

※ 考生請注意：本試題可使用計算機。請於答案卷(卡)作答，於本試題紙上作答者，不予計分。材料科學共 50 題選擇題，每題答對得 2 分，答錯倒扣 0.5 分；滿分 100 分，倒扣至 0 分為止。

1. The following five values of Rockwell B hardness were measured on a steel: 80.7, 84.4, 87.2, 86.2 and 88.3. Determine the standard deviation values of hardness. (a) 2.65 (b) 2.97 (c) 5.93 (d) 5.34 (e) 2.42
2. Estimate the yield stress (in MPa) of the material using Vickers hardness test under 500g with the length of diagonal 250 μm . (a) 48.5 (b) 14.8 (c) 4.9 (d) 145.4 (e) 65.3
3. A 50 mm long rod of Si_3N_4 has a rectangular cross section with width and height dimensions of 6 mm and 3 mm, respectively. If the rod was tested in three-point bending, the rod fails at the applied load of 670 N. Calculate the rupture stress MPa. (a) 310 (b) 465 (c) 520 (d) 630 (e) 930
4. For a metal under a stress state with $\sigma_x=350$ MPa, $\sigma_y=70$ MPa and $\tau_{xy}=210$ MPa, calculate the maximal shear stress in MPa. (a) 180 (b) 200 (c) 280 (d) 380 (e) 480
5. A 6061-T4 aluminum alloy occurs to yield at the following stress state of $\sigma_x=70$ MPa, $\sigma_y=120$ MPa and $\tau_{xy}=60$ MPa, determine the yield stress in MPa according to the Tresca criteria. (a) 120 (b) 70 (c) 60 (d) 150 (e) 160
6. Which one is correct? (a) A typical engineering stress-strain curve is concave under tension. (b) The engineering stress is larger than the true stress for a compression testing at the same strain. (c) A typical engineering stress-strain curve is convex under compression. (d) The engineering stress is larger than the true stress for a tension testing at the same strain. (e) Barreling happens in a tension testing.
7. After elastic deformation "easy glide" which is a linear region of low strain-hardening is observed at which direction is parallel to the tension axis for tension deformation of a fcc single crystal. (a) $\langle 100 \rangle$ (b) $\langle 110 \rangle$ (c) $\langle 111 \rangle$ (d) $\langle 112 \rangle$ (e) $\langle 145 \rangle$
8. Calculate the stored energy (J/m^3) in a copper crystal with a dislocation density of 10^{11}cm^{-2} and $G=48$ GPa and a lattice constant $a=0.36\text{nm}$. (a) 1.5×10^3 (b) 1.5×10^4 (c) 1.5×10^5 (d) 1.5×10^6 (e) 1.5×10^2
9. Calculate the fracture toughness K_{IC} ($\text{MPa}\cdot\text{m}^{-1/2}$) for a 0.45C-Ni-Cr-Ti steel having a flaw size of 4.8 mm and a yield strength of 760 MPa. (a) 26 (b) 36 (c) 46 (d) 56 (e) 66
10. The number of vacancies in solids (a) increases linearly with temperature (b) increases exponentially with temperature (c) is independent to the temperature (d) decreases linearly with temperature (e) decreases exponentially with temperature.
11. For most metals, the fraction of vacancies just below the melting temperature is on the order (a) 10^{-1} (b) 10^{-2} (c) 10^{-3} (d) 10^{-4} (e) 10^{-5}
12. A twin boundary is (a) a special type of grain boundary (b) a specific mirror lattice symmetry (c)

resulted from atomic displacements (d) an interfacial defect (e) all of them.






13. What kind of structure with the atomic coordinates of (0, 0, 0) and (1/2, 1/2, 1/2)? (a) BCC (b) FCC (c) HCP (d) SC (e) none of them.
14. Annealing twins are typically found in metals with (a) FCC (b) BCC (c) HCP (d) diamond (e) SC structure.
15. Thus atoms of some elements have two or more different atomic masses, which are called (a) diatomic molecules (b) isotopes (c) crystals (d) Ionics (e) none of them.
16. The table below exhibits the electronegativity value for the elements. Which one of the following materials has the highest “% ionic character”?

