Review for Quiz 2: Ionic and Covalent Compounds

1. Know and understand the definitions of: metal, non-metal, ionic compound, covalent (molecular) compound, binary compound and electrolyte.
   - **ionic compounds** are pure substances that form when metal and non-metal atoms are chemically bonded together by an ionic bond (electrostatic attraction). Ionic compounds form a huge crystal lattice structure.
   - **covalent compounds** are pure substances that form when two or more types of non-metal atoms are chemically bonded together by covalent bonds (sharing electrons). Covalent compounds form individual, separate molecules so they are also called molecular compounds.
   - **binary compounds** contain only two TYPES of atoms chemically bonded together. Binary compounds can be ionic or covalent.
   - **electrolytes** are substances that dissolve in distilled water to produce solutions that can conduct an electric current. Ionic compounds are electrolytes – they don’t conduct electricity in their pure (solid) form, but they do conduct electricity in solution.

2. Be able to recognize ionic and covalent compounds from their chemical formulas.
   - ionic compounds have a metal as their first element
   - covalent compounds have a non-metal as their first element (consider hydrogen as a non-metal)

3. Be able to predict and compare the properties of metals, non-metals, ionic compounds and covalent compounds. (see the answers to later questions)

4. Complete the following statements:
   a) Atoms lose, gain or share electrons to achieve a **stable octet** electron arrangement.
   b) Metals are elements that are found on the left side of the staircase line on the Periodic table.
   c) Metals tend to **lose** electrons to form ions with a **positive** charge, called **cations**.
   d) Non-metal elements are found on the right side of the staircase line on the Periodic table.
   e) Non-metals tend to **gain** electrons to form ions with a **negative** charge, called **anions**.
   f) Positive and negative ions are held together by **ionic** bonds to form **ionic** compounds.
   g) Two or more non-metal atoms can **share** valence electrons to complete a stable octet.
   h) A compound that contains two TYPES of elements is called a **binary** compound. The names of these types of compound ends in the suffix: **ide**.
   i) The suffix “ate” indicates that a polyatomic ionic compound contains **oxygen**.

5. In the list of substances below, underline all ionic compounds:
   - SCℓ₆
   - Na₂SO₄
   - CℓO₂
   - Li
   - Zn(OH)₂
   - CrP
   - Br₂
   - XeF₄
   - Fe₃
   - NH₃
   - SnO₂

6. In the list of substances above, circle all covalent compounds.

7. List six physical properties for each of the following substances:

<table>
<thead>
<tr>
<th>cobalt (a metal)</th>
<th>cobalt (III) nitrate (an ionic compound)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• good conductor of electricity in its pure form</td>
<td>• does not conduct in its pure form</td>
</tr>
<tr>
<td>• does not dissolve in water</td>
<td>• dissolves well in water</td>
</tr>
<tr>
<td>• high melting point</td>
<td>• high melting point</td>
</tr>
<tr>
<td>• metallic solid at room temperature</td>
<td>• crystalline solid at room temperature</td>
</tr>
<tr>
<td>• shiny</td>
<td>• probably does not have an odour</td>
</tr>
<tr>
<td>• malleable</td>
<td>• conducts electricity in solution</td>
</tr>
<tr>
<td>• silver-coloured</td>
<td></td>
</tr>
</tbody>
</table>
8. Write the chemical formulas for the following ionic compounds:

a) iron (III) carbonate $\text{Fe}_2(\text{CO}_3)_3$

b) manganese (IV) chlorate $\text{Mn(ClO}_3)_4$

c) ammonium nitride $(\text{NH}_3)_3\text{N}$

d) lead (II) sulfide $\text{PbS}$

e) zinc fluoride $\text{ZnF}_2$

f) tin (IV) hydrogen phosphate $\text{Sn(HPO}_4)_2$

g) calcium hydroxide $\text{Ca(OH)}_2$

h) mercury (I) nitrate $\text{Hg(NO}_3)_2$

i) cobalt (II) hydrogen sulfate $\text{Co(HSO}_4)_2$

j) chromium (III) oxide $\text{Cr}_2\text{O}_3$

9. Name the following ionic compounds. Include Roman numerals where necessary:

a) $\text{NH}_3\text{OH}$ ammonium hydroxide

b) $\text{CrSO}_4$ chromium (II) sulfate

c) $\text{Sn}_2\text{C}$ tin (II) carbide

d) $\text{Hg}_3\text{N}$ mercury (I) nitride

e) $\text{MnCO}_3$ manganese (II) carbonate

f) $\text{AgNO}_3$ silver nitrate

g) $\text{Co(HSO}_4)_3