Chapter 6 Practice Worksheet: Ionic Bonds and Some Main-Group Chemistry

1) Write electron configurations of the following ions:
   a) $K^+$ (long hand notation): $1s^2 \ 2s^2 \ 2p^6 \ 3s^2 \ 3p^6$
   b) $F^-$ (long hand): $1s^2 \ 2s^2 \ 2p^6$
   c) $Ni^{2+}$ (short hand): $[Ar] \ 4s^0 \ 3d^8$
   d) $Zn^{2+}$ (short hand): $[Ar] \ 4s^0 \ 3d^{10}$
   e) $Br^-$ (short hand): $[Ar] \ 4s^2 \ 3d^{10} \ 4p^6$
   f) $Cu^{2+}$ (short hand): $[Ar] \ 4s^0 \ 3d^9$
   g) $Ag^+$ (short hand): $[Kr] \ 5s^0 \ 4d^{10}$

2) Draw orbital diagrams (for valence electrons only) for the following ions:
   a) $K^+$
      \[ \uparrow \uparrow \ \text{3s} \] \[ \uparrow \uparrow \ \text{3p} \]
   b) $Br^-$
      \[ \uparrow \downarrow \ \text{4s} \] \[ \uparrow \uparrow \uparrow \uparrow \ \text{3d} \] \[ \uparrow \uparrow \uparrow \uparrow \ \text{4p} \]
   c) $Ni^{2+}$
      \[ \uparrow \uparrow \ \text{4s} \] \[ \uparrow \uparrow \uparrow \ \text{3d} \] \[ \uparrow \uparrow \uparrow \uparrow \ \text{3d} \]
   d) $Zn^{2+}$
      \[ \uparrow \uparrow \ \text{4s} \] \[ \uparrow \uparrow \uparrow \uparrow \ \text{3d} \]

3) Define the following terms: atomic radius and ionic radius. Describe the periodic trend for each one.

Atomic radius measures half the distance between the nuclei of two adjacent atoms. (Since the orbital boundaries of atoms are not absolutely defined, atomic radius cannot be measured for a single atom.) Ionic radius is defined similarly but for ions in an ionic compound. Both periodic trends increase going down a group. Atomic radius generally decreases going from left to right across the periodic table. Ionic radius also decreases left to right but jumps in size at the transition between cations and anions.
4) Define $Z_{\text{eff}}$ (effective nuclear charge). How does this property affect radii of atoms as you move from left to right in a period? Does it affect atomic radius as you move down a group?

Effective nuclear charge defines strength of the attraction between protons and electrons. As you move from left to right in across the periodic table, the number of protons increases, but the valence electrons are in the same shell.

5) Arrange the following atoms in order of increasing radius: N, Sb, P, Bi, As

$N < P < As < Sb < Bi$

6) Define the phrase iso electronic series. Describe how sizes of ions change as you move from the most positively charged ion to the most negatively charged ion in an iso electronic series.

Isoelectronic means ions that have the same electron configuration. Sizes of ions increase as you move from the most positively charged ion to the most negatively charged ion in a series. Example: $S^2-$ has 18 e$^-$ and 16 p$^+$; $Ca^{2+}$ has 18 e$^-$ and 20 p$^+$. Ca has more protons to pull in its electrons and results in a smaller ion.

7) Arrange the following ions in order of increasing radius: $F^-, Na^+, O^{2-}, Mg^{2+}, N^{3-}$

$Mg^{2+} < Na^+ < F^- < O^{2-} < N^{3-}$

8) Define: ionization energy (write a chemical equation to demonstrate this) and electron affinity (write a chemical equation to demonstrate this).

Ionization energy is the amount of energy required to remove an electron from an element: $El \rightarrow El^+ + e^-$

Electron affinity is the amount of energy given off when an element gains an electron: $El + e^- \rightarrow El^-$

9) Show the direction in which each trend from #8 increases. Use the periodic table below to draw arrows of increasing value for each property.

Both trends increase going up a group and from left to right across the periodic table.
10) Arrange the following atoms in order of increasing first ionization energy: Ba, Ca, Be, Sr, Mg

Ba < Sr < Ca < Mg < Be

11) Arrange the following atoms in order of increasing electron affinity: Br, Sb, I, Te, Cl

Sb < Te < I < Br < Cl

12) What product do you predict to form when metal oxides react with water? Give an example.
Base: Na₂O + H₂O → NaOH

13) What product do you predict to form when nonmetal oxides react with water? Give an example.
Acid: SO₃ + H₂O → H₂SO₄

14) What two properties affect the lattice energy of an ionic compound? What is the relationship between these properties and lattice energy (i.e., are they inversely or directly related to lattice energy)?

Charge of ion (directly related to lattice energy); Radius (inversely related to lattice energy)

15) What physical properties does lattice energy affect?
Melting point, boiling point, heats of fusion and vaporization

16) Does a stronger or weaker lattice energy result in a stronger ionic bond? How will this affect melting and boiling points of a crystal lattice?

Stronger lattice energy results in a stronger bond. The stronger the bond, the more energy (as heat) required to separate ions.

17) Determine which compound in each pair below will have a higher lattice energy. Defend your answer on the line to the right.

a. NaCl   NaBr   Cl is smaller than Br (all ions have a charge of +/-1)

b. KF     CaF₂   Ca is smaller and has a larger charge than K

c. MgO    Na₂O   Mg is smaller and has a larger charge than Na

d. KF     CsCl   K and F are smaller than both Cs and Cl (same charges on all)

e. RbBr   CaCl₂   Ca is smaller and has a larger charge than Rb; Cl is smaller than Br