國 立 清 華 大 學 命 題 紙

八十八學年度 材料科學工程研究所(系) 系(所) 乙 組碩士班研究生招生考試

科目 冶金熱力學 科號 1702 共 4 頁第 1 頁 *請在試卷【答案卷】內作答

(10%) 1. A piece of metal is compressed slowly and reversibly from $P_1=0$ atm, $T_1 = 298°K$ to $P_2 = 500atm$, $T = 300°K$. Evaluate the change of entropy ΔS for this process in the unit of cal/°K·mole. List any assumptions you make.

Given $Cp = 6$ cal/°K·mole

$\alpha = 5 \times 10^{-5}$/°K

density = 9 g/cm^3

atomic weight = 63 g/mole

$\beta = 7 \times 10^{-7}$/atm

and 1 atm · cm^3 = 0.024 cal

(10%) 2. In a wire drawing operation a metal wire is pulled rapidly through the die by a force of 150 kg. Estimate the temperature rise of the wire as it passes through the die if the finished diameter is 2.5 mm. List assumptions if any.

Given $Cv = 6$ cal/°K·mole

molar volume = 6 cm^3/mole

(10%) 3. Evaluate the entropy change of mixing 1 mole of gas A at P = 1atm with 2 moles of A at P = 2 atm if the mixing is carried out at constant total volume.

(10%) 4. Consider the gas reaction

$A + 4B \rightarrow 2C + 3D$

at 1000 ℃ and P_{total}= 1atm.

The volume ratio of A:B:C:D = 4:3:2:1 before reaction occurs.

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八十八學年度 材料科學工程研究所(系) 系(所) 甲 乙 組碩士班研究生招生考試

科目 冶金熱力學 科號 1602 1702 共 4 頁第 2 頁 *請在試卷【答案卷】內作答

1) Write down the expression for equilibrium constant at fixed pressure K_p in terms of partial pressure of A, i.e. p_A. (8%)

2) Discuss the effect of total pressure on p_A. (2%)

(10%) 5. Consider the reversible expansion process by a working substance of 1 mole of an ideal diatomic gas from state I to state II in which $P_I = 1$ atm, $P_{II} = 2$ atm, and $T_I = 300°K$. Assume that pressure is proportional to volume during the process.

1) Show that $T_I/T_{II} = (V_I/V_{II})^2$ (4%)

2) Evaluate T_{II} (3%)

3) Find the work for this process in calories. (3%)

6. Consider the case that a miscibility gap forms in a binary phase diagram.
(a) Draw a schematic ΔG_{mix} - X_2 curve at a temperature below the critical temperature.
(b) How to define the spinodal region and the two-phase region ?
(c) Explain the difference in diffusion behavior, when the alloy composition lies inside or outside the spinodal region. (2%, 4%, 4%)

7. Consider the oxidation of some metal, $M + O_2 = MO_2$. The following information is known:

Heat of formation of $MO_2(s)$, $\Delta H_f = -300$ KJ/mole.

Entropies: $S^0_{298}(MO_2) = 65$ J/mole-K, $S^0_{298}(O_2) = 205$ J/mole-K, $S^0_{298}(M) = 40$ J/mole-K,

Melting temperature: $T_m(M) = 600$ K, $T_m(MO_2) = 1000$ K

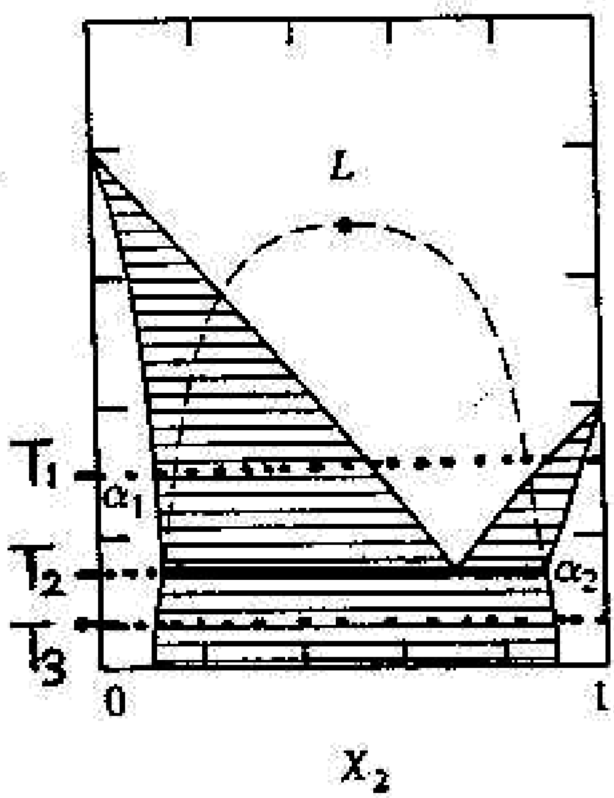
Entropy of melting: $\Delta S_m(M) = 10$ J/mole-K, $\Delta S_m(MO_2) = 20$ J/mole-K

Boiling temperature: $T_b(M) = 1400$ K, $T_b(MO_2) = 1800$ K,

Entropy of vaporization: $\Delta S_b(M) = 100$ J/mole-K, $\Delta S_b(MO_2) = 120$ J/mole-K.

Calculate (a) the value of ΔG^o at T = 0 K ; and (b) the <u>slope</u> of every part of the line; then draw the Ellingham line (ΔG^o versus T diagram) for the oxidation reaction in the temperature range 0 ~ 1750 K. (15%)

8. Given the phase diagram below. Sketch the ΔG-X_2 diagrams at temperatures T_1, T_2, and T_3. You should use the same reference states, i.e. $G_1^{0\alpha}$, G_2^{0L}. (10%)



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科目 冶金熱力學 科號 1602/1702 共 4 頁第 4 頁 *請在試卷【答案卷】內作答

. Use Richardson-Ellingham chart for oxides to answer the following questions: (15%)

(a) What is the dissociation pressure of CoO at 1000 °C ?

(b) What is the ratio of a H_2/H_2O gas mixture that can prevent the oxidation of Cr at 1000 °C ?

(c) What is the composition of the H_2/H_2O gas mixture that has the same oxygen potential as the CO/CO_2 gas mixture with a ratio of 10^3 at 900 °C.

(d) What is the oxygen potential in (c) ?

(e) List the stability sequence of the oxides at 200 °C: CoO, Al_2O_3, ZnO, TiO_2, NiO.