

材料科學工程學系

入學考試試題

科目： 材料科學導論 第 頁共 頁

A. Crystal structure: (38%)

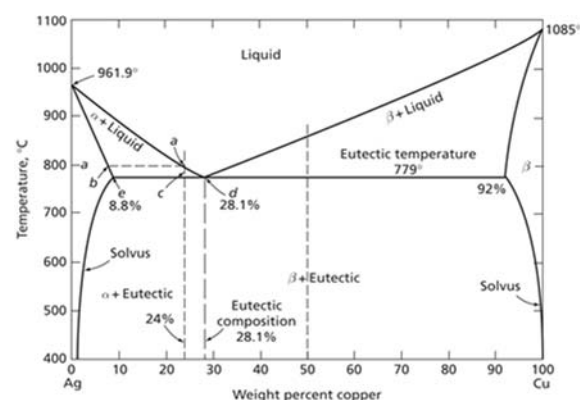
1. (4%) What is the atomic packing density of the face-centered-cubic crystal? (a) 0.34 (b) 0.52 (c) 0.68 (d) 0.74 (e) 0.78
2. (4%) The coordination number for the hexagonal structure is (a) 4 (b) 6 (c) 8 (d) 10 (e) 12.
3. (4%) What is the closest packed direction in the body-centered cubic structure? (a) [100] (b) [110] (c) [111] (d) [211] (e) [311]
4. (4%) Pure carbon exists as several allotropes. Which of the following is not included? (a) diamond (b) graphene (c) benzene (d) fullerene (e) graphite
5. (4%) Which of the following structures has the lowest atomic packing density? (a) FCC (b) BCC (c) HCP (d) diamond (e) simple cubic
6. (4%) In which crystal structure each atom is not tetrahedrally coordinated? (a) diamond (b) zinc blende (c) sphalerite (d) wurtzite (e) rocksalt
7. (4%) What is the general formula for a material with perovskite structure? (a) ABO (b) ABO₂ (c) ABO₃ (d) ABO₄ (e) AB₂O₄
8. (10%) Above 882°C, titanium has a BCC crystal structure, with $a = 0.332$ nm. Below this temperature, titanium has an HCP structure, with $a = 0.29503$ nm and $c = 0.46831$ nm. Determine the percent volume change when BCC titanium transforms to HCP titanium. Is this a contraction or expansion?

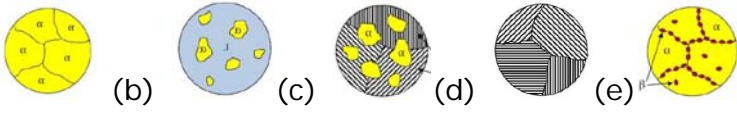
B. Defects: (26%)

9. (4%) Which of the following is a line defect? (a) vacancy (b) stacking fault (c) dislocation (d) interstitial (e) grain boundary.
10. (4%) Which of the following materials has the smallest burgers vector? (a) BCC metals (b) FCC metals (c) ionic solids (d) covalent solids (e) polymer
11. (4%) Among the following defects, which of the following is an equilibrium defect? (a) vacancy (b) dislocation (c) grain boundary (d) stacking fault (e) twin boundary
12. (4%) Which of the following elements act as a donor when added to pure silicon? (a) boron (b) indium (c) germanium (d) gallium (e) phosphorous
13. (10%) Aluminum-doped ZnO films (AZO) are considered the most promising alternative to expensive indium-based ITO for transparent conducting oxide materials. In this case, Al³⁺ substitution of Zn²⁺ in ZnO is a favorable mechanism. Two Al³⁺ cations replace two Zn²⁺ cation host positions and create a Zn²⁺ cation vacancy to maintain charge neutrality. Please write this defect reaction using Kröger-Vink notation.

