I. Please indicate if each of the following statement is true (T) or false (F) in the parenthesis provided after the statement. (10 points) −4

F(~~T~~)1. There are 5 classes of engineered materials, they are metals, ceramics, polymers, minerals, and composite materials. 工程材料：金属 非金属、高分子/聚合物、复合

F(~~T~~)2. Optical properties are related to transmission of heat (light) and heat (light) capacity. → heat → Thermal

(F) 3. In Bohr's atomic model, an electron position is considered to be the probability of an electron's being at various locations around the nucleus.

(T) 4. Ionic and metallic bonds are both non-directional bonds.

(F) 5. An atom can covalently bond with at most 18-N' (8-N') other atoms, where N' = number of valence electrons.

(F) 6. In order to form ionic bond, elements with similar electronegativity (不同电性) are required.

(F) 7. The energies are quantized, that is, continuous values of energy are allowed. 连续 X. Jump to change energy.

T(~~F~~)8. The slope of the stress-strain curve in the elastic region is defined as the elastic modulus. 弹性模量：应力-应变曲线斜率 √.

F(~~T~~)9. Because Cr has one electron in the outermost occupied *s* subshell, it belongs to alkali metals. 碱金属

(T) 10. The atomic weights of the elements ordinarily are not integers because the atomic masses of the atoms generally are not integers (except for ^{12}C), and the atomic weight is taken as the weighted average of the atomic masses of an atom's naturally occurring isotopes.

II. Fill in the blanks in the following statement. (5 points) −2

1. A measure of how willing atoms are to accept electrons is termed as ~~electronegatre~~ electronegativity
2. The maximum number of electrons per shell is __32__, given the principal quantum number *n*.
3. Give the electron configuration of Fe^{3+}: __$1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$__, given that the atomic number of Fe is 56.
4. ~~electronic~~ Mechanical properties relate deformation to an applied load or force. 负载、承力
5. The relationship between processing, structure, property, and performance is called the ~~component~~ tetrahedron 四面体 of Materials Science and Engineering.

III. Choose the best answer for the following questions or complete the sentences from the choices given below. (20 points)

1. F, Cl, Br, etc., are examples of ____________.
   ~~A~~ C
   (a) alkali (b) inert gases (c) halogens 卤素 (d) rare earth elements 稀有元素

2. An atom is composed of a nucleus and ______________.
   C
   (a) protons (b) neutrons (c) electrons (d) photons (e)phonons

3. HF is an example of ____________ bonding.
   ~~C~~ d
   (a) metallic (b) ionic (c) van der Walls (d) covalent

4. The theory "Energy of electrons are quantized; that is, electrons are permitted to have only specific value of energy." were proposed by ____________.
   量化
   B
   (a) Shrödinger (b) Bohr (c) L.de Broiglie (d) Pauli (e) Einstein

5. In ____________, valence electrons are detached from atoms, and spread in an "electron sea" that "glues" the ions together.
   脱离
   A
   (a) metals (b) ceramics (c) semiconductors
   (d) composites (e) polymers

6. Elements to the left of the Periodic Table have ________ electronegativity compared to those to the right of the Periodic Table.
   电负性
   B
   (a) larger (b) smaller (c) the same (d) comparable

7. Subshells with one missing electron have ________ electronegativity than subshells with one electron.
   ~~B~~ a
   (a) larger (b) smaller (c) the same (d) comparable

8. The predominant type of bonding for diamond (C) is ________.
   钻石.
   ~~C~~ d
   (a) metallic (b) ionic (c) van der Walls (d) covalent

9. When atoms are brought close to each other, according to the Pauli Exclusion Principle, when the electronic clouds surrounding the atoms starts to overlap, the energy of the system ________.
   B
   (a) increases (b) decreases (c) does not change (d) reaches a plateau

10. Which of the following bonding is not a type of Primary Bonding? ________.
   A
   (a) Van der Walls (b) Ionic (c) Metallic (d) Covalent

11. Electron volt is the energy lost/gained by an electron when it is taken through a potential difference

B of one volt, where 1 eV = ________ J.

