

Mid-Term Exam

Student ID: _____

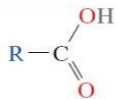
Name: _____

Seat No: _____

2019. 04. 25. 15:00~16:50, Closed Book

Instructor: Seungtae CHOI

Question: Regarding the following questions 1-20, please make a circle on T if you think the statement is true, or make a circle on F if you think the statement is not true. It should be noted that minus points will be given to incorrect answers, and thus, if you are not sure about a correct answer, you would better not choose any one of T or F.

1. HCl is a typical example of ionic bonding.	T	F
<i>Note: HCl is a typical example of covalent bonding.</i>		
2. Many polymeric materials are composed of long chains of carbon atoms that are bonded together using sp^3 tetrahedral covalent hybrids.	T	F
3. The electronic configuration of sodium ion (Na^+) (atomic number of Na = 11) is $1s^2 2s^2 2p^6 3s^1$.	T	F
<i>Note: The electronic configuration of sodium ion (Na^+) is $1s^2 2s^2 2p^6$.</i>		
4. In Miller index system, (hkl) represents a family of crystallographic planes.	T	F
<i>Note: (hkl) represents a crystallographic plane.</i>		
5. In tetragonal systems, three edge lengths a , b , and c , and three interaxial angles, α , β , and γ have the following relations: $a=b \neq c$ and $\alpha = \beta = \gamma = 90^\circ$.	T	F
6. An extruded thermoplastic polymer, of which most of polymer chains are aligned along the extrusion direction, can be macroscopically considered as a homogeneous and anisotropic material.	T	F
7. The planar density of a (110) plane of face-centered cubic (FCC) crystals is equal to $\sqrt{2}/a^2$, where a is the lattice constant of the FCC crystal.	T	F
8. The coordination number (the number of nearest neighbor or touching atoms) of body-centered cubic (BCC) crystals is 4.	T	F
9. The atomic packing factor (APF) of a BCC structure is 0.64.	T	F
10. The following drawing represents the characteristic unit of aldehydes.	T	F
		
11. A copolymer of which chain is made from one type of monomers with branches of another type is called a graft copolymer.	T	F

12. The repeating unit of poly(vinyl chloride) (PVC) is $-C_2H_2Cl_2-$.	T	F
Note: The repeating unit of poly(vinyl chloride) (PVC) is $-C_2H_3Cl-$.		
13. The Burgers vector of an edge dislocation is perpendicular to the line vector of the edge dislocation.	T	F
14. Generally, the equilibrium number of vacancies for a given quantity of materials may increase if the activation energy (the energy required for the formation of vacancy) is higher.	T	F
Note: Generally, the equilibrium number of vacancies for a given quantity of materials may decrease if the activation energy is higher.		
15. In FCC crystals, slip occurs on $\{111\}$ planes (closed-packed) in $\langle 110 \rangle$ directions (closed-packed), and therefore, FCC crystals have totally 12 slip systems.	T	F
16. Diffusion of substitutional atoms is much faster than that of interstitial atoms.	T	F
17. Diffusion of hydrogen atoms in sapphire (Al_2O_3) may be faster than that in highly crystalline polyethylene.	T	F
18. Thermosetting polymers become soft during their first heating and become permanently hard when cooled. They do not soften during subsequent heating. Hence, they cannot be remolded/reshaped by subsequent heating.	T	F
19. In semicrystalline polymers, heat treatment causes crystalline regions to grow and % crystallinity to increase.	T	F
20. Graphite is a layered structure of hexagonal arrays of carbon atoms, and carbon atoms are covalently bonded across the layers.	T	F

Question: Please select only one answer to the following problems 21-40. Two points are allotted to each problem.

21. Please choose an answer including all the correct statements on atomic structure.

Statements

- A. All isotopes of a given element have the same number of protons but different numbers of neutrons in each atom.
- B. Principal quantum number is related to the size of an electron's orbital.
- C. The smaller the principal quantum number, the higher the energy level.
- D. Ionic bonding is always found in compounds composed of both metallic elements (+ ions) and nonmetallic elements (- ions).

① A, B

② A, B, C

③ A, B, D

④ B, C, D

⑤ A, B, C, D

Note: The larger the principal quantum number, the higher the energy level.

