●可以使用不具儲存程式功能之電子計算機

1. An ideal gas undergoes the following sequence of reversible processes

(a) 100℃, 5 bar --> 200℃ (adiabatic)

(b) 200℃ --> 100℃ (constant pressure)

(c) 100℃ --> original (isothermal)

Please calculate W (J), Q (J), ΔU (J) and ΔH (J) for each processes (4 pts for each processes) and the entire cycle (4 pts). (total 16 pts)

$Cv = \frac{3}{2}R$, $Cp = \frac{5}{2}R$, **R = 8.314 J/mole.K**

2. The virial expansion of a gas is $Z = 1 + B'P + C'P^2 + DP^3 + \ldots$

Please show the equation for isothermal work in a reversible compression is

$W = RT \cdot \ln\left(\frac{P_1}{P_2}\right)$ **in the extreme low pressure. (4 pts)**

3. One built a well-insulated vessel containing 10 kg of water initially at 600K. The vessel is made of copper and weighs 1 kg. A copper block, weighing 2 kg, with an initial temperature of 1200K is immersed in the water and allowed to come to equilibrium.

(a) What is the change in internal energy (kJ) of water? (3 pts)

(b) What is the change in internal energy (kJ) of the entire system including the vessel ? (3 pts)

(c) What is the entropy change (kJ/K) for the copper block ? (3 pts)

(d) What is the entropy change (kJ/K) for the entire system, including the vessel ? (3 pts)

Ignore the effect of expansion and contraction, the specific heats are constants at $4.2\frac{kJ}{kg \cdot K}$ **for water and** $0.42\frac{kJ}{kg \cdot K}$ **for copper.**

4. A gas (Cv & Cp are constants) obey Vander Waals equation of sate

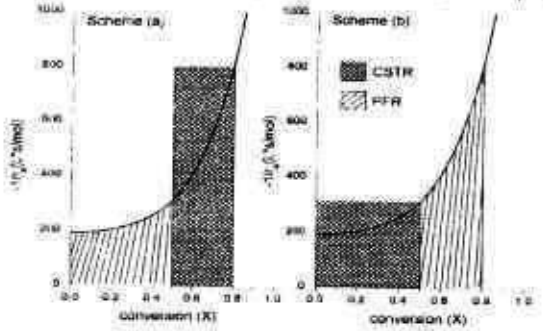
$\left(P + \frac{n^2 a}{V^2}\right)(V - nb) = nRT$, **assume condition is from** T_1, V_1, P_1 **to** T_2, V_2, P_2

Please find : W, Q, ΔS ΔU and ΔH expression. (2 pts for each, total 10 pts)

5. Equation of state: $PV = RT - aP$, $a = 0.7$

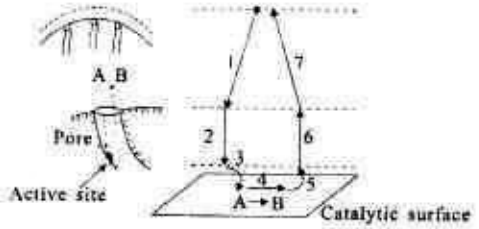
Please find the fugacity (4 pts) and fugacity coefficient (4-pts) at 10000 mmHg and 200℃. (gas constant: 0.082 $\frac{m^3 \cdot atm}{kg \cdot mole \cdot K}$**)**

6. Calculate the individual reactor volume and the total reactor volume for each following scheme. At conversion (X) equals to 0.5 and F_{A0} equals to 0.867 mol/s. *(Total 12 pts)*



X	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.85
$-1/r_A$ (L*s/mol)	189	192	200	222	250	303	400	556	800	1000

7. Heterogeneous catalysis conversion of A to B can be portrayed as following figure. *(Total 13 pts)* Please (a) itemize and explain each step. *(7 pts)* (b) If conversion of A to B is extremely rapid (e.g., oxidation), which step(s) will be varied significantly, why? *(3 pts)* (c) If gradually increase the external stream flow, which step(s) will be varied significantly, why? *(3 pts)*



8. Chemical vapor deposition (CVD) is used to grow stable thin film of polycrystalline silicon for application in semiconductor industry. Consider the deposition of silicon as following steps:

$$SiH_2(g) + * \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} SiH_2* \quad \text{(step 1)}$$

$$SiH_2* \xrightarrow{k_2} Si(s) + H_2* \quad \text{(step 2)}$$

$$H_2* \underset{k_{-3}}{\overset{k_3}{\rightleftharpoons}} H_2(g) + * \quad \text{(step 3)}$$

Assuming step 2 is the rate-determining step. *(Total 13 pts)*

(a) Please derive the rate equation based on the above-mentioned mechanism. *(7 pts)*

(b) If you want to estimate the kinetic parameter(s) of the rate equation derived above and your experimental outcomes are listed as the table below. Please find the remaining kinetic parameter(s) by assuming step 3 is very fast. *(6 pts)*

Reaction rate (mol/(g*s))	SiH_2 (mol/L)	H_2 (mol/L)
0.10	0.1	0.1
0.12	0.3	0.3
0.14	0.8	0.8
0.16	1.3	1.1
0.18	1.6	1.5
0.20	1.8	1.8

9. Explain the following terms: *(Total 12 pts)*

(a) Differential method of rate analysis *(3 pts)*

(b) Integral method *(3 pts)*

(c) Gas hourly space velocity *(3 pts)*

(d) Fluidized bed reactor *(3 pts)*