

## MATRL 100A: Structure and Properties I, Assignment 2

This assignment is due on Wednesday, October 18.

### Chapter 2

1. Iron has 4 stable isotopes including  $^{56}\text{Fe}$  which is the end product of stellar nucleosynthesis. Using the information in the table below, calculate the average atomic mass of iron and check your answer on a periodic table.

Isotope	Atomic Mass (amu)	Frequency
$^{54}\text{Fe}$	53.9396	0.05845
$^{56}\text{Fe}$	55.9349	0.91754
$^{57}\text{Fe}$	56.9354	0.02119
$^{58}\text{Fe}$	57.9333	0.00282

2. Gold has an atomic mass of 196.967 g/mol and a density of 19.32 g/cm<sup>3</sup>. Calculate the number of gold atoms in a 1 cm wide gold cube.
3. Give the electron configuration for the following ions:  $\text{Ca}^{2+}$ ,  $\text{Fe}^{3+}$ ,  $\text{Ag}^+$ ,  $\text{O}^{2-}$  in noble gas notation.
4. Which of the following compounds have interatomic bonds with the highest percent ionic character:  $\text{Al}_2\text{O}_3$ ,  $\text{GaAs}$ ,  $\text{SiC}$ , or  $\text{Fe}_2\text{O}_3$ ? Compute the percent ionic character of that compound.
5. The net potential energy between two adjacent ions,  $E_N$ , may be modeled with the following equation:

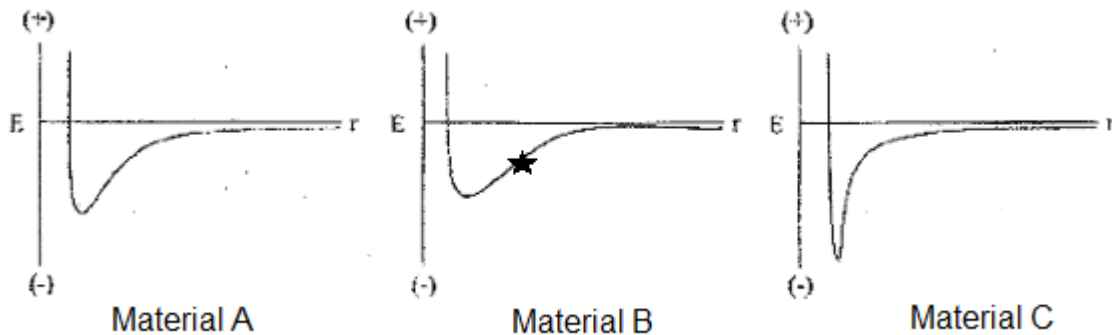
$$E_N = -\frac{A}{r} + \frac{B}{r^n}$$

Calculate the bonding energy  $E_0$  and equilibrium bond length  $r_0$  in terms of A, B, and n using the following procedure:

- (a) Differentiate  $E_N$  with respect to r, and then set the resulting expression equal to zero to find the minimum.
  - (b) Solve for r in terms of A, B, and n, which yields  $r_0$ , the equilibrium interionic spacing.
  - (c) Determine the expression for  $E_0$  by substituting  $r_0$  into the equation for  $E_N$ .
6. Consider a hypothetical  $X^+Y^-$  ion pair. The bonding energy and equilibrium atomic spacing have been observed to be -7.89 eV and 0.31 nm respectively.
    - (a) Assuming  $n = 10$ , determine explicit expressions for the attractive and repulsive energies  $E_A$  and  $E_R$  in terms of  $r$  using the equations you found in the previous problem.

(b) Plot  $E_A$ ,  $E_R$ , and their sum  $E_N$ , superimposed on the same plot from  $r = 0$  nm to  $r = 1$  nm.

7. Energy vs atomic spacing curves describing the bonding of three different materials are shown below. Use them to answer the following questions. Give a short justification for your answers.



- Which material has the lowest melting point?
  - Which material has the lowest thermal expansion coefficient?
  - Which material is the stiffest?
  - For the point marked with a star (material B), is the net force between the atoms attractive, repulsive, or zero?
8. Use your knowledge of secondary bonding to explain why the melting point of polymers increases as molecular weight (the length of the polymer chains) increases.
9. The atomic packing factor (APF) refers to the number of atoms per unit volume in a material. The APF of diamond is 0.34, while the APF of sodium chloride is 0.66. In other words, there is much more “empty space” between the atoms in diamond than there is between the ions in sodium chloride. How can the different types of bonds in these materials explain this difference.