Due Date: July 3rd 2013

Name: _____

Student #: _____

Materials 1M03 – Assignment 1 - Answer Sheet

1. a) (1 mark) What is the attraction energy between a Ca^{2+} ion and an N^{3-} ion the centers of which are separated by a distance of 3.55 nm.

Answer:

$$E_A = \frac{-A}{r}$$

$$E_A = \frac{-(Z_1 e)(Z_2 e)}{4\pi\varepsilon_0 r}$$

$$E_A = \frac{-[(2)(1.602\times10^{-19})][(3)(1.602\times10^{-19})]}{4\pi(8.85\times10^{-12})(3.55\times10^{-9}m)}$$

$$E_A = -3.90\times10^{-19}\ \frac{C^2}{F}$$

b) (2 marks) Calculate the force of attraction between a Ca^{2+} and an N^{3-} ion the centers of which are separated by a distance of 3.55 nm.

Answer: The attractive force between two ions *FA* is just the derivative with respect to the interatomic separation of the attractive energy expression, which is just

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

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

$$F_A = \frac{[(2)(1.602\times10^{-19})][(3)(1.602\times10^{-19})]}{4\pi(8.85\times10^{-12})(3.55\times10^{-9}m)^2}$$

$$F_A = 1.10\times10^{-10}$$

2. (2 marks) Write a brief description on the differences between covalent and ionic bonds?

Covalent Bonds	Ionic Bonds
- Sharing of electrons - Directional - Found in diamonds, silicon and germanium - May be strong or weak	- donors and acceptors for electrons - combine a metal and a non-metal - large difference in electronegativity - nondirectional - characteristically hard and brittle

3. (1 mark) Out of the different types of crystals, which crystal(s) has one whole atom (ie. Not split, cut or part of an atom) within its unit cell?

Answer: BCC (Body Centered Cubic) Structure

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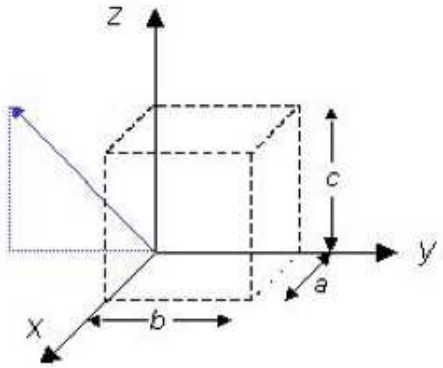
4. a) (1 mark) What is a coordination number in terms of a crystal structure?

Answer: The coordination number is how many atoms are in contact with another atom inside a crystal structure.

b) (1 mark) What is the coordination number of a **BCC** (body centered cubic) crystal structure?

Answer: 8

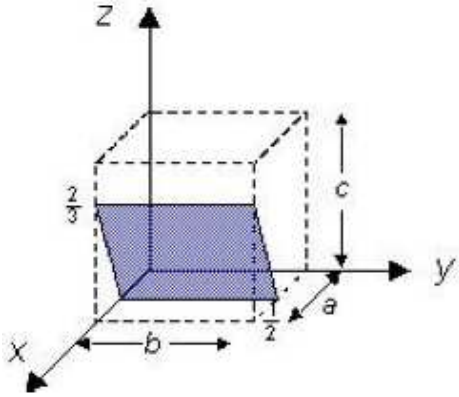
5. (1 mark) Choose the correct indices for the direction shown



a. [$\bar{1}$ 1 1] b. [0 1 1] c. [0 $\bar{1}$ $\bar{1}$] d. [0 $\bar{1}$ 1] e. [$\bar{1}$ $\bar{1}$ 0]

Answer: d

6. (1 Mark) Choose the correct indices for the plane shown below:



a. ($\bar{4}$ 0 3) b. ($\overline{1/2}$ 0 2/3) c. ($\bar{3}$ 0 4) d. (2 0 3/2) e. (0 $\bar{4}$ 3)

Answer: a

7. (2 marks) Derive and explain how to find the edge length *a* for an BCC Crystal

structure, in terms of the atomic radius *R*.

Answer: For an BCC structure it can be seen that diagonally across the body of the structure that the length of 4R can be attained. Using Pythagorean theorem and a simple substitution the edge length of the crystal structure can be attained.

To get the body diagonal (bd) use Pythagorean theorem
$bd^2 = fd^2 + a^2$
Where fd is a face diagonal which has the formula
$fd^2 = a^2 + a^2$
which is obtained by once again using Pythagorean theorem.

Using substitution
$bd^2 = a^2 + a^2 + a^2$

And looking at the crystal it can be seen
$bd = 4R$

Substituting again
$(4R)^2 = 3a^2$

And rearrange to get
$$a = \frac{4}{\sqrt{3}}R$$

8. (3 marks) For a metal that has the face-centered cubic crystal structure, calculate the atomic radius if the metal has a density of 7.22 g/cm^3 and an atomic weight of 80.1 g/mol. Give your answer in nm. Use decimal notation, digits after decimal: 3.

$\rho = 7.22$ g/cm^3 $A = 80.1$ g/mol $N_A = 6.022*10^{23}$ atoms/mol $n_{FCC} = 4$

$$\rho = \frac{n}{V_c}\left(\frac{A}{N_A}\right)$$
$$V_c = \frac{n}{\rho}\left(\frac{A}{N_A}\right)$$
$$V_c = \frac{4}{7.22\ g/cm^3}\left(\frac{80.1\ g/mol}{6.022\times10^{23}\ atoms/mol}\right)$$
$$V_c = 7.37\times10^{-23}\frac{cm^3}{atom}$$

For an FCC structure $V_c = 16R^3\sqrt{2}$

$$7.37\times10^{-23}\frac{cm^3}{atom} = 16(R^3)\sqrt{2}$$

$$\sqrt[3]{\frac{7.37\times10^{-23}}{16\times\sqrt{2}}\frac{cm^3}{atom}} = R$$

$1.48\times10^{-8} cm$/atom

9. (2 marks) Consider a metal with an FCC crystal structure. The interplanar spacing is known to be 0.199 nm. If the first-order angle of diffraction (2*Θ) is found to be 28.5° for the (211) set of planes in this metal, what wavelength of monochromatic x-radiation (in nm) must have been used for the diffraction?
Use decimal notation, digits after decimal: 3

d = 0.199nm Θ = 14.25 λ = ? n = 1

$$n\lambda = 2d\sin\Theta$$

$$\lambda = \frac{2d\sin\Theta}{n}$$

$$\lambda = \frac{2(0.199)\sin(14.25)}{1}$$

$$\lambda = 0.098 \text{ nm}$$

10. (1 mark) Non-crystalline solids are also known as <u>amorphous</u> solids.

11. (1 mark) The region of atomic mismatch where grains meet is called a <u>grain boundary</u>.

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