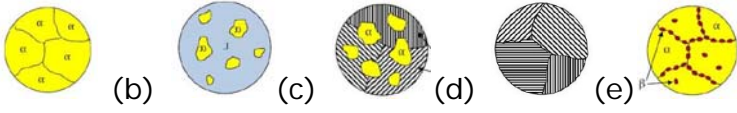
C. Phase diagram: (32%)

14. (4%) Metals Ag and Cu are mutually soluble in the liquid state, but only partially soluble in the solid state. α phase represents the solid solution for solute Cu in solvent Ag. β phase represents the solid solution for solute Ag in solvent Cu. What is the weight percentage of α phase for the eutectic composition just below 779°C? (a) 23% (b) 43% (c) 57% (d) 77% (e) 83%
15. (4%) Same as Problem 14, what is the weight percentage of the eutectic phase for the 76%Ag - 24%Cu alloy just below the eutectic temperature. (a) 21% (b) 41% (c) 59% (d) 76% (e) 79%
16. (4%) Same as Problem 14, what is the microstructure for the 76%Ag - 24%Cu alloy at room temperature? (a)

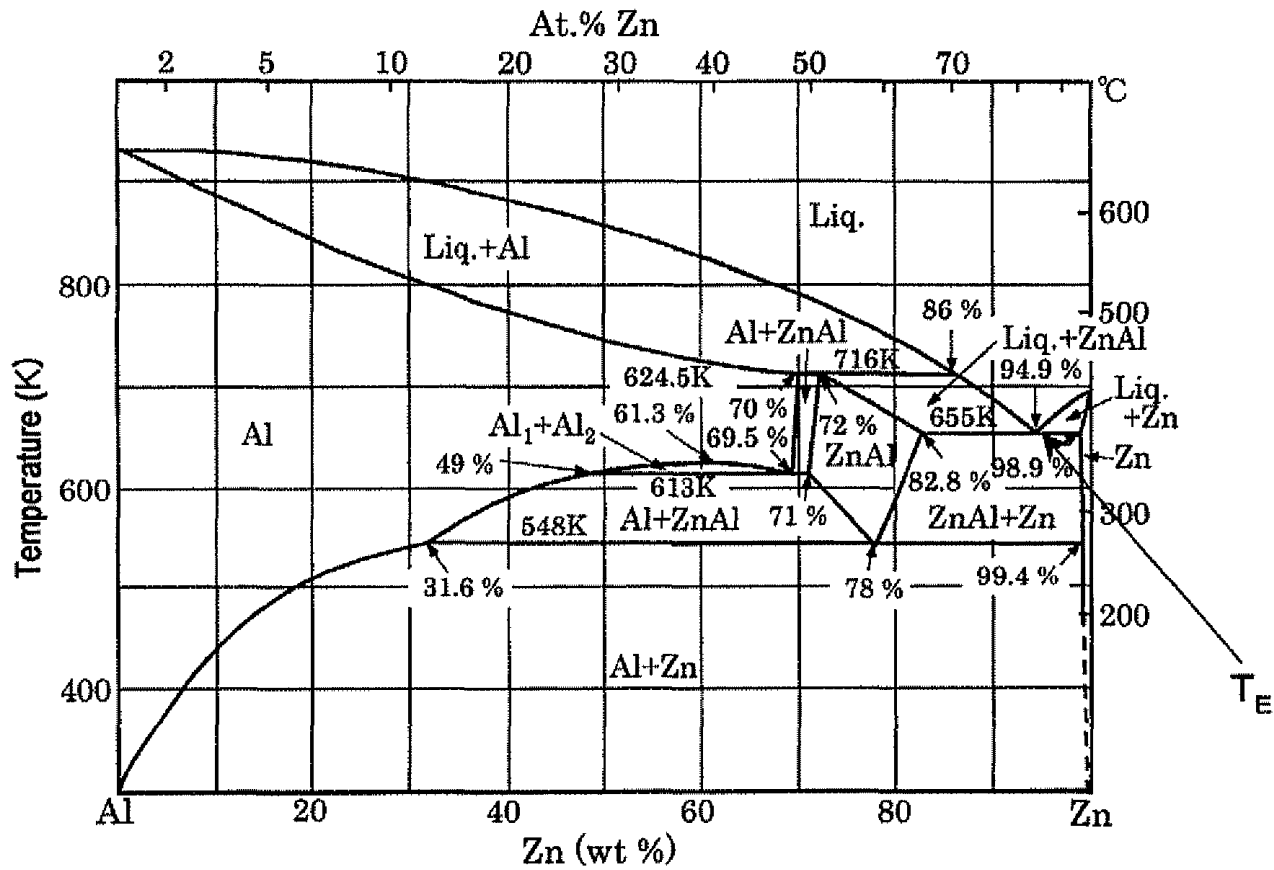




17.(4%) Same as Problem 14, what is the microstructure for the 95%Ag - 5%Cu alloy at room temperature? (a)



18.(16%) The following Figure shows the Al-Zn phase diagram. Write down a list of all the INVARIANT points and congruent points on the Al-Zn phase diagram. For each point, list the composition and temperature of the invariant point, and what kind of invariant it is (the invariant points of pure metals are excluded).



Type	Temperature	Composition
	716 K	72 wt% Zn
	548 K	78 wt% Zn
	655 K	94.9 wt% Zn
	613 K	69.5 wt% Zn

D. Diffusion: (28%)