(a) 1.6×10^{19} (b) 1.6×10^{-19} (c) 1.9×10^{-16} (d) 1.9×10^{16}

12. MgO is an example of ______________ bonding.

B

(a) metallic (b) ionic (c) van der Walls (d) covalent

13. Electrons are ____________ in stead of ____________ in covalent bonding.

B

(a) transferred…shared (b) shared…transferred

(c) dipoled…lost (d) lost…dipoled

14. 1/12 of the atomic mass of the most common isotope of carbon atom that has 6 protons (Z=6) and

D six neutrons (N=6) is defined as ____________.

(a) 1 gram (b) Avogadro's Number (c) 1 mole (d) 1 amu

15. What type(s) of electron subshell(s) does an *L* shell contain?

f

(a) *d* (b) *p* (c) *f* (d) *s*

(e) *s* and *f* (f) *s* and *p* (g) *s*, *p* and *f*

16. Permanent dipole moments exist in some molecules by virtue of an asymmetrical arrangement

B of positively and negatively charged regions; such molecules are termed ________________.

(a) dipoles 偶极子 (b) polar molecules 极性分子 (c) van der Walls bond

(d) hydrogen bond (e) bond energy

17. The timeline of the development of materials: from the Stone Age, Bronze Age, ________Age to

C the Age of Advanced Materials.

(a) Ceramic (b) Copper (c) Iron (d) Alloy

18. Materials with larger bond energy usually have a ________ melting temperature than materials

A with lower bond energy. bonding energy↑ → melting point↑ → 弹模↑.

(a) larger (b) smaller (c) the same (d) comparable

↓ CTE↓ 热膨胀系数

~~B~~ 19. 15 Angstroms = ____________ micrometers. $1Å = 10^{-10}$ m $1mm = 10^{-}$

(a) 1.5×10^{-6} (b) 1.5×10^{-3} (c) 1.5×10^{3} (d) 1.5×10^{6}

B

20. The manner in which atoms, ions, or molecules are spatially arranged is termed the

C ________________ of the material.

(a) electronic structure (b) microstrucure

(c) crystal structure (d) molecular structure

IV. Please solve the following problems with detailed steps. (65 points)

1. From the fundamentals of quantum theory, we know the energy of each state is given by the simple formula $E = \frac{-A}{n^2}$, where A is a constant equal to 13.6 eV, and E is the energy level with principal quantum number n. What energy is required to liberate an electron in the $n=4$ orbital of a hydrogen atom? (5 points)

$\because n=4$

$\therefore E = -\frac{13.6}{4^2} eV = -3.4 eV$

$\therefore E > 3.4 eV$

-3

$\because n=4$

$\therefore E = \frac{-13.6}{4^2} eV = -0.85 eV$

2. Calculate the force of attraction between a K^+ and an O^{2-} ion the centers of which are separated by a distance of 1.5 nm. (10 points)

$F_A = \frac{d(E_A)}{dr} = \frac{d(-\frac{A}{r})}{dr} = -\frac{A}{r^2}$

-3

$F_A = \frac{1}{4\pi\varepsilon_0 r^2}(|Z_1|e)(|Z_2|e)$

$= \frac{1}{4\pi \times (8.85\times10^{-12} F/m) r^2}(|Z_1| \times 1.602\times10^{-19} C)(|Z_2| \times 1.602\times10^{-19} C)$

$\cancel{= \frac{2.31\times10^{-28} N\cdot m^2}{(1.5\times10^{-9} m)^2}\cdot|+1|\cdot|-2| = 3.08\times10^{-19} N}$

$= \frac{2.31\times10^{-28} N\cdot m^2}{(1.5\times10^{-9} m)^2}\cdot|+1|\cdot|-2| = 2.05\times10^{-10} N$

3. Silicon has 3 naturally-occurring isotopes: 92.23% of ^{28}Si, with an atomic weight of 27.9769 amu, 4.68% of ^{29}Si, with an atomic weight of 28.9765 amu, 3.09% of ^{30}Si, with an atomic weight of 29.9738 amu. On the basis of these data, confirm that the average atomic weight of Si. (10 points)