1 H 2.1																	5 B 2.0	6 C 2.5	7 N 3.0	8 O 3.5	9 F 4.0													
3 Li 1.0	4 Be 1.5																	13 Al 1.5	14 Si 1.8	15 P 2.1	16 S 2.5	17 Cl 3.0												
11 Na 0.9	12 Mg 1.2																	19 K 0.8	20 Ca 1.0	21 Sc 1.3	22 Ti 1.5	23 V 1.6	24 Cr 1.6	25 Mn 1.5	26 Fe 1.8	27 Co 1.9	28 Ni 1.9	29 Cu 1.9	30 Zn 1.6	31 Ga 1.6	32 Ge 1.8	33 As 2.0	34 Se 2.4	35 Br 2.8
37 Rb 0.8	38 Sr 1.0	39 Y 1.2	40 Zr 1.4	41 Nb 1.6	42 Mo 1.8	43 Tc 1.9	44 Ru 2.2	45 Rh 2.2	46 Pd 2.2	47 Ag 1.9	48 Cd 1.7	49 In 1.7	50 Sn 1.8	51 Sb 1.9	52 Te 2.1	53 I 2.5																		
55 Cs 0.7	56 Ba 0.9	57 La 1.1	72 Hf 1.3	73 Ta 1.5	74 W 1.7	75 Re 1.9	76 Os 2.2	77 Ir 2.2	78 Pt 2.2	79 Au 2.4	80 Hg 1.9	81 Tl 1.8	82 Pb 1.9	83 Bi 1.9	84 Po 2.0	85 At 2.2																		
87 Fr 0.7	88 Ra 0.9	89 Ac 1.1																																

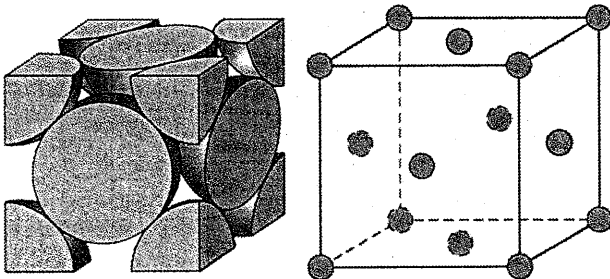
Electronegativities of the Elements

- (a) ZnS (b) NaCl (c) MgO (d) SiC (e) TiN.

17. Which one of the following has the highest degree of crystallinity? (a) Metallic Glass (b) Kaolinite Clay (c) Amorphous Carbon (d) Poly(vinyl chloride) (e) Water.
18. The coordination numbers and nearest-neighbor geometries for various r_c/r_A ratios are presented in the following table. For the crystal structure of cesium chloride (CsCl), what is the coordination number for Cs^+ ? Note that the ionic radius of Cs^+ and Cl^- are 1.70 Å and 1.81 Å, respectively. (a) 2 (b) 3 (c) 4 (d) 6 (e) 8.

Coordination Number	Cation-Anion Radius Ratio	Coordination Geometry
2	< 0.155	
3	0.155-0.225	
4	0.225-0.414	
6	0.414-0.732	
8	0.732-1.0	

19. Which one of following is a WRONG statement about graphite? (a) Graphite is more stable than diamond at ambient temperature and pressure (b) Graphite is one of the most widely adopted as the anode material for lithium ion battery (c) The graphite structure is composed of layers of hexagonally arranged carbon atoms (d) The electron participates in weak van der Waals type of bond between the layers in graphite (e) Each carbon bonds to four other carbons (sp^3 hybridization), and these bonds are totally covalent.
20. Which one of the following carbon allotropes composed of a closely packed **SINGLE** layer of carbon atoms with sp^2 hybridization, forming a 2D honeycomb lattice plane? (a) graphite (b) graphene (c) fullerene (d) carbon nanotube (e) diamond.
21. The figure shows a hard sphere model for FACE-CENTERED CUBIC (FCC) unit cell. The atom centers are represented by small circles to provide a better perspective of atom positions. Assume that the spheres have the same diameter. Which one of the following is a WRONG characteristic?