- 19.(4%) The Fick's Second law is derived based on which one? (a) Conservation of matter (b) Interstitial diffusion mechanism (c) Thermodynamic first law (d) Thermodynamic second law (e) Maxwell-Boltzmann distribution.
- 20.(4%) Diffusion coefficient is not a function of (a) diffusion species (b) concentration gradient (c) composition of diffusion medium (d) structure of diffusion medium (e) temperature
- 21.(4%) The activation energy for diffusion can be determined by a plot of: (D : diffusivity; C : concentration) (a) $\ln D$ vs. $1/T$ (b) $\ln C$ vs. $1/T$ (c) $\ln D$ vs. T (d) $\ln C$ vs. T (e) $\ln D$ vs. T^2
- 22.(4%) Give the order of diffusion rate in the following three paths: lattice (D_l), surface (D_s), and grain boundary (D_b). (a) $D_b > D_l > D_s$ (b) $D_s > D_l > D_b$ (c) $D_b > D_s > D_l$ (d) $D_s > D_b > D_l$ (e) $D_l > D_b > D_s$

23. (12%) An FCC iron-carbon steel alloy initially containing 0.05 wt% C is carburized at an elevated temperature in an atmosphere that maintains the surface carbon concentration at 1.05 wt% C. After 40 hours, the concentration of carbon is 0.35 wt% C at a position 3.5 mm below the surface. What is the diffusivity of carbon in iron at this heat treatment temperature?

y	erf(y)	y	erf(y)
0	0	0.7	0.6778
0.1	0.1125	0.8	0.7421
0.2	0.2227	0.9	0.797
0.3	0.3286	1	0.8427
0.4	0.4234	1.1	0.8802
0.5	0.5205	1.2	0.9103
0.6	0.6039	1.3	0.934

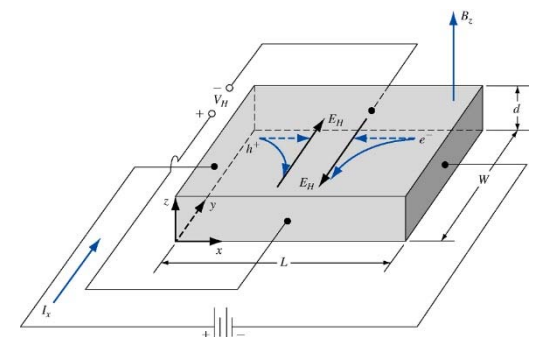
E. Ceramics (28%)

