**MEMT 201 Section 001**

Instructor: Prabhu Arumugam

**HW #1 (Due: 3/27/19)**

**For the following questions, provide brief answers (1-2 sentences only).**

1. Why the cooling rate (an important processing parameter) affects the hardness of steel?

The size and amount of the formation of microstructures like pearlite is dependent on the rate at which the steel cools.

1. What happens to the electrical resistivity of copper at higher temperatures (increases, decreases or remains the same?) And why?

At higher temperatures, the copper atoms vibrate with greater amplitude. This causes an increase in the rate at which those atoms collide with electrons flowing through the copper, which generally decreases flow rate thus increasing resistance.

1. What is the average density of ceramics? And how that compares to metals and polymers?

The density of ceramics on average ranges between 1.8 to 7 g/cm3. This is a lower average than that of steels, and a higher average than that of polymers.

1. Among metals, ceramics and polymers, which material type exhibits the lowest thermal coefficient of expansion? And why?

Ceramics exhibit the lowest coefficient of expansion due to having the highest bond energy.

1. Among metals, ceramics and polymers, which material type exhibits the highest tensile strength? And why?

Metals exhibit the highest tensile strength because the ordered crystalline structure of metals allows the material to hold itself together against stronger forces.

1. Among metals, ceramics and polymers, which material type exhibits the lowest density? And why?

Polymers exhibit the lowest density due to typically being made up of lighter nonmetals as well as often having unordered non-crystalline structures.

1. What is the unique advantage of using metal nanoparticles (an example of advanced materials) in catalysis?

The stability of metal nanoparticles as catalysts can be easily altered by introducing other materials that disturb van der Waals interactions between the metals.

1. How electron configuration affects properties?

Electron configuration primarily effects the strength of bonds between two or more atoms. The strength of bonds is directly related with important properties such as tensile strength and hardness.

1. Which type of bond requires electron transfer between the participating atoms?

Ionic bonds.

1. How electronegativity affects the formation of ionic or covalent bonds?

Electronegativity of an element determines with which another elements bonding would be most stable and likely.

1. Why metals are ductile and workable?

Unlike in bonds of other materials, electrons involved in metallic bonds readily move across atoms. This and the ordered structure of metallic materials means metals can easily change their shape.

1. What is hydrogen bonding?

Hydrogen bonding is a type of bond that occurs between Hydrogen and another highly electronegative element or molecule.

**For the following questions, use engineering format (a sample format is posted in the moodle).**

1. Calculate the force of attraction between a Ca2+ and an O2– ion whose centers are separated by a distance of 1.25 nm. (Note: it forms an ionic bond and the force is coulombic in nature).

**Given:**

* Involved Ions: Ca2+ and O2-
* Distance between ions, x: 1.25 x 10-9 m

**Required:**

* Force (N) of ionic bond

**Solution:**

* Valence state of Ca2+, z1: 2
* Valence state of O2-, z2: 2
* Charge of an electron, e: 1.602 x 10-19 C
* Permittivity of a vacuum, ɛ0: 8.85 x 10-12 F/m
* Force of ionic attraction:

**Discussion:**

Given the ions involved and the distance between them, all that is needed to find force of attraction is a single formula. Using the formula above, the resulting answer is of an expected magnitude two keep two single ions together with a relatively tight pull.

1. Molybdenum (Mo) has a BCC crystal structure, an atomic radius of 0.1363 nm, and an atomic weight of 95.94 g/mol. Compute its theoretical density in g/cm3.

**Given:**

* Properties of Mo
  + BCC Structure, n (2 atoms / cell)
  + Atomic radius, r: 1.363 x 10-10 m
  + Atomic weight, A: 95.94 x 10-3 g/mol

**Required:**

* Theoretical density (g/cm3) of Mo

**Solution:**

* Theoretical density:
  + Volume of unit cell,
    - for BCC
  + Avagadro’s Number, N: 6.022 x 1023

**Discussion:**

Given the element of concern, all of the information is available to determine the theoretical density. Under this assumption, a square meter of pure Molybdenum would weigh about 10215 kilograms.

1. Calculate the radius of a palladium (Pd) atom, given that Pd has an FCC crystal structure, a density of 12.0 g/cm3, and an atomic weight of 106.4 g/mol.

**Given:**

* Properties of Pd
  + FCC Structure, n (4 atoms / cell)
  + Density, ρ: 12.0 g/cm3
  + Atomic weight, A: 106.4 g/mol

**Required:**

* Atomic radius (m) or Pd

**Solution:**

* Theoretical density:

**Discussion:**

Given an element of concern, the same equation can be used was in the last question. Filling all variables, we can solve for R to fin the atomic radius of palladium.