25 °C 昇高至 35 °C，反應速率增為原來的 2 倍。

二.下列水溶液中的反應為一基本反應(elementary reaction)，

$$A \underset{K_2}{\overset{K_1}{\rightleftharpoons}} R$$

以批式反應器(batch reactor) 在 25°C 下進行反應，其正、逆向反應之活化能 E_1 和 E_2 分別為 60 和 100 KJ mol^{-1}，A 和 R 初始濃度和分別為 1.2 和 0 M，

1. 反應達平衡時，正、逆向反應速率 (r_1, r_2)， r_1 = – r_2 = 0；

2. 正向反應為放熱反應，逆向反應為吸熱反應；

3. 反應溫度上昇至 30 °C 溫度，正、逆向反應活化能皆維持不變；

4. 反應溫度由 25 °C 上昇至 30 °C 溫度，平衡濃度比值[R]/[A]維持不變。

三. 下列水溶液反應在一 10 liter 攪拌反應器中反應至 90% 轉化率，進料流率為 1.0 liter min.$^{-1}$ ，

$r_R = dC_R/dt = 3.6\ C_A$, M min^{-1}

$r_s = dC_s/dt = 0.06$, M min^{-1}

1. 進料 A 濃度由原來 1.0 增為 2.0 M，產品選擇性 φ (生成 R mole 數/生成 S mole 數)變為原來 2 倍；

2. 以同體積管狀反應器(plug flow reactor, PFR)取代攪拌反應器進行反應，相同 90%轉化率下，所得 φ 值變小；

3. 以 PFR 進行反應，進料流率增大時，反應物 A 的轉化率(conversion)變大；

4. 以 PFR 進行反應，進料流率增加時，所得 φ 值變大。

四. 本題含三小題，每對 1 題 5 分，全對 14 分

An irreversible first- order reaction A$_{(aq.)}$ → R$_{(aq.)}$, having a reaction rate constant of 1.20 min^{-1}, is carried out at 25 °C in a 50 liter batch reactor. The initial concentration of A is 2.0 M.

(1) Please find out the reaction time for 90% conversion of A.

(2) If the reaction is carried out in two 50 liter plug flow reactors connected in series, for the same 90% conversion of A, how much can the inlet flow rate be fed in to the first reactor?

(3) If the reaction is carried out in two 50 liter mixed flow reactors connected

in series, for the same 90% conversion of A, how much can the inlet flow rate be fed to the first reactor?