- 24.(4%) Which of the following is not a ceramic material? (a) soda ash (b) carbon (c) rouge (d) salt cake (e) dolomite
- 25.(4%) Which of the following is not the polymorphs of silica? (a) albite (b) quartz (c) tridymite (d) cristobalite (e) coesite
- 26.(4%) Regarding sintering, which of the following is not true? (a) diffusion of atoms (b) mass transport of atoms (c) reduction of total surface (d) necking occurs (e) free energy increases
- 27.(4%) Which of the following ions has a large effect on the color of glass? (a) Na⁺ ions (b) Ca²⁺ ions (c) Fe²⁺ ions (d) K⁺ ions (e) Mg²⁺
- 28.(12%) Draw a volume/enthalpy diagram showing the behavior of a melt which cools to form (a) glass and (b) crystals. Label each section of this diagram.

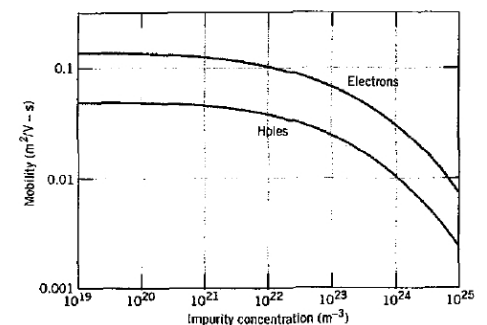
F. Semiconductor: (28%)

- 29.(4%) The intrinsic carrier concentration of Si at 300 K is around (a) $1.5 \times 10^6 \text{ cm}^{-3}$ (b) $1.5 \times 10^8 \text{ cm}^{-3}$ (c) $1.5 \times 10^{10} \text{ cm}^{-3}$ (d) $1.5 \times 10^{12} \text{ cm}^{-3}$ (e) $1.5 \times 10^{14} \text{ cm}^{-3}$
- 30.(4%) A semiconductor that contains both donors and acceptors in the same semiconductor region is called (a) intrinsic semiconductor (b) extrinsic semiconductor (c) degenerated semiconductor (d) compensated semiconductor (e) III-V semiconductor
- 31.(4%) The high-mobility charge carrier in semiconductors under an applied electric field is usually (a) electron (b) hole (c) cation (d) anion (e) impurity.

32.(4%) A semiconductor Hall device is shown on the right. The following parameters are measured: $I_x = 0.5 \text{ mA}$, $V_x = 1 \text{ V}$, $V_H = +5.0 \text{ mV}$, and $B_z = 0.20 \text{ tesla}$. Is the semiconductor p-type or n-type?



33. For silicon, dependence of room temperature electron and hole mobilities (logarithmic scale) on dopant concentration (logarithmic scale) is shown in the following diagram. To high-purity silicon is added 10^{23} m^{-3} arsenic atoms. (a) Is this material n-type or p-type? (4%) (b) Calculate the room-temperature electrical conductivity of this material. (8%)



G. Polymer (20%)

- 34.(4%) Regarding thermosetting polymers, which of the following is not true? (a) Long chains of molecules strongly cross-linked to form a 3-D network structure (b) Stronger, but more brittle than thermoplastics (c) Decompose on heating instead of melting (d) Upon heating, soften and melt (e) Not easily recyclable due to cross-linking
- 35.(4%) Binders are polymers used to join other materials such as polymers, ceramics, metals. Which of the following is not the desirable characteristics of binders? (a) easily burn out (b) good adhesive to powders (c) low cost (d) good solubility in fluidizing liquid (e) none of the above
- 36.(4%) Regarding conjugated polymer, which of the following is not true? (a) It is also known as conducting polymers (b) It can be distinguished by alternating single and double bonds between carbon atoms on the polymer backbone (c) Like silicon, its conductivity depends on the doping level (d) The doping level depends on the oxidation state of the polymer (e) They are usually n-doped.
- 37.(4%) The molecular structure of organic semiconductors shown on the right is (a) Alq3 (b) CuPc (c) pentacene (d) PPV (e) P3AT
- 38.(4%) An amorphous polystyrene deformed at 120°C behaves as a rubbery material. It will exhibit which of the behaviors shown below?

