

國立高雄科技大學 109 學年度碩士班 招生考試 試題紙

系 所 別： 化學工程與材料工程系碩士班

組 別： 乙組

考科代碼： 1014

考 科： 物理化學

注意事項：

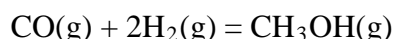
- 1、各考科一律可使用本校提供之電子計算器，**考生不得使用自備計算器**，違者該科不予計分。
- 2、請於答案卷上規定之範圍作答，違者該題不予計分。

本試題共六題，共 100 分。

Given: 1 atm = 1.013 bar = 760 torr, 1 bar = 10^5 Pa

$$\ln(0.1) = -2.303, \ln(0.64) = -0.446, (1/10)^{0.4} = 0.398$$

1. Methanol, a fuel for direct methanol fuel cells, can be synthesized by the following reaction:



The reaction was carried out at 523 K and the equilibrium constant K is 6.5×10^{-3} . Calculate the total pressure (bar) required for an 80% conversion to methanol if CO(g) and $\text{H}_2\text{(g)}$ are initially in a 1:2 molar ratio. **(5 points)**

2. Benzene and toluene form very nearly ideal solutions. At 333 K, the vapor pressures of benzene and toluene are 51.3 and 18.5 kPa, respectively.

- (a) As the pressure reduced, at what pressure the equimolar mixture of benzene and toluene begins to boiling and what will be the composition of the first bubble of vapor? **(8 points)**
- (b) What composition of solution would boil at 333 K under reduced pressure of 190 torr? **(4 points)**

3. One mole of monoatomic ideal gas was initially at 10 bar and 300 K, please calculate w , q , ΔU and ΔS when the gas is allowed to expand according to the following processes:

- (a) Isothermally, reversible to 1.0 bar (w , q , ΔU and ΔS =?) **(12 points)**
- (b) Adiabatically, reversible to 1.0 bar (w , q , ΔU and ΔS =?) **(12 points)**
- (c) Adiabatically against a constant pressure of 1.0 bar until the final pressure is 1.0 bar (w , q , ΔU and ΔS =?) **(14 points)**

Note: w =work, q =heat, ΔU =internal energy change and ΔS = entropy change

$$C_v = (3/2)R \text{ and } C_p = (5/2)R \text{ for monoatomic ideal gas, } R=8.314 \text{ J K}^{-1} \text{ mol}^{-1}$$

4. Derive (a) the internal energy change (ΔU) and (b) the entropy change (ΔS) of the system undergoes an isothermal, reversible expansion from initial volume V_1 to final volume V_2 for gas following the equation of state of van der Waals gas as below. **(10 points)**

$$\left(p + \frac{an^2}{V^2}\right)(V - nb) = nRT$$

5. Effect of temperature on the Gibbs energy:

- (a) Please derive the Gibbs-Helmholtz equation **(5 points)**

$$H = -T^2 \left[\frac{\partial G/T}{\partial T} \right]_P$$

- (b) If the Gibbs energy varies with temperature according to

$$G/T = a + b/T + c/T^2$$

Where a and b are constants, how will the enthalpy and entropy vary with temperature?

(10 points)

- (c) Integrate the Gibbs-Helmholtz equation to obtain an expression for ΔG_2 at temperature T_2 in terms of ΔG_1 and T_1 , assuming that ΔH is independent of temperature. **(5 points)**

6. A gas follows the virial equation

$$Z = \frac{P\bar{V}}{RT} = 1 + \left(b - \frac{a}{RT}\right) \frac{P}{RT}$$

- (a) What is the expression for fugacity, f ? you can start from the equation below **(5 points)**

$$\ln\left(\frac{f}{P}\right) = \frac{1}{RT} \int_0^P (\bar{V} - \bar{V}^{\text{id}}) dP$$

where \bar{V} is molar volume, \bar{V}^{id} is molar volume of ideal gas

- (b) What is the expression for Joule-Thomson coefficient? **(10 points)**