甲. 化工熱力學部份 [50%]

以下資料可供作題之參考：

(1)The 1st law of thermodynamics for flow processes:

$$\frac{dE_{c.v.}}{dt}=\Sigma\dot{M}_i\left[h_i+\frac{v_i^2}{2}+gz_i\right]+\dot{Q}_{c.v.}-\Sigma\dot{M}_e\left[h_e+\frac{v_e^2}{2}+gz_e\right]-\dot{W}_{c.v.}$$

(2)heat capacity for air (-50~25 ℃), C_p=1.0035 kJ/kg · k

(11%)一、 The rate of heat transfer to the surroundings from a person at rest is about 400 kJ per hour. Suppose that the ventilation system(空調系統) fails in an auditorium(禮堂) containing 2000 people.

(a)How much does the internal energy of the air in the auditorium increase during the first 20 minutes after the ventilation system fails?(4%)

(b) Considering the auditorium and all the people as a system, and assuming no heat transfer to the surroundings, how much does the internal energy of the system change?(4%) How do you explain the fact that the temperature of the air increases?(3%)

(10%)二、 A small, high-speed turbine operating on compressed air produces 0.1 kW. The inlet and exit conditions are 400 kPa, 25 ℃ and 100 kPa, -50 ℃, respectively. Assuming the velocities to be low, find the required mass flow rate of air.

(15%)三、 A Carnot cycle heat engine receives 500 kJ from a reservoir at 500 ℃, and rejects heat at 25 ℃.

(a)Show the cycle on a T-S diagram, considering the working fluid as the system.(3%)

(b)Calculate the work and efficiency of the cycle.(6%)

(c) Calculate the change in entropy of the high-temperature and low-temperature reservoirs.(6%)

(14%)四、在一氣-液相平衡之系統中，氣相之壓力為 P，溫度為 T，某一 component i 在氣相之 mole fraction，fugacity，fugacity coefficient，及 chemical potential 各為 y_i, $\hat{f}_i^{v}$, $\hat{\phi}_i^{v}$, μ_i^{v}，在液相之 mole fraction，fugacity，activity coefficient 及 chemical potential 各為 χ_i, $\hat{f}_i^{L}$, γ_i, μ_i^{L}，此 component 在相同 T，P 狀況下，單獨存在時為液體，其 fugacity 為 f_i，試回答下列各項：

(1)液相之溫度，壓力各為何？(2%)

(2)寫下 $\hat{f}_i^{v}$ 與 P 之關係式。(3%)

(3)寫下 $\hat{f}_i^{L}$ 與 f_i 之關係式。(3%)

(4)寫下 $\hat{f}_i^{v}$ 與 $\hat{f}_i^{L}$ 之關係式。(2%)

(5)寫下 μ_i^{v} 與 μ_i^{L} 之關係式。(2%)

(6)mixture 與 component i 之 molar 與 partial molar Gibbs energy 各為 G 與 $\overline{G}_i$，寫下 G 與 $\overline{G}_i$ 之關係式。(2%)

(背面仍有題目,請繼續作答)

乙、化學反應工程部份[50%]

參考資料：

$$[(k_c d_p/D)(\varepsilon_b/(1-\varepsilon_b))(1/\gamma)] = [(U d_p \rho)/(\mu(1-\varepsilon_b)\gamma)]^{1/2}[\mu/(\rho D)]^{1/3}$$

k_c = 外質傳系數，D = 擴散系數，ε_b = 床孔隙度，γ = 形狀因子，
U = 流速，ρ = 密度，d_p = 粒徑，μ = 黏度

一、簡答下列問題 (每小題佔 2%)

(1) 擔體觸媒通常含有那兩部份？並請舉一例。
(2) 那一類型的觸媒使用前需要還原？並請舉一例。
(3) 以固體觸媒催化反應，何以氣相反應之外質傳阻力常可忽略而液相反應則否？
(4) 當填充床中觸媒用量(重量或體積)保持一定，在何種情況下反應速率($-r_A'$)不隨觸媒粒徑(d_p)而變？
(5) 同上題前半段，在何種情況下，$(-r_A') \propto 1/d_p^{3/2}$ ？

二、有一具孔性之平板形礦石(兩端以惰性物質密封)，置於酸液中，酸液中之成份 A 會與礦石中之成份 B 反應：$2A(L) + B(S) \rightarrow P(L)$，生成物 P 會溶於酸液中。已知 B 在礦石中所佔之百分率很小，因此反應後礦石之外形與孔徑無顯著改變。請寫出平板礦石中 A 與 B 之質量平衡式與相關之起始條件與邊界條件。 (7%)

三、氣相放熱反應在管狀反應器中進行時，反應器外保持溫度 T_R，進料溫度 T_0。若 $T_R < T_0$，請畫沿反應器的溫度分佈圖(溫度座標上請標明 T_R 及 T_0)，並說明此溫度變化的理由。(5%)

四、反應物 A 在管狀反應器中進行氣相反應成 B 與 C，

$A \rightarrow B$ $\quad r_B = k_1 C_A^2$ $\quad k_1 = 1$ *l*/gmol·sec
$A \rightarrow C$ $\quad r_C = k_2 C_A$ $\quad k_2 = 0.01$ sec^{-1}

體積流率為 0.01 *l*/sec，A 進口濃度為 0.1 gmole/*l*，求 A 出口濃度為 0.01 gmole/*l* 時 B 與 C 的濃度及所需的反應器體積。 (11%)

五、Propane is oxidized into CO_2 and H_2O in an isothermal, constant pressure combustion reactor. Please derive the reactor volume as a function of conversion, $X_{propane}$. Assume the ideal gas law.
Initial conditions: $P_0 = 1$ atm, $n_{propane} = 0.1$, $n_{O2} = 0.5$, $n_{Ar} = 0.4$, V = 10 liter. (5%)

六、When a reaction is one and half order inside a cylindrical tube reactor, please predict and explain in detail which one in the following two cases:
(a) a plug flow inside the tube, and
(b) a laminar flow inside the tube,
has a higher conversion, if the reaction temperature, reactor volume, reactor pressure, and total inlet flow rate are all maintained the same in both cases. (6%)

七、If a complex reaction, $A + 2B \rightarrow C + 4D$, is first order with respect to A in the temperature range between 100°C and 350°C, and is second order with respect to B in the temperature range between 350°C and 500°C. Please explain what may cause such a change. Is it possible that the reaction mechanism is changed into a new one when the temperature is raised from 200°C to 425°C? (6%)