22. Please choose an answer including all the correct statements on atomic structure.

Statements

- A. The valence electrons are not bounded to any particular atom in solid and are free to drift.
 B. The metallic bond is directional.
 C. Metals are good conductors of both electricity and heat as a consequence of their free electrons.
 D. The strongest secondary bonding is the hydrogen bonding, a special case of polar molecule bonding.

- ① A, C ② A, B, C ③ A, B, D ④ B, C, D ⑤ A, C, D

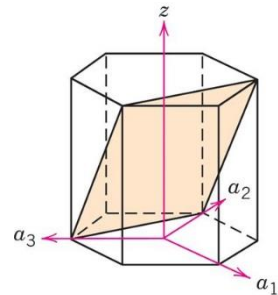
Note: The metallic bond is nondirectional.

23. Please choose an answer best describing the macroscopic mechanical properties of bamboos.

- ① Anisotropic & Inhomogeneous ② Anisotropic & Homogeneous
 ③ Isotropic & Inhomogeneous ④ Isotropic & Homogeneous

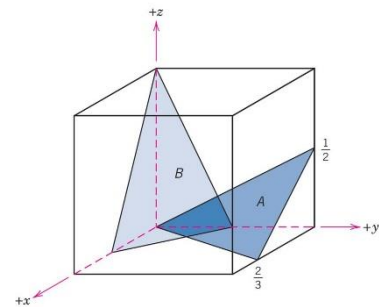
24. Please choose the Miller-Bravais indices of the crystallographic plane given in the following hexagonal unit cell.

- ① $(\bar{1}221)$ ② $(1\bar{2}\bar{2}1)$ ③ $(\bar{1}222)$
 ④ $(\bar{2}112)$ ⑤ $(2\bar{1}\bar{1}2)$



25. Please choose the Miller indices for the crystallographic planes given in the following unit cell.

- ① A: (001), B: (221) ② A: (001), B: (112)
 ③ A: $(3\bar{2}4)$, B: (221) ④ A: $(3\bar{2}4)$, B: (112)

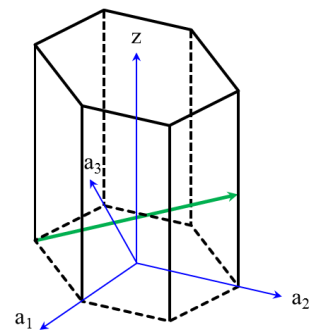


26. For hexagonal close-packed (HCP) crystal structures, Please choose an answer correctly listing up the values of the number of atoms per unit cell, N, and atomic packing factor (APF). Please use $c/a = 1.633$.

- ① N = 4, APF = 0.68 ② N = 6, APF = 0.68
 ③ N = 4, APF = 0.74 ④ N = 6, APF = 0.74

27. Please choose the indices of the crystallographic direction given in the following hexagonal unit cell.

- ① $[\bar{1}2\bar{1}3]$ ② $[\bar{2}4\bar{2}3]$ ③ $[\bar{4}8\bar{4}3]$
 ④ $[\bar{2}4\bar{2}1]$ ⑤ $[\bar{4}8\bar{4}1]$



28. Please choose an incorrect statement on polymorphic forms of carbon.

- ① Graphene is an allotrope of carbon in the form of a two-dimensional, atomic-scale, hexagonal lattice in which one atom forms each vertex.
 ② Carbon nanotubes (CNTs) are allotropes of carbon with a cylindrical nanostructure.
 ③ Buckminsterfullerene (or bucky-ball) is a spherical fullerene molecule with the formula C_{60} .
 ④ Diamond has sp^2 hybridized bonds of carbon atoms

29. Please choose an answer including all the correct statements on polymers & hydrocarbons.

Statements

- A. Proteins, enzymes, starches, and cellulose are typical examples of naturally occurring polymers.
- B. The synthetic polymers can be produced inexpensively, and their properties may be managed to the degree that many are superior to their natural counterparts.
- C. Most polymers are hydrocarbons, i.e., made up of hydrogen and carbon.
- D. Intramolecular bonds are covalent.

