八十七學年度材料科學工程研究所(含奈(所) 乙一 組碩士班研究生入學考試

自 冶金熱力學 科號 1503 1603 共 3 頁第 1 頁 *請在試卷【答案卷】內作答

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 (Liq = A + 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:
   $C_{p(Fe,\alpha)} = 17.5 + 24.8\times10^{-3}T$ Joule/K·mole (from 273 to 1033K)
   $C_{p(Fe,\beta)} = 38$ Joule/K·mole (1033 - 1181 K)
   $C_{p(Fe,\gamma)} = 7.7 + 19.5\times10^{-3}T$ Joule/K·mole (1181 - 1687 K)
   $C_{p(Fe,\delta)} = 43.9$ Joule/K·mole (1687 - 1808 K)
   $C_{p(Fe,liq)} = 41.8$ Joule/K·mole (1808 - 1873 K)
   $\Delta H_{(Fe,\alpha-\beta)} = 5020$ Joule/mole at 1033 K
   $\Delta H_{(Fe,\beta-\gamma)} = 920$ Joule/mole at 1181 K
   $\Delta H_{(Fe,\gamma-\delta)} = 880$ Joule/mole at 1687 K
   $\Delta H_{(Fe,\delta-liq)} = 13800$ 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 α at 1033K to δ at 1674 K. [6%]
   (c) What is the origin of the phase transition α to β? [3%]
   given: ln10 = 2.303, ln7 = 1.946, ln5 = 1.609, ln3 = 1.098, ln2 = 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:
   $H_2 + 0.5O_2 = H_2O$, $\Delta G^\circ = -249{,}432 + 8.314T\ln T - 13.32T$ Joules
   and $e^2 = 7.389$, $e^3 = 20.08$, $e^7 = 1097$

5. Consider the following reaction which is employed in the chemical vapor deposition of SiO_2 for optical fiber preforms The reaction takes place at 1700K. (10%)

$$SiCl_4(g) + O_2(g) = SiO_2(s) + 2Cl_2(g)$$

(a) Determine how much pure $SiO_2(s)$ would be deposited from a gas consisting initially of 1 mole of $SiCl_4$ and 1 mole of O_2 under a total pressure of 10^5 Pa.

(b) Could the yield of $SiO_2(s)$ be improved by changing the temperature or pressure? Explain.

The following data are for 1700K

	$\Delta_f G^o$(kJ/mol)	$\Delta_f H^o$(kJ/mol)
HCl(g)	-105.0	- 95 4
$SiCl_4(g)$	-441.3	-707.2
$SiO_2(s)$	-609.1	-941.6

Note: $\exp(11.87)=1.43\times10^5$

6. Consider the A-B system. Solid A and Solid B are mutually immiscible but form two solid stoichiometric compounds of AB and AB_2

$$A(s) + B(s) = AB(s) \qquad \Delta G^o = -25500 - 4.78T \text{ joules}$$

$$A(s) + 2B(s) = AB_2(s) \qquad \Delta G^o = -24400 - 6.43T \text{ joules}$$

Determine the minimum temperatures at which AB and AB_2 are stable. (10%)

7. Zinc surfide (ZnS) is reacted in pure oxygen to form zinc sulfate ($ZnSO_4$).(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 ZnS and $ZnSO_4$ exist in equilibrium?

8. This problem is concerned with interpreting the attached Al-Ni binary phase diagram. (20%)

(a) Identify all the invariant (three-phase) reactions that occur in this system,

indicating the temperature and phases involved in each reaction.

(b) Draw schematic plot of the molar Gibbs energy at 1385℃.

(c) Draw schematic plots of the chemical potential and activities at 1385℃.

(d) Draw an equilibrium cooling curve for a liquid initially of composition X_{Ni}=0.30 at 1600℃ which is cooled to room temperature. For each portion of the curve indicate the phases present.

(e) 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℃.

(f) If you desire to grow a single-crystal of Al_3Ni from a liquid melt, what liquid compositions could you use? Explain your answer.