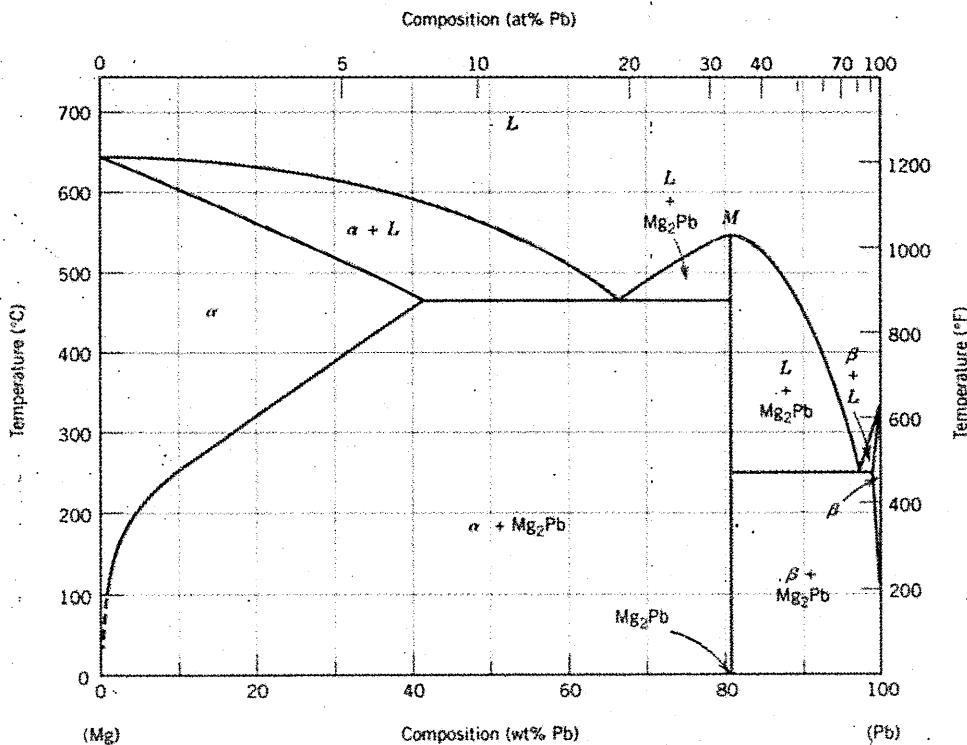
- (a) Each corner atom is shared among eight unit cell (b) Each face-centered atom is shared by two unit cell (c) Each corner atom has a coordination number of 8 (d) Each face-centered atom has a coordination number of 12 (e) The atomic packing factor is 0.74.

22. Aluminum has a FCC crystal structure and an atomic radius of 1.431 Å. The lattice constant of aluminum is 4.048 Å. What is the interplanar spacing for the (200) set of planes? (a) 1.431 Å (b) 2.024 Å (c) 2.337 Å (d) 2.862 Å (e) 4.048 Å.
23. Which one of the following is CORRECT lattice parameter relationship of a CUBIC structure? (a) $a = b = c, \alpha = \beta = \gamma = 90^\circ$ (b) $a = b = c; \alpha = \beta = \gamma \neq 90^\circ$ (c) $a \neq b \neq c, \alpha = \beta = \gamma = 90^\circ$ (d) $a = b \neq c, \alpha = \beta = \gamma = 90^\circ$ (e) $a = b \neq c, \alpha = \beta = 90^\circ, \gamma = 120^\circ$.
24. Which of the following statement about microsegregation is correct? (a) dendritic spacing (b) ingot center (c) rolling structure (d) recrystallization
25. Which of the following statement is not support about the dominant factor of increasing hardness and strength of an oversaturated solid solution aluminum alloy pertaining to artificial aging (a) diffusional phenomenon (b) GP zone (c) strain induced phenomenon (d) precipitation hardening
26. Which of the following statement is support about minimizing the free energy barrier for nucleation? (a) grain refinement (b) alloying (c) preheating (d) undercooling.
27. Which of the following statement is support about shortening the holding time of heat-treatment under an identical holding temperature? (a) deformation (b) quenching (c) refining (d) inoculation
28. Which of the following statement is support about the eutectoid composition? (a) Aluminum alloy (b) low carbon steel (c) high carbon steel (d) stainless steel
29. Which of the following statement is support about the strain hardening effect (a) oversaturated solid solution (b) precipitations (c) deformation (d) diffusion
30. Which of the following statement is not support about the diffusionless transformation? (a) strain induced transformation (b) martensite (c) stress induced transformation (d) GP zone
31. Mechanical twins (Deformation twins) generally occur in? (a) Ni (b) Cu (c) Al (d) Mg.
32. What does dominate Up-hill diffusion for the phase transformation of metals: (a) kirkendall effect (b) interstitial diffusion (c) composition (d) free energy.
33. T-T-T diagrams, why, the low-temperature transformation time is short? (a) down hill (b) coherent interface (c) large strain (d) large driving force.
34. Why does add the Inoculant (inoculum) during solidification? (a) increase cooling rate (b) decrease intersurface energy (c) increase concentration (d) form grain boundary.
35. What is the most critical factor for explosion nucleation in uniform nucleation and solidification: (a) chemical composition (b) undercooling (c) interface energy (d) direction of heat transfer.