- ① A, B ② A, B, C ③ A, B, D ④ B, C, D ⑤ A, B, C, D

30. Please choose an incorrect combination between commodity polymer and its repeat unit.

- ① Polyethylene (PE) – C_2H_4 ② Polytetrafluoroethylene (PTFE) – C_2F_4
 ③ Polypropylene (PP) – $C_2H_3CH_3$ ④ Polyvinylidene fluoride (PVDF) – $C_2H_4F_2$

Note: Polyvinylidene fluoride (PVDF) – $C_2H_2F_2$.

31. Please choose an answer including all the correct statements on polymers.

Statements

- A. Paraffin wax for candles is short polyethylene.
- B. In terpolymer, chains are composed of three different repeat units.
- C. Macromolecules are organic chemicals that have a high vapor pressure at ordinary room temperature.

- ① B ② A, B ③ B, C ④ A, C ⑤ A, B, C

Note: Volatile organic compounds (VOCs) are organic chemicals that have a high vapor pressure at ordinary room temperature.

32. Please choose an answer including all the correct statements on thermoplastic polymers.

Statements

- A. Thermoplastic polymers soften when heated and harden when cooled.
- B. On the molecular level, when the temperature is raised, the primary bonding forces are diminished so that the relative movement of adjacent chains is facilitated when a stress is applied.
- C. Most linear polymers and those having branched structures with flexible chains are thermoplastics.
- D. Thermoplastics are very soft and ductile.

- ① A, B, C ② A, B, D ③ A, C, D ④ B, C, D ⑤ A, B, C, D

Note: On the molecular level, when the temperature is raised, the secondary bonding forces are diminished so that the relative movement of adjacent chains is facilitated when a stress is applied.

33. Please choose an answer including all the correct statements on thermosetting polymers.

Statements

- A. During the initial heating, ionic crosslinks are formed between adjacent molecular chains.
- B. Only heating to excessive temperatures will cause severance of these crosslink bonds and polymer degradation.
- C. Thermoset polymers are harder, stronger, and more brittle than thermoplastics.
- D. Thermosets cannot be recycled, do not melt, and are more chemically inert.

- ① A, B, C ② A, B, D ③ A, C, D ④ B, C, D ⑤ A, B, C, D

Note: During the initial heating, covalent crosslinks are formed between adjacent molecular chains.

34. Please choose an answer including all the correct statements on imperfections in solids.

Statements

- A. Vacancies, vacant atomic sites in a structure, may produce compressive stress in a crystal.
- B. Second phase particles have different composition and often different structure.
- C. Equilibrium concentration of point defects is highly dependent on temperature.
- D. Fast cooling rate may produce fine microstructure.

- ① A, B, C ② A, B, D ③ A, C, D ④ B, C, D ⑤ A, B, C, D

Note: Vacancies, vacant atomic sites in a structure, may produce tensile stress in a crystal.

35. Please choose an incorrect combination between type of imperfections and its example.

- ① Point defects – substitutional atoms
- ② Line defects – dislocations
- ③ Area defects – phase boundaries
- ④ Volume defects – stacking faults

Note: Volume defects: Pores, cracks, foreign inclusions, other phases, etc.

36. Please choose an atom most favorable for solid solution in Cu.

- ① Ni ② Fe ③ Cr ④ Zn ⑤ Al

Element	Atomic Radius (nm)	Crystal Structure	Electro- negativity	Valence
Cu	0.1278	FCC	1.9	+2
Ag	0.1445	FCC	1.9	+1
Al	0.1431	FCC	1.5	+3
Co	0.1253	HCP	1.8	+2
Cr	0.1249	BCC	1.6	+3
Fe	0.1241	BCC	1.8	+2
Ni	0.1246	FCC	1.8	+2
Pd	0.1376	FCC	2.2	+2
Zn	0.1332	HCP	1.6	+2

37. Please choose an answer including all the correct statements on slip systems and dislocations.

Statements

- A. In metals, plastic deformation is produced by dislocation motions.
- B. A unit vector, $\mathbf{t}$, tangent to the dislocation line is called a tangent vector or the line vector.
- C. The magnitude and the direction of the slip is represented by a vector $\mathbf{b}$ called the Burgers vector.
- D. The closure failure of the Burgers circuit is an indication of a presence of a dislocation piercing through the surface of the circuit.

