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國立臺北科技大學 106 學年度碩士班招生考試

系所組別：3510 化學工程與生物科技系化學工程碩士班甲組

第二節　化工熱力學與反應工程　試題

注意事項：

1. 本試題共 5 題，每題 20 分，共 100 分。
2. 請標明大題、子題編號作答，不必抄題。
3. 全部答案均須在答案卷之答案欄內作答，否則不予計分。

1. One mole n-octane, 12.5 moles oxygen and 50 moles nitrogen were mixed in an engine. The temperature and pressure in the engine is 25 °C and 1 atm, respectively. Consider all the gases are idea gas or idea mixture.

(1) (5%) The n-octane was ignited and completely reacted, and the volume remained unchanged. Calculate the internal energy change before and after the reaction as well as the temperature. Assume the heat transfer from the system to the engine is small enough to be neglected.

(2) (10%) Calculate the temperature and the pressure for the gas in the engine after the ignition. Consider the materials in the engine is a unit system. Please first use the information in the following table to calculate the internal energy change for the following chemical reaction under standard conditions.

$$C_8H_{18(l)} + 12.5O_{2(g)} + 50N_{2(g)} \rightarrow 8CO_{2(g)} + 9H_2O_{(g)} + 50N_{2(g)}$$

Then calculate the internal energy of this product gas at any pressure (P) and any temperature (T) by assuming the specific heat is independent of the temperature and the internal energy of the product gas is 0 kJ at 25 °C and 1 atm.

(3) (5%) After the ignition, the high pressure gas expanded via pushing the valve. Since the process happens very quickly, the process is considered to be isothermal. If the final pressure is 1 atm, calculate the final temperature and the maximum work done by the engine to the environment during this process.

	ΔH_f^0 (kJ/mol)	C_v (J/mol K)
C_8H_{18}	-208	
O_2	0	25
N_2	0	24
CO_2	-394	43
H_2O	-242	31

2. (20%) A propane gas expands isentropically in a turbine from 18 bar to 1 bar at 500 K. The propane was considered to be an ideal gas. Determine the temperature of the expanded gas and the maximum work obtained from the turbine. The constant-pressure heat capacity of the propane gas (C_P) is expressed as $\frac{C_P}{R} = 0.0303\times T - 5.0038\times10^{-6}\times T^2$, where R and T are the universal gas constant and the absolute temperature in the Kelvin scale, respectively.

3. For a pure substance the relationship between the fugacity (f) and the chemical potential (μ) is $\mu = \mu_0 + RT\ln f$, where μ_0 is only depend on the temperature.

(1) (10%) Show the fugacity coefficient ϕ ($\phi = f/P$, P is the gas pressure) of a pure gas at a constant temperature is $\ln\phi = \int_0^P (Z-1)\frac{dP}{P}$, where Z is the compressibility factor.

Please start with the differential of the chemical potential ($d\mu$) and apply a basic equation of $dg = -sdT + vdP$ (g, s, and v are respectively the molar Gibbs free energy, entropy, and volume).

(2) (10%) Show the relation between $\ln\phi$ and the residual Gibbs free energy (G^R).

4. Consider the reaction $A \rightarrow B + C$

(1) (5%) Develop the rate law ($-r_A'$) based on the experimental data in the following table.

(2) (6%) Suggest an absorption-surface reaction-desorption mechanism consistent with the rate law obtained in (1).

(3) (9%) Verify the proposed absorption-surface reaction-desorption mechanism proposed in (2) fits the rate law obtained in (1).

Run	Rate (mol/g cat. · h)	Partial Pressure (atm)		
		A	B	C
1	0.058	10	2	0
2	0.005	0.1	2	0
3	0.024	0.5	2	1
4	0.083	15	1	1
5	0.085	10	1	0
6	0.079	15	1	10

注意：背面尚有試題

5. An irreversible first-order gas-phase reaction A → B is carried out isothermally in a fluidized catalytic CSTR containing 50 kg of catalyst. A pure A was entering the system at the pressure of 20 atm. A 50% conversion was achieved after exiting the CSTR. Assure no pressure drop in the CSTR. Also, it is proposed to put a PBR containing the same catalyst weight in series with the CSTR. The pressure drop parameter for the PBR, $\alpha = 0.018\ kg^{-1}$. The particle size is 0.2 mm and the bed porosity is 40%, and the viscosity is the same as that of air at 200 °C.
   (1) (5%) What is the conversion exiting the last reactor?
   (2) (5%) What is the pressure at the exit of the packed bed?
   (3) (5%) If the catalyst diameter decreased by a factor of and the PBR diameter increased by 50%, what is the conversion exiting the last reactor?
   (4) (5%) Continue the last question, what is the pressure at the exit of the packed bed?