

1. Briefly answer the following questions:

- (a) How many is(are) the degree(s) of freedom for the eutectic reaction between liquid and the components A and B ( $\text{Liq} = \text{A} + \text{B}$ )? [3%]
- (b) What is(are) the possible degree(s) of freedom for the above question? [3%]
- (c) Give at least six different forms of energy and work. [3%]
- (d) Molar heat capacity (in terms of Joule/K·mole) of all solids. [3%]
- (e) The van der Waal's equation of non-ideal gases. [3%]

2. Let  $C_v$  and  $C_p$  represent heat capacity at constant volume and constant pressure, respectively. (a) Deduce an expression for  $C_v - C_p$  in terms of the state functions P (pressure), V (volume), and U (internal energy) for a gas. [6%] (b) Derive the value of  $C_v - C_p$  in terms of Joule/K·mole, for an ideal gas. [4%]

3. Phase transitions of iron have been thoroughly studied and well-known, such as:

$$C_{p(\text{Fe},\alpha)} = 17.5 + 24.8 \times 10^{-3} T \text{ Joule/K}\cdot\text{mole (from 273 to 1033K)}$$

$$C_{p(\text{Fe},\beta)} = 38 \text{ Joule/K}\cdot\text{mole (1033 - 1181 K)}$$

$$C_{p(\text{Fe},\gamma)} = 7.7 + 19.5 \times 10^{-3} T \text{ Joule/K}\cdot\text{mole (1181 - 1687 K)}$$

$$C_{p(\text{Fe},\delta)} = 43.9 \text{ Joule/K}\cdot\text{mole (1687 - 1808 K)}$$

$$C_{p(\text{Fe},\text{liq})} = 41.8 \text{ Joule/K}\cdot\text{mole (1808 - 1873 K)}$$

$$\Delta H_{(\alpha,\beta)} = 5020 \text{ Joule/mole at 1033 K}$$

$$\Delta H_{(\beta,\gamma)} = 920 \text{ Joule/mole at 1181 K}$$

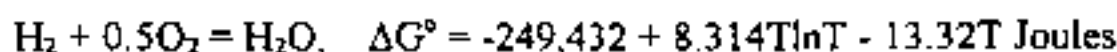
$$\Delta H_{(\gamma,\delta)} = 880 \text{ Joule/mole at 1687 K}$$

$$\Delta H_{(\delta,\text{liq})} = 13800 \text{ Joule/mole at 1808 K}$$

- (a) Calculate total enthalpy change for one mole of iron from 27°C to 1600°C. [8%]
- (b) Calculate total entropy change of the transition of  $\alpha$  at 1033K to  $\delta$  at 1674 K. [6%]
- (c) What is the origin of the phase transition  $\alpha$  to  $\beta$ ? [3%]

$$\text{given: } \ln 10 = 2.303, \ln 7 = 1.946, \ln 5 = 1.609, \ln 3 = 1.098, \ln 2 = 0.6931$$

4. A material synthesis calls for an environment that the temperature is 2000 K, and the oxygen partial pressure is smaller than  $10^{-12}$  atm. If this is adjusted by the hydrogen atmosphere, calculate the minimum partial pressure between the hydrogen supplied and the water vapor produced. [8%] Given:

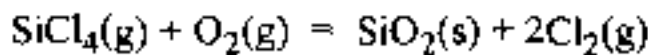


$$\text{and } e^2 = 7.389, e^3 = 20.08, e^7 = 1097$$

八一七學年度材料科學工程研究所(系)(所) 21 組碩士班研究生入學考試

科目 冶金熱力學 科號 1503 共 3 頁第 2 頁 \*請在試卷【答案卷】內作答

5. Consider the following reaction which is employed in the chemical vapor (10%) deposition of  $\text{SiO}_2$  for optical fiber preforms. The reaction takes place at 1700K.



- (a) Determine how much pure  $\text{SiO}_2(\text{s})$  would be deposited from a gas consisting initially of 1 mole of  $\text{SiCl}_4$  and 1 mole of  $\text{O}_2$  under a total pressure of  $10^5$  Pa.
- (b) Could the yield of  $\text{SiO}_2(\text{s})$  be improved by changing the temperature or pressure? Explain.

The following data are for 1700K

	$\Delta_f G^\circ(\text{kJ/mol})$	$\Delta_f H^\circ(\text{kJ/mol})$
HCl(g)	-105.0	-95.4
$\text{SiCl}_4(\text{g})$	-441.3	-707.2
$\text{SiO}_2(\text{s})$	-609.1	-941.6

Note:  $\exp(11.87) = 1.43 \times 10^5$

6. Consider the A-B system. Solid A and Solid B are mutually immiscible but form two solid stoichiometric compounds of  $\text{AB}$  and  $\text{AB}_2$ .



Determine the minimum temperatures at which  $\text{AB}$  and  $\text{AB}_2$  are stable. (10%)

7. Zinc sulfide ( $\text{ZnS}$ ) is reacted in pure oxygen to form zinc sulfate ( $\text{ZnSO}_4$ ). (10%)

- (a) Write the chemical reaction representing the process.
- (b) How many solid phases may exist in equilibrium if pressure and temperature are arbitrarily fixed?
- (c) If the temperature is fixed, will the pressure be determined if  $\text{ZnS}$  and  $\text{ZnSO}_4$  exist in equilibrium?

八十七學年度材料科學工程研究所(系) (所) 乙一 組碩士班研究生入學考試

冶金熱力學

科號 1503  
1603

共 3 頁第 3 頁

請在試卷【答案卷】內作答

8. This problem is concerned with interpreting the attached Al-Ni binary phase diagram. (20%)
- Identify all the invariant (three-phase) reactions that occur in this system, indicating the temperature and phases involved in each reaction.
  - Draw schematic plot of the molar Gibbs energy at 1385°C.
  - Draw schematic plots of the chemical potential and activities at 1385°C.
  - Draw an equilibrium cooling curve for a liquid initially of composition  $X_{Ni}=0.30$  at 1600°C which is cooled to room temperature. For each portion of the curve indicate the phases present.
  - For the composition  $X_{Ni}=0.30$ , use the lever rule to determine the amount of  $Al_3Ni_2$  and  $Al_3Ni$  present at 600°C.
  - If you desire to grow a single-crystal of  $Al_3Ni$  from a liquid melt, what liquid compositions could you use? Explain your answer.

