國立臺灣大學99學年度碩士班招生考試試題

共七題

1. One mole of a monatomic ideal gas is contained adiabatically at 10 atm and 300 K.
(a) Would you expect the temperature of the ideal gas to be greater than, the same as, or less than 300 K when the ideal gas undergoes free expansion to 5 atm? Reason your answer. (10%)
(b) Would you expect the entropy of the ideal gas to increase, remain constant, or decrease when the ideal gas undergoes free expansion to 5 atm? Reason your answer. (10%)

2. About the Clapeyron equation
(a) Briefly describe the applications of the Clapeyron equation. (6%)
(b) The ice of an outdoor skating rink is at the temperature of $-2.0\,^{\circ}C$. Calculate the minimum pressure (applied for example by a skate) necessary to melt the ice. Data: At $0^{\circ}C$, the specific volume of water is 1.000 cm^3/g and that of ice is 1.090 cm^3/g; the heat of fusion is 80 cal/g. Unit conversions: 1 atm = 101325 N/m^2, 1 cal = 4.18 J. (14%)

3. The activity coefficient of Zn in liquid Zn-Cd alloys at 435 °C can be represented as
$\ln \gamma_{Zn} = 0.875 (X_{Cd})^2 - 0.30 (X_{Cd})^3$, where X_{Cd} is the mole fraction of Cd.
(a) Derive the corresponding expression for the dependence of $\ln \gamma_{Cd}$ on composition. (5%)
(b) Calculate the activity of Cd in the alloy of X_{Cd}=0.5 at 435 °C. Does this alloy exhibit a positive deviation or negative deviation from the ideal solution at this composition and temperature? Do Zn and Cd like or dislike each other? (10%)

4. What is the minimum value that the activity of MgO can have in $MgO.Al_2O_3$ at 1000 °C. (10%)

$$MgO + Al_2O_3 = MgO.Al_2O_3 \qquad \Delta G^{\circ} \text{ (at } 1000\,^{\circ}C) = -38220\ J$$

5. Tin obeys Henry's law in dilute solutions of Sn and Cd, and the Henrian activity coefficient of Sn, γ°_{Sn} varies with temperature as

$$\ln \gamma^{\circ}_{Sn} = -840/T + 1.58.$$

Calculate the change in temperature when one mole of liquid Sn and 99 moles of liquid Cd are mixed in an adiabatic enclosure. The molar constant pressure heat capacity of the liquid ally formed is 29.5 J/K. (10%)

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6. Use the Ellingham diagram to answer the following question.
   (a) If we want to grow a layer of TiO_2 over a clean Ti substrate at 1000 °C in a vacuum chamber, what is the minimum O_2 pressure we must have in the chamber? (5%)
   (b) Continue the question in (a). If this O_2 pressure is maintained through the equilibrium between H_2 and H_2O, what ratio of H_2 over H_2O we must use? (5%)

