Material Science
EXAM I Nov. 14, 2014

I. Explain the following terms: (24%)

1. hydrogen bond
2. vacancy
3. APF
4. Electronegativity.
5. equiaxed grains
6. columnar grains
7. embryo
8. Schottky imperfection
9. Frenkel imperfection
10. interstitial solid solution
11. substitution solid solution
12. solidification

I. Short answer:(43%)

1. What are the closest-packed directions in (a) the BCC structure, (b) the FCCstructure, and (c) the HCP structure?
2. Identify the close-packed planes in (a) the FCC structure, (b) the HCP structure
3. For a BCC unit cell, (a) how many atoms are there inside the unit cell, (b) what isthe coordination number for the atoms, (c) whatis the atomic packing factor?
4. What are the {100} family of planes of the cubic system?
5. What are the directions of the<111>family or form for a unit cube?
6. What are the conditions that are favorable for extensive solid solubility of one element in another (Hume-Rothery rules)? (4%)
7. What are the primary bonds?
8. For each bond in the following series of bonds, determine the bond order, rank bond length, and rank bond strength. C-C; C=C; C≡C.
9. In HCP, the three-index expression for a direction is [100], what is its four-index expression?
10. Methane (CH_4) has a much lower boiling temperature than does water (H_2O) Explain why this is true in terms of the bonding between molecules in each of these two substances.
11. Name as many carbon allotropes as you can(at least two allotropes).
12. What are the three most common metal crystal structures?
13. What are the four primary traditional experimental equipments used in the study of material science?
14. 陶瓷材料有何優點與缺點？

III.單選題 12%)

1. Determine which one of the following combinations of quantum numbers is acceptable.

(A) n = 3, ℓ= 0, m_ℓ = +1
(B) n = 6, ℓ= 2, m_ℓ = -3
(C) n = 3, ℓ= 3, m_ℓ = -1
(D) n = 2, ℓ= 1, m_ℓ = +1

2. Which of the following types of bonding is directional? (A) metallic bonding, (B) ionic bonding, (C) covalent bonding.
3. Which of the following ones is the four-parameter Miller-Bravais indices of a plane in a hexagonal unit cell? (A) $(\bar{1}0\bar{1}0)$, (B) $(10\bar{1}0)$, and (C) $(\bar{1}\,\bar{1}\,\bar{1}0)$.
4. 造成鐵達尼號快速沉船之原因是當時在作材料機械性質分析沒考慮到 (A)溫度 (B)重力，(C)風速，(D)濕度的因素。
5. What theory or phenomenon is applied in STM? (A) Fourier law, (B) tunneling effect, (C) Hook's law, (D) Energy conservation.
6. For a BCC crystal, the extinct diffraction plane is (A) (100), (B) (110), (C) (200), (D) (220).

IV. Draw the following directions in a BCC unit cell,(a) [100], (b) [110], (c) [111]. (6%)

V. Draw the following crystallographic

planes in a BCC unit cell: (a) (100), (b) (110), (c) (111). (6%)

VI. If there are 400 grains per square 2.54×10^{-2} m on a photomicrograph of a ceramic material at 200x, what is the ASTM grain-size number of the material? (4%)

VII. X-rays of an unknown wavelength are diffracted by a gold sample. The 2θ angle was 64.582° for the {220} planes. What is the wavelength of the X-rays used? (The lattice constant of gold = 0.40788 nm; assume first-order diffraction, n = 1.) (5%)

VIII. An X-ray diffractometer recorder chart for an element that has either the BCC or the FCC crystal structure showed diffraction peaks at the following 2θ angles: 41.069°, 47.782°, 69.879°, and 84.396°. The wavelength of the incoming radiation was 0.15405 nm. (X-ray diffraction data courtesy of the International Centre for Diffraction Data.)

(*a*) Determine the crystal structure of the element. (3%)

(*b*) Determine the lattice constant of the element. (3%)

IX. If the value of the principal quantum number, n, is 3, write down all other possible quantum numbers for ℓ and m_ℓ. (5%)

X. Calculate the planar atomic density in atoms per square millimeter for the (100) crystal plane in FCC gold, which has a lattice constant of 0.40788 nm. (4%)

XI. What are the indices of the direction vector **b** and plane **A** shown in the following figure? (6%)