

MATRL 100A: Structure and Properties I, Problem Set 1

This problem set is due in lecture on **Wednesday, Oct 10th** in hard copy. Please write neatly, make sure your work is legible, and include units in all answers. While you are free to discuss this problem set with your classmates, the product that you turn in must be your own work. Do not copy or paraphrase each other's work.

Chapter 1

1. Make your own "Ashby" diagram of any two properties that interest you. You could for example, relate the electronegativity of elements with the density or electrical conductivity versus thermal conductivity, and make a suitable plot for 10 select elements from different parts of the periodic table. Comment on what you learn. [10]

Chapter 2

2. Iron has four naturally occurring isotopes: 5.845% of ^{54}Fe , with an atomic weight of 53.940 amu; 91.754% of ^{56}Fe , with an atomic weight of 55.935 amu; 2.119% of ^{57}Fe , with an atomic weight of 56.935 amu; and 0.286% of ^{58}Fe , with an atomic weight of 57.933 amu. On the basis of these data, calculate the average atomic weight of Fe in amu. [2]
3. (a) How many grams are there in one amu of a material? [1]
(b) Mole, in the context of this book, is taken in units of gram-mole. On this basis, how many atoms are there in a pound-mole of a substance? [2]
4. Give the electron configurations for the following ions: Mn^+ , Sc^{3+} , Zn^{2+} , Sr^{2+} , Cl^- , and Se^{2-} . [6]
5. Determine whether each of the following electron configurations is an inert gas, a halogen, an alkali metal, an alkaline earth metal, or a transition metal. Briefly justify your choices.
 - (a) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^7 4s^2$ [1]
 - (b) $1s^2 2s^2 2p^5$ [1]
 - (c) $1s^2 2s^2 2p^6 3s^2 3p^6$ [1]
6. Lithium chloride (LiCl) exhibits predominantly ionic bonding. The Li^+ and Cl^- ions have electron structures that are identical to which two inert gases? [2]
7. Calculate the force of attraction between a K^+ and an O^{2-} ion whose centers are separated by a distance of 2.1 nm. [2]
8. The net potential energy between two adjacent ions, E_N , may be represented by:

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

Calculate the bonding energy E_0 in terms of the parameters A , B , and n using the following procedure:

1. Differentiate E_N with respect to r , and then set the resulting expression equal to zero, because the curve of E_N versus r is a minimum at E_0 . [3]
2. Solve for r in terms of A , B , and n , which yields r_0 , the equilibrium interionic spacing. [3]
3. Determine the expression for E_0 by substituting r_0 into the equation for E_N . [3]

9. For a $\text{Na}^+ - \text{Cl}^-$ ion pair, attractive and repulsive energies E_A and E_R , respectively, depend on the distance between the ions r , according to

$$E_A = -\frac{2.468}{r}$$

$$E_R = \frac{10.35 \times 10^{-6}}{r^9}$$

For these expressions, energies are expressed in electron volts per $\text{Na}^+ - \text{Cl}^-$ pair, and r is the distance in nanometers. The net energy E_N is just the sum of the preceding two expressions.

- (a) Superimpose on a single plot E_N , E_R , and E_A versus r up to 2.0 nm. [5]
- (b) On the basis of this plot, determine (i) the equilibrium spacing r_0 between the Na^+ and Cl^- ions, and (ii) the magnitude of the bonding energy E_0 between the two ions. [2]
10. Compute the percent ionic character of the interatomic bonds for the following compounds: MgO , CaF_2 , SiC , ZrO_2 , and Al_2O_3 . [5]
11. Using Table 2.2 (in eds. 8 and 9) or Table 2.3 (in ed. 10), determine the number of covalent bonds that are possible for atoms of the following elements: arsenic, bromine, gallium, and silicon. [2]