# Engr. 161, FALL 2020

## HW #1: Callister, 9th Ed., Chapter 2: 1, 2, 6, 16, 18, 19, 22(a), 25, 27

**USE YOUR OWN WORDS for Explanations. Make all plots to scale.**

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2.1 Cite the difference between *atomic mass* and *atomic weight*. **USE YOUR OWN WORDS**.

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2.2 Silicon has three 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; and 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 is 28.0854 amu.

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2.6 (a) Cite two important quantum-mechanical concepts associated with the Bohr model of the atom.
(b) Cite two important additional refinements that resulted from the wave-mechanical atomic model.

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2.16 The atomic (ionic) radii of $Mg^{2+}$ and $F^{-}$ ions are 0.072 and 0.133 nm, respectively.
(a) Calculate the force of attraction between these two ions at their <u>equilibrium</u> interionic separation (i.e., when the ions just touch one another).
(b) What is the force of repulsion at this same separation distance?

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2.18 The net potential energy between two adjacent ions, $E_N$, may be represented by the sum of Equations 2.9 and 2.11; that is,

$$E_N = -\frac{A}{r} + \frac{B}{r^n} \qquad (2.17)$$

Calculate the **bonding energy** $E_0$ (which is the minimum value of $E_N$) 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, since the curve of $E_N$ versus $r$ is a minimum at $E_0$, **[and thus its slope is zero there].**
2. Solve for $r$ in terms of $A$, $B$, and $n$, which yields $r_o$, the equilibrium inter-ionic spacing.
3. Determine the expression for $E_o$ by substitution of $r_o$ into Equation 2.17.

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

$$E_A = -\frac{1.436}{r}$$

$$E_R = \frac{7.32 \times 10^{-6}}{r^8}$$

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

**Use EXCEL to plot a smooth curve.**

(a) Superimpose on a single plot $E_N$, $E_R$, and $E_A$ versus $r$ up to 1.0 nm. **[Plot three curves on one plot. The increment of *r* should made small enough so that the curve is smooth… use 0.05 nm.] Limit the energy values (vertical axis) so you can clearly see and measure the minimum value.**

(b) On the basis of this plot [**reading your graph**], determine (i) the equilibrium spacing $r_o$ between the $Na^{+}$ and $Cl^{-}$ ions, and (ii) the magnitude of the bonding energy $E_o$ between the two ions.

(c) Mathematically determine the $r_o$ and $E_o$ values using the solutions to Problem 2.18 and compare these with the graphical results from part (b).

**[Hint: <u>Use Microsoft EXCEL to make the plot</u>. The increment of *r* should made small enough so that the curve is smooth... do not plot markers, but a smooth curve through many points. In general, when plotting by hand <u>or</u> by Excel, make all plots to scale, label axes correctly, title plots.]**

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2.22a (a) Briefly cite the main differences among ionic, covalent and metallic bonding.

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2.25 Computer the % IC for the interatomic bond for each of the following compounds: MgO, GaP, CsF, ~~CdS, and FeO~~. **[only do the first 3]**

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2.27 What type(s) of bonding would be expected for each of the following materials: solid xenon, calcium fluoride ($CaF_2$), bronze, cadmium telluride (CdTe), rubber, and tungsten? **[justify your answer].**