$\bar{A} = \sum f_i \cdot M_i$

$= \left(\frac{92.23\%}{100}\right) \times 27.9769\,\text{amu} + \left(\frac{4.68\%}{100}\right) \times 28.9765\,\text{amu} + \left(\frac{3.09\%}{100}\right) \times 29.9738\,\text{amu}$

$= 28.0854\,\text{amu}$

4. What type(s) of bonding would be expected for each of the following materials: (1) brass (a copper-zinc alloy), (2) rubber, (3) barium sulfide (BaS), (4) solid xenon, (5) bronze, (6) nylon, and (7) aluminum phosphide (AlP)? (15 Points)

-3

(1) brass is metallic bonding.

(2) rubber is covalent bonding

(3) barium sulfide is Pedominantly ionic bonding

(4) solid xenon is ~~covalent bonding~~ Var der Waals

(5) bronze is metallic bonding

(6) nylon is covalent bonding and vander Waals

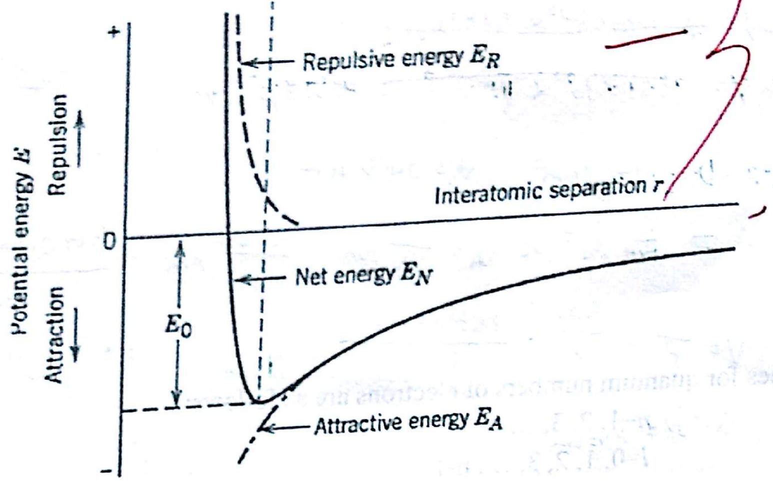
(7) aluminum phosphide is pedominantly ~~ionic~~ covalent bonding ~~with slight ionic bonding.~~

5. The net potential energy between two adjacent ions, E_N, may be represented by the sum of attractive energy E_A and repulsive energy E_R, that is,

$$E_N = -\frac{A}{r} + \frac{B}{r^n}$$

Calculate the equilibrium bonding energy E_0 in terms of the parameters A, B, and n.

(10 points)



$$\because F_N = \frac{d(E_N)}{dr} = \frac{d(-\frac{A}{r})}{dr} + \frac{d(\frac{B}{r^n})}{dr} = -\frac{A}{r^2} + \frac{nB}{r^{n+1}}$$

$$F_N = 0 \Rightarrow \frac{nB}{r_0^{n+1}} = \frac{A}{r_0^2} \quad r_0 = \sqrt[n]{\left(\frac{A}{nB}\right)^{2(n+1)}} \quad r_0 = \left(\frac{\cancel{A}\cdot nB}{A}\right)^{\frac{1}{n+1}}$$

$$\therefore E_0 = -\frac{A}{\sqrt[n]{\left(\frac{A}{nB}\right)^{2n+2}}} + \frac{B}{\sqrt[n]{\left(\frac{A}{nB}\right)^{2n+2}}} \quad E_0 = \frac{A}{\left(\frac{nB}{A}\right)^{\frac{1}{n+1}}} + \frac{B}{\left(\frac{nB}{A}\right)^{\frac{n}{n+1}}}$$

6. (1) Calculate the number of atoms sampled in a 1 μm-diameter by 1 μm-deep cylinder in the surface of solid magnesium (20°C). (5 points)

(2) Calculate the dimensions of a cube containing 1 mole of solid copper (20°C). (5 points)

(1) ~~$n = N_{av} \times \frac{d}{m} = 6.02\times10^{23} \cdot \frac{1.74\,g/cm^3}{24.31\,amu} = 4.31\times10^{22}$~~

