

## 國立臺灣科技大學103學年度碩士班招生試題

系所組別：材料科學與工程系碩士班丙組

科目：熱力學

(總分為100分)

1. (1) define  $c_p$  and  $c_v$  (10%)
- (2) derive that  $c_p - c_v = \left(\frac{\partial V}{\partial T}\right)_p \left[ P + \left(\frac{\partial U}{\partial V}\right)_T \right]$  (10%)
- (3) compute  $c_p - c_v$  of aluminum at 20°C. At this temperature, aluminum has the following properties:  
 $c_p = 24.36 \text{ J/mole}\cdot\text{K}$ , the isobaric thermal expansivity  $\alpha = \frac{1}{V} \left(\frac{\partial V}{\partial T}\right)_p$ , the isothermal compressibility of a system  $\beta = -\frac{1}{V} \left(\frac{\partial V}{\partial P}\right)_T$ , atomic weight is 26.98 g/mole, density is 2.7 g/cm<sup>3</sup>.  
 (hint:  $P = -\left(\frac{\partial A}{\partial V}\right)_T$ ,  $A = U - TS$ ,  $\left(\frac{\partial S}{\partial V}\right)_T = \left(\frac{\partial P}{\partial T}\right)_V$ ) (10%)
2. The virial equation of state for n-butane at 460 K is  $Z = 1 + \frac{A}{V} + \frac{B}{V^2}$  in which  $A = -265 \text{ cm}^3/\text{g}\cdot\text{mole}$  and  $B = 30250 \text{ cm}^6\cdot\text{mole}^2$ . Calculate the change in the Gibbs free energy when the volume of one mole of n-butane is increased from 100 to 500 cm<sup>3</sup> at 460 K. (10%)
3. The specific heat of solid copper above 300K is given by  $C_p = 22.64 + 6.28 \times 10^{-3}T \text{ Jmol}^{-1}\text{K}^{-1}$ .  
 By how much do the enthalpy and entropy increase on heating from 300 to 1358 K. (10%)
4. (1) Please derive the relationship between Henry's and Raoult's laws for a binary A-B solution. (5%) (2) If A-B solution is an ideal solution and exhibits positive deviation characteristics, please draw a schematic diagram of activities of A vs  $X_A$  (mole fraction of A). (5%) (3) Please describe the relationship of temperature and activity with this solution behavior. (5%)
5. At 900 K, the reaction of NiO with Cl<sub>2</sub> gas is
- $$\text{NiO}_{(s)} + \text{Cl}_{2(g)} = \text{NiCl}_{2(s)} + \frac{1}{2} \text{O}_{2(g)}$$
- and
- $$\Delta G^0 = -15,490 \text{ J}$$
- Calculation the total pressure as conversion rate of Cl<sub>2(g)</sub> is 90%. (10%)
6. (1) At equilibrium state, a solution reaction is
- $$aA + bB = cC + dD$$
- Please define the equilibrium constant for the reaction (5%). (2) At constant pressure and temperature, please describe the relationship of reaction constant and equilibrium constant with reaction direction. (5%)



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7. For a binary A-B solution system, at constant temperature and pressure. (1) Please define system free energy. (5%) (2) Please discuss the stability of curve I and II in the figure. (10%)

