In-tutorial Exercise # 1 **MECH 221** **Fall 2018**

Name:

Student ID:

Question 1: [6 marks]

- **i)** Briefly cite the main differences between ionic, covalent, and metallic bonding
- **ii)** State the expected type of bonding for each of the following compounds, for partially ionic bonds calculate the percent ionic character: (a) solid argon, (b) polyethylene, (c) $CaCl_2$, & (d) gallium phosphide.
- **iii)** Why covalently bonded materials are generally less dense than those who are ionically or metallically bonded?

Solution:

i) The main differences between the various forms of primary bonding are:
Ionic--there is electrostatic attraction between oppositely charged ions.
Covalent--there is electron sharing between two adjacent atoms such that each atom assumes a stable electron configuration.
Metallic--the positively charged ion cores are shielded from one another, and also "glued" together by the sea of valence electrons.

ii) (a) Solid argon: the bonding is van der Waals since argon is an inert gas.

(b) Polyethylene: Covalent bonds hold the atoms in the polyethylene molecules together and

Secondary bonds (van der waals) then hold groups of polymer chains together to form the polyethylene

(c) $CaCl_2$: $X_{Ca} = 1.0$ and $X_{Cl} = 3.0$, and therefore,

%IC= [1-exp [-(0.25) $(3.0\text{-}1.0)^2$]] × 100 = %63.2

(d) Gallium phosphide: the bonding is partially ionic with some covalent character

%IC= [1-exp [-(0.25) $(1.6\text{-}2.1)^2$]] × 100 = %6

iii) Covalently bonded materials are less dense than metallic or ionically bonded ones because covalent bonds are directional in nature whereas metallic and ionic are not; when bonds are directional, the atoms cannot pack together in as dense a manner, yielding a lower mass density.

Question 2: [4 marks]

Calculate the force of attraction between a K+ and an O2- ion the centers of which are separated by a distance of 1.5 nm.

The constant A, in the equation of attractive energy between two atoms is determined using:

$$A = \frac{1}{4\pi\epsilon_0}(Z_1 e)(Z_2 e)$$

Where ϵ_0 is the permittivity of a vacuum (8.85×10^{-12} F/m), Z_1 and Z_2 are the valences of the two ion types, and e is the electronic charge (1.602×10^{-19} C).

Solution:

$$A = \frac{1}{4\pi\epsilon_0}(Z_1 e)(Z_2 e) = \frac{1 \times 2 \times (1.602 \times 10^{-19} C)^2}{4 \times \pi \times 8.85 \times 10^{-12} F/m} = 9.23 \times 10^{-28}$$

$$attraction\ force: F_A = \frac{dE_A}{dr} = \frac{d\left(-\frac{A}{r}\right)}{dr} = \frac{A}{r^2}$$

$$r = 1.5 \times 10^{-9} m$$

$$\Rightarrow F_A = \frac{9.23 \times 10^{-28}}{(1.5 \times 10^{-9})^2} = 2.05 \times 10^{-10}\ N$$