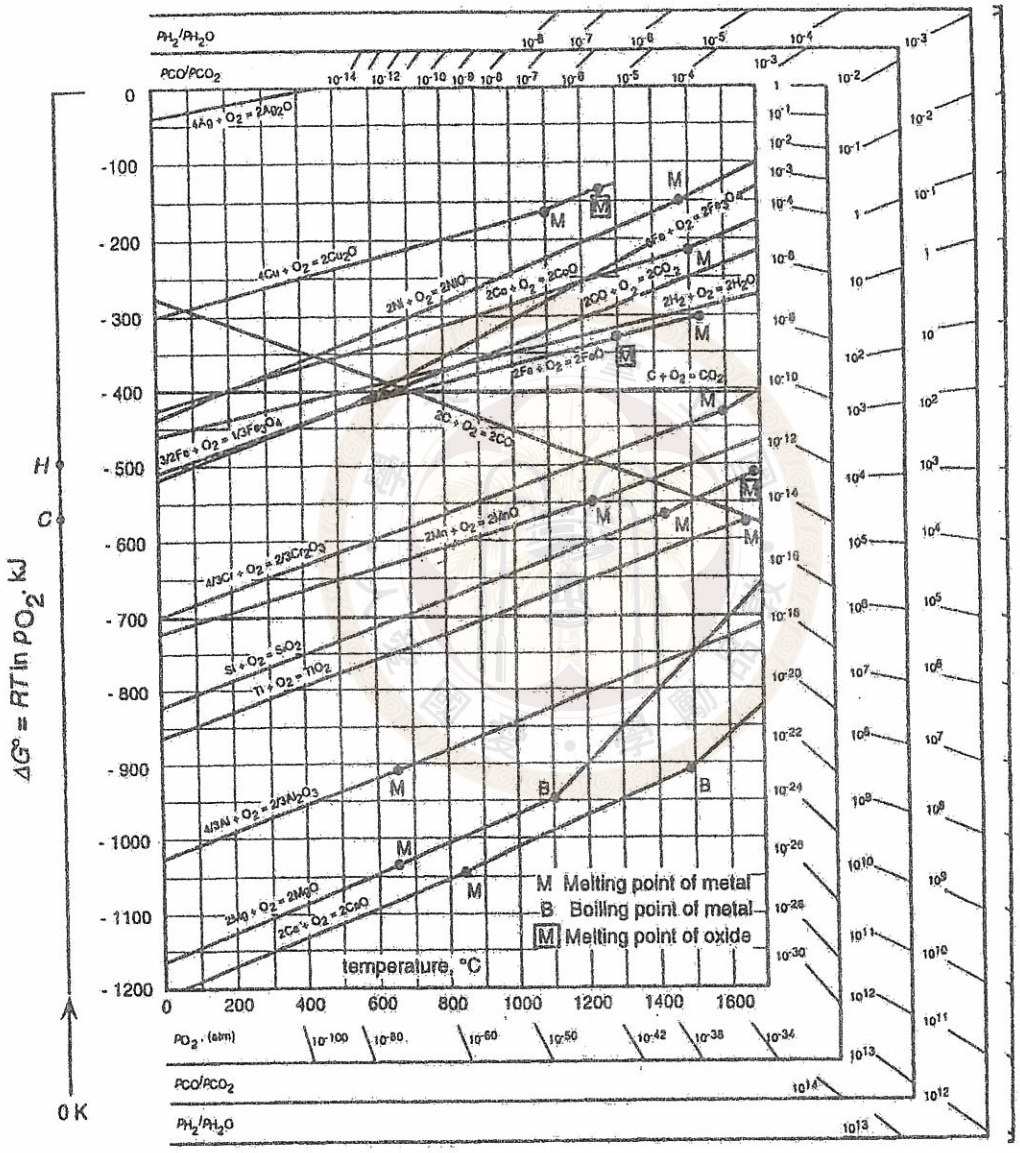

Figure The Ellingham diagram for selected oxides.

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7. Consider a binary system that has α and L phases. Both α and L are regular solutions. These two phases can form a series of binary phase diagrams shown below by adjusting the regular solution parameters for the α phase, Ω^{α}, and that for the L phase, Ω^{L}. Answer the following questions.

(a) Which diagram is for the system that α and L are both idea solution? Write down the number of that diagram. (5%)

(b) Consider diagrams on the central column (3, 8, 13, and 18), these diagram have the same Ω^{L} , but different Ω^{α}. Which diagram has the highest Ω^{α} value? Which diagram has the lowest Ω^{α} value? Write down the numbers of these diagrams. (5%)

(c) Consider diagrams on the third row (11, 12, 13, 14, and 15), these diagram have the same Ω^{α} , but different Ω^{L}. Which diagram has the highest Ω^{L} value? Which diagram has the lowest Ω^{L} value? (5%)

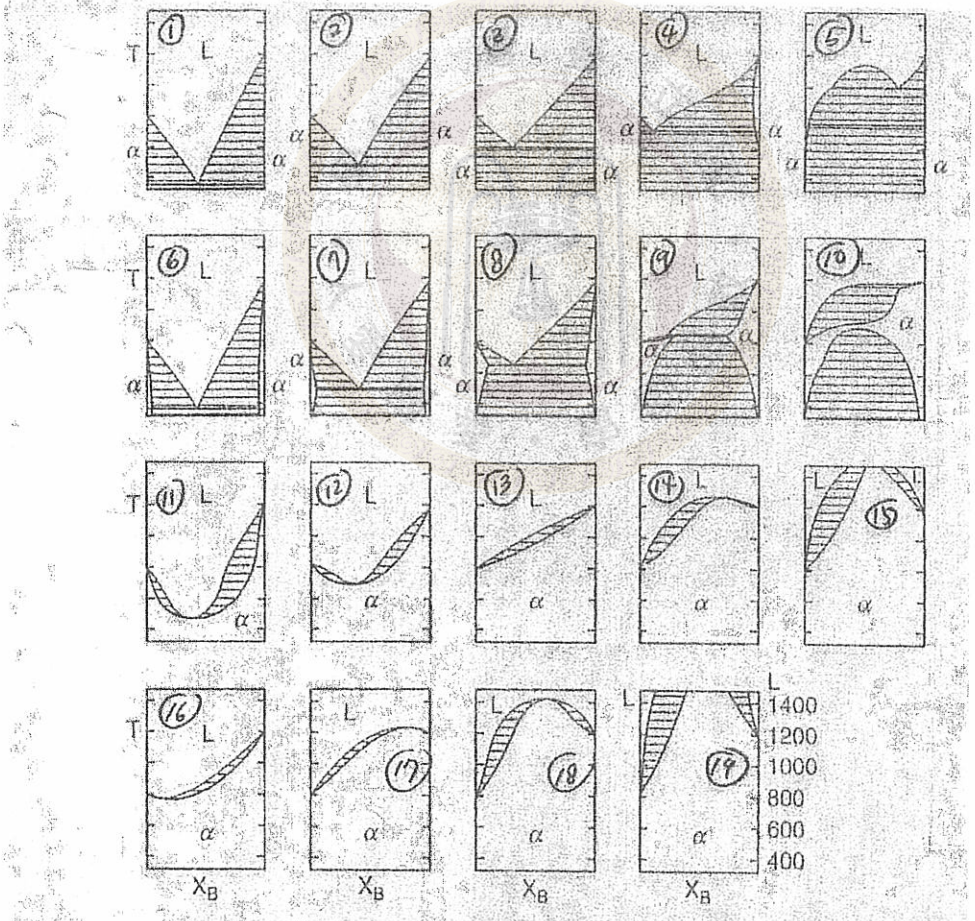

FIGURE Patterns of phase diagrams that can be generated by only two phases, α and L, with the simplest regular solution model.