國立臺灣科技大學 111 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：材料導論

(總分為 100 分；所有試題務必於答案卷內頁依序作答，否則不予計分)

1. X-ray diffraction is one of important techniques. (20%)
   (1) Describe about this technique and its theory. (8%)
   (2) The element X (simple cubic with the lattice parameter of 0.3 nm) has the three diffraction peaks (using Cr-Kalpha of 2.2936nm) with the corresponding "two theta" angles of 44.95, 65.45, and 82.92°. Please calculate these three d-spacings in nm. (9%)
   (3) Please identify the hkl values of these three peaks. (3%)

2. (20%)
   (1) What is a solid solution for metal materials (5%).
   (2) Please describe solid solution strengthening (5%).
   (3) Explain the two main types of solid solution strengthening (10%).

3. Calculate the bonding energy and bonding length of the $M^+ - N^-$ by using the attractive and repulsive energies E_A and E_R as below (10 %)

$E_A=\frac{-1.59}{r}$, $E_R=\frac{4.28\times10^{-5}}{r^{10}}$

(Note: unit of r is nm and unit of E_A and E_R are eV)

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4. (10%)

(1) Write and explain the equation for the Fick's first law of diffusion. (5%)

(2) The diffusion coefficients for Fe in γ-Fe are 1.1×10^{-17} m^2/s at 900°C and 7.8×10^{-16} m^2/s at 1100°C, respectively. The ideal gas constant R is 8.31 J/mol·K. Calculate the activation energy for diffusion for Fe in γ-Fe. (5%)

5. Bi and Sb are completely soluble in each other in both liquid and solid phases. The melting point of pure Bi is 271°C and the melting point of pure Sb is 631°C. (15%)

(1) Draw the Bi–Sb binary phase diagram. Then indicate the phase(s) and degree of freedom in each region in the phase diagram. (10%)

(2) An alloy with a composition of 40 wt.% Bi–60 wt.% Sb is slowly cooled from liquid to solid. Based on your drawing, give the composition of the solid phase first formed and the composition of the liquid phase last disappeared during cooling. (5%)

6. The band gap (Eg) is 1.1 eV and the electron affinity (χ) is 4.15 eV for Si crystal. The work function (ϕ_m) is 5.1 eV for Au metal. (15%)

(1) Draw the band diagrams for Au and a low doping n-type Si before and after they are brought in contact. (5%)

(2) What is the type of contact for this Au/n-type Si device? Draw the I–V curve for this Au/n-type Si device. (5%)

(3) What are the majority and minority charge carriers in n-type Si and in Au? (5%)

7. (10%)

(1) Draw the polarization versus electrical field (P–E) curves for a ferroelectric material at temperatures above and below Curie temperature (T_c), respectively. (5%)

(2) Give the three polarization sources contributing to dielectric constant of insulators. (5%)