36. Why does not consider the grain boundary diffusion under high temperature condition for metal materials: (a) coarse grains (b) segregation (c) recrystallization (d) high temperature brittleness.
37. What is the order of surface energy (γ) of different surfaces in iron crystal? (a) $\gamma(111) > \gamma(110) > \gamma(100)$ (b) $\gamma(110) > \gamma(111) > \gamma(100)$ (c) $\gamma(100) > \gamma(111) > \gamma(110)$ (d) $\gamma(110) > \gamma(100) > \gamma(111)$
38. For two edge dislocations of opposite signs lying on the same slip plane, which of the following interactions is not likely to happen? (a) Annihilation of each other (b) Creation of another extra half plane of atoms (c) Creation of rows of vacancies (d) Creation of rows of interstitials
39. One type of the defect in ionic crystal involves a cation-vacancy and anion-vacancy is called: (a) Frenkel defect (b) Schottky defect (c) Interstitial defect (d) Substitutional defect
40. For a binary solid solution with two different inter-diffusing coefficients, which of the following equations is used to describe the net flux of vacancy into the diffusion bonding interface? (a) Darken's equation (b) Arrhenius' equation (c) Avrami equation (d) Fick's 1st law equation
41. Grain boundary strengthening is an important mechanism to enhance the mechanical properties of metallic alloys. Which of the following statement is correct related to the grain boundary strengthening? (a) The larger the grain size the less defect density and better mechanical property. (b) The grain boundaries act as pinning points that will impede the propagation of dislocations and result in lower mechanical properties. (c) Grain boundary strengthening is also known as the Hall-Petch strengthening. (d) The grain size of metallic alloys can be changed by aging treatment.
42. The typical dislocation density of alloy after heat treatment is about: (a) 10^{8-9} mm^{-3} (b) 10^{5-6} mm^{-3} (c) 10^{2-3} mm^{-3} (d) 10^{0-1} mm^{-2}
43. The activation energy is an important parameter related to diffusion coefficients. Which of the following four conditions has the largest activation energy? (a) Mn atom on the ferrite grain boundary (b) Carbon atom in the ferrite grain (c) Mn atom in the surface of MnS inclusion (d) Mn atom in the ferrite grain
44. Diffusion mechanism is the result of which of the following: (a) Concentration gradient (b) Internal mechanical stress (c) Random motion of particles (d) Thermally activated kinetic energy
45. A hydrogen gas container with an internal pressure of 20 kg/m^3 , the thickness of the container is 5 mm, and the steady-state diffusion coefficients is $10^{-10} \text{ m}^2/\text{s}$. Please estimate the hydrogen leakage rate of this container. (a) $4 \times 10^{-10} \text{ kg/m}^2\text{sec}$ (b) $1 \times 10^{-8} \text{ kg/sec}$ (c) $4 \times 10^{-7} \text{ kg/m}^2\text{sec}$ (d) $2 \times 10^{-9} \text{ kg/m sec}$
46. Which of the following heat treatments can make steels have a maximum softness and ductility? (a) Normalizing (b) Full annealing (c) Spheroidizing (d) Austenitizing (e) Process annealing

47. For the process of a ceramic material, during firing the formed piece shrinks and experiences a reduction of porosity and improvement in mechanical integrity; the process is termed ? (a) drying (b) vitrification (c) sintering (d) quench (e) age hardening
48. For the metal after cold working, which of the following statements about the phenomenon of grain growth is incorrect? (a) growing by the movement of grain boundary (b) atoms get through grain boundary by diffusion (c) the smaller grains are consumed by the bigger grains (d) the driving force is strain energy (e) grain growth is related to the initial grain size.
49. Which of the following statements about heat treating is incorrect ?(a) the composition of a precipitation-hardenable alloy must be less than the maximum solubility. (b) stress relief annealing heat treatment in which the piece is heated to the recommended temperature, held there long enough to attain a uniform temperature, and finally cooled to room temperature. (c) the influence of alloy composition on the ability of a steel alloy to transform to martensite for a particular quenching treatment is related to a parameter called hardness. (d) air cooling of austenitized plain carbon steels ordinarily produces an almost totally pearlitic structure. (e) reduction in strength and hardness that occurs after long time periods is known as overaging.

50.



With the Mg-Pb phase diagram above, what is the reaction of Pb at 67 wt% when $T=465^{\circ}\text{C}$?

- (a) eutectic (b) monotectic (c) eutectoid (d) peritectoid (e) peritectic