- ① A, B, C ② A, B, D ③ A, C, D ④ B, C, D ⑤ A, B, C, D

38. Please choose an answer including all the correct statements on grain boundaries.

Statements

- A. Grain boundaries represent transition boundaries from lattice of one region to that of the other.
 B. Grain boundaries are slightly disordered.
 C. Grain boundaries have high density, high diffusivity, and high chemical reactivity.

- ① B ② A, B ③ A, C ④ B, C ⑤ A, B, C

Note: Grain boundaries have low density, high diffusivity, and high chemical reactivity.

39. Please choose an answer including all the correct statements on diffusion.

Statements

- A. Solid-state diffusion is a means of mass transport within solid materials by stepwise atomic motion.
 B. Diffusion process is relatively slower in close-packed structures.
 C. Diffusion process is relatively slower with larger diffusing atoms.

- ① A ② A, B ③ A, C ④ B, C ⑤ A, B, C

40. Please choose an answer including all the correct statements on steady-state diffusion.

Statements

- A. The concentration of diffusing species is a function of both time and position.
 B. Flux is proportional to concentration gradient.
 C. Temperature has a profound influence on the diffusion rate.

- ① B ② A, B ③ A, C ④ B, C ⑤ A, B, C

Note: In steady-state diffusion, the concentration of diffusing species is a function of position only.

Question: Please write down a short answer in the parenthesis of the following questions, 41-50.

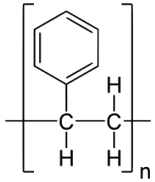
41. Among four quantum numbers, (subsidiary) quantum number is related to the shape of an electron's orbital.

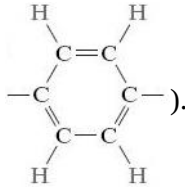
42. The electronic configuration of Krypton (atomic number of Krypton = 36) is ($1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6$).

43. The number of atoms per unit cell, N , of BCC structures is (2).

44. The linear density of a BCC crystal in [111] direction is ($2/\sqrt{3}a$). (Express the answer in terms of the lattice constant, a , of the BCC crystal.

45. The characteristic unit of ethers family is ($R - O - R'$).

46. The repeating unit of polystyrene (PS) is ( , in which aromatic ring is



47. (**Transmission electron microscopy**) is a microscopy technique in which a beam of electrons is transmitted through an ultra-thin specimen, interacting with the specimen as it passes through it. (Write down the full name.)
48. A (**dislocation**) line is the boundary between slip and no slip regions of a crystal.
49. Two diffusion mechanisms are interstitial diffusion and (**vacancy**) diffusion.
50. (**Stereoisomerism**) is a form of isomerism in which molecules have the same molecular formula and sequence of bonded atoms (constitution), but differ in the three-dimensional orientations of their atoms in space.

Question: Please answer the following questions, 51-52.

51. (10 points) Please explain three types of primary interatomic bonds.

(1) Ionic bonding

- ✓ Ionic bonding is always found in compounds composed of both metallic elements (+ ions) and nonmetallic elements (- ions).
- ✓ Ionic bonding requires electron transfer and thus large difference in electronegativity.
- ✓ Ionic bonding is nondirectional.

(2) Covalent bonding

- ✓ Similar electronegativity → share electrons
- ✓ Bonds determined by valence – s & p orbitals dominate bonding
- ✓ Covalent bonding is directional.

(3) Metallic Bonding

- ✓ The valence electrons form a “sea of electrons” or “electron cloud” that can freely move around the metal ion cores, which makes metals electrically conductive.
- ✓ These free electrons act as a “glue” to hold the ion cores together.
- ✓ The metallic bond is nondirectional.

52. (10 points) Please list up, draw, and explain four types of copolymers.

1. Statistical copolymer (Random): Two or more different repeating unit are distributed randomly
2. Alternating copolymer are made of alternating sequences of the different monomers
3. Block copolymer: Long sequences of a monomer are followed by long sequences of another monomer
4. Graft copolymer consist of a chain made from one type of monomers with branches of another type