~~$N = n \cdot V = 4.31\times10^{22} \times (1\times10$~~

~~$N = n \cdot V = 4.31\times10^{22} \times (1\,nm)^3 = 4.31\times10^{-23}\,nm^3$~~

(2) (1) $\because D = 1.74\,g/cm^3 \quad M = 24.31\,amu.$

$\therefore N = n \cdot N_A = \frac{m}{M} N_A = \frac{\rho \cdot V}{M} \cdot N_A = \frac{1.74\,g/cm^3 \times \pi (\frac{1\mu m}{2})^2 \times 1\mu m}{24.31\,amu} \times 6.02\times10^{23}$

$= 3.39\times10^{10}$

(2) $V = \frac{m}{\rho} = \frac{nM}{\rho} = \frac{1\times63.55\,amu}{8.94\,g/cm^3} = 7.11\,cm^3$

$a = \sqrt[3]{V} = 1.92\,cm$

7. Allowed values for quantum numbers of electrons are as follows:

n=1, 2, 3, …

l=0, 1, 2, 3, …, n-1

m_l=0, ±1, ±2, ±3, … , ±l

$m_s=\pm\frac{1}{2}$

Relative to the subshells,

l=0 corresponds to an s subshell

l=1 corresponds to a p subshell

l=2 corresponds to a d subshell

l=3 corresponds to an f subshell

For the K shell, the four quantum numbers for each of the two electrons in the 1s state, in the order of nlm_lm_s, are $100(\frac{1}{2})$ and $100(-\frac{1}{2})$.

Write the four quantum numbers for all of the electrons in the M shells, and note which correspond to the s, p, and d subshells. (5 points)

$\because$ electrons in the M shells

$\therefore n=3$

$\therefore$ ~~s: $100(\frac{1}{2})$,~~ $100(-\frac{1}{2})$

~~p: $200(\frac{1}{2})$, $200(-\frac{1}{2})$, $210(\frac{1}{2})$, $210(-\frac{1}{2})$, $211(\frac{1}{2})$, $211(-\frac{1}{2})$, $21(-1)(\frac{1}{2})$, $21(-1)(-\frac{1}{2})$~~

~~d: $300(\frac{1}{2})$, $300(-\frac{1}{2})$, $310(\frac{1}{2})$, $310(-\frac{1}{2})$, $311(\frac{1}{2})$, $311(-\frac{1}{2})$~~

3s: $300(-\frac{1}{2})$, $300(\frac{1}{2})$

3p: $310(-\frac{1}{2})$, $310(\frac{1}{2})$

$311(-\frac{1}{2})$, $311(\frac{1}{2})$

$31(-1)(-\frac{1}{2})$, $31(-1)(\frac{1}{2})$

3d: $320(-\frac{1}{2})$, $320(\frac{1}{2})$

$321(-\frac{1}{2})$, $321(\frac{1}{2})$

$32(-1)(-\frac{1}{2})$, $32(-1)(\frac{1}{2})$

$322(-\frac{1}{2})$, $322(\frac{1}{2})$

$32(-2)(-\frac{1}{2})$, $32(-2)(\frac{1}{2})$

s: ~~$100(\frac{1}{2})$, $100(-\frac{1}{2})$, $200(\frac{1}{2})$, $200(-\frac{1}{2})$~~, $300(\frac{1}{2})$, $300(-\frac{1}{2})$

p: ~~$210(\frac{1}{2})$, $210(-\frac{1}{2})$, $211(\frac{1}{2})$, $211(-\frac{1}{2})$, $21(-1)(\frac{1}{2})$, $21(-1)(-\frac{1}{2})$~~

$310(\frac{1}{2})$, $310(-\frac{1}{2})$, $311(\frac{1}{2})$, $311(-\frac{1}{2})$, $31(-1)(\frac{1}{2})$, $31(-1)(-\frac{1}{2})$

d: $320(\frac{1}{2})$, $320(-\frac{1}{2})$, $321(\frac{1}{2})$, $321(-\frac{1}{2})$, $32(-1)(\frac{1}{2})$, $32(-1)(-\frac{1}{2})$