國立成功大學 105 學年度碩士班招生考試試題

系　所：化學工程學系

考試科目：化工熱力學

考試日期：0227，節次：2

※ 考生請注意：本試題可使用計算機。　請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

Problem 1 (20%)

For fluoromethane, *aka* Freon 41, at 297.76K, the second and third virial coefficients are

B = -209.47 cm^3/mol and C = 21,500 cm^6/mol^2, respectively.

(1) What is the molar volume of Freon 41 at 297.76K and 50 bar? **[8%]**

(2) What is the work of mechanically reversible, isothermal compression of 1 mol of Freon 41 from 1 bar to 50 bar at 297.76K? **[12%]**

Problem 2 (14%)

A compressed air tank is to be re-pressurized to 50 bar by being connected to a high-pressure line containing air at 70 bar and 293.15K. As the re-pressurization process proceeds so quickly, it is feasible to assume that such a process is adiabatic and there is no heat transfer from the air to the tank. Assume air to be an ideal gas with C_V=21 *J/(mol·K)*. If the tank initially contains air at 1 bar and 293.15K, what will be the temperature of the air in the tank in the end of gas filling process? Please make your assumption as more practically reasonable as possible.

Problem 3 (20%)

(1) Define the thermal efficiency η for a Carnot device operating in a *counterclockwise* manner in a PV diagram. The gas obeys the following equation of state:

$$P = \frac{RT}{V-b},$$

where *b* is a positive constant. Derive η in terms of the temperatures of cold and hot reservoirs T_C and T_H. C_V is assumed constant. **[12%]**.

(2) Follow (1). Draw the corresponding cycle in an S-T diagram. What is the physical meaning of the enclosed area in this S-T diagram? **[4%]**

(3) If a device is **irreversible** and undergoes the same PV cycle as in (1), then will the enclosed ST area be larger or smaller than that of (2)? Why? **[4%]**

Problem 4 (13%).

A pure fluid is described by the canonical equation of state:

$$G = \Gamma(T) + RT \ln P,$$

where Γ(T) is some given function of temperature. Determine *V*, *S*, *H*, C_p, and C_v in terms of Γ, *T*, and *P*. These results are consistent with those described by an important gas model. What is this model?

Problem 5 (18%)

The partial molar volume and activity coefficient of species 2 in a binary liquid mixture of components 1 and 2 at given T and P can be expressed as [$\mathbf{600 + 40\, x_1^3}$] and [$\mathbf{\exp(A\, x_1^2)}$], respectively. The parameter A is a function of temperature only, and x_1 is the mole fraction of species 1 in the binary liquid mixture. Derive the expressions for the molar volume of the binary liquid mixture and the activity coefficient of species 1 in the binary liquid mixture as functions of x_1, and explain what extra information is required to derive the expressions if not enough information is given.

Problem 6 (15%)

Discuss the major assumptions required to reduce vapor/liquid equilibrium calculations to Raoult's law and explain the physical meaning of the Lewis/Randall rule.

<u>END OF PAPER.</u>