Assignment #1 Answers Materials 100A

Problem 1

Write out the complete electronic configuration for the following species:

(a) N, Si, Ga

(b) N^{+3} (as in NF_3), Si^{+4} (as in SiO_2), Ga^{+3} (as in GaN)

a. N - $1s^2, 2s^2, 2p^3$ = [He] $2s^2, 2p^3$
   Si - $1s^2, 2s^2, 2p^6, 3s^2, 3p^2$ = [Ne] $3s^2, 3p^2$
   Ga - $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^{10}, 4p^1$ = [Ar] $4s^2, 3d^{10}, 4p^1$
b. N^{3+} - $1s^2, 2s^2, 2p^0$ = [He] $2s^2, 2p^0$
   Si^{4+} - $1s^2, 2s^2, 2p^6, 3s^0, 3p^0$ = [Ne] $3s^0, 3p^0$
   Ga^{3+} - $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^0, 3d^{10}, 4p^0$ = [Ar] $4s^0, 3d^{10}, 4p^0$

Problem 2

For the transition metals (from Ti through Cu, from Y through Ag and La through Au) the electronic configurations are a little more difficult to write out. Firstly we use a shorthand notation: For Ti, for example, we write [Ar] $4s^2$, $3d^2$ where [Ar] refers to Ar — that takes care of everything earlier than K. Similarly, for Y, we would write [Kr]$5s^2$,$4d^1$. We then use the rule that s electrons are removed first, and that s^0, d^5 and d^{10} are stable — we should form these when we have the choice. For example, Cu is [Ar]$4s^1$, $3d^{10}$, Cu^{1+} is [Ar]$4s^0$, $3d^{10}$ but Cu^{2+} is [Ar] $4s^0$, $3d^9$. Write the electronic configurations (in the shorthand notation) for:

(a) Ag, Ag^+, Au, Au^{3+}

(b) Co^{3+}, Fe^{3+}, Zn^{2+}

a. Ag - [Kr] $5s^2, 4d^9$
   Ag^+ - [Kr] $5s^0, 4d^{10}$
   Au - [Xe] $6s^1, 4f^{14}, 5d^{10}$
   Au^{3+} - [Xe] $6s^0, 4f^{14}, 5d^8$
b. Co^{3+} - [Ar] $4s^1, 3d^5$
   Fe^{3+} - [Ar] $4s^0, 3d^5$
   Zn^{2+} - [Ar] $4s^0, 3d^{10}$

Problem 3

How many electrons must be removed from Si so that it has the electronic configuration of the nearest noble gas (and which gas). How many electrons must be added to Si so that it has the electronic configuration of the nearest noble gas (and which gas). What does this tell us about the nature of Si? What do you expect the configuration of Si to be in SiO2 (sand) and in the hypothetical compound Na_4Si.

- ✓ Remove 4 e-, to get to [Ne]
- ✓ Add 4 e-, to get to [Ar]

- ✓ This tells us that Si prefers to involve all of its valence electrons in interactions to gain stabilityand it does this best by sharing (covalency).
- ✓ [Ne] is the configuration Si will take on in SiO_2
- ✓ [Ar] is the configuration Si will take on in Na_4Si

Problem 4

Use the periodic table and the electronegativity periodic table to guess the nature of bonding in the following:

(a) GaN, GaP, GaAs, GaSb (is there a trend?)
(b) CsAu, MnBi, LiAlSi (this last one is a bit tricky!)

a.) GaN – Mostly ionic but with covalent behavior
GaP – Mixed covalent/ionic
GaAs – More covalent than ionic
GaSb - Covalent
Trend – The bonds become more covalent as the electronegativity differences get smaller, with the nitrogen group element becoming heavier.

b.) CsAu – More ionic than covalent with Cs giving and electron (forming [Xe]) to Au which becomes Au^- with the (stable) configuration [Xe] $4f^{14}5d^{10}6s^2$
MnBi – Mostly covalent but with unpaired electrons (this system will be metallic)
LiAlSi – Li will be ionic as Li^+, Al – Si – is covalent. If Al picks up the electron from Li, it becomes Al^- with the Si configuration (4 electrons) and Si and Al^- together then form the lattice that Si takes on on its own.

Problem 5

Atoms and ions in solids are held together by some attractive force. In the absence of any sort of attraction, can a gas be turned into a crystalline solid? How?

- ✓ Increase the pressure so that the atoms (spheres) are obliged to form a crystal so that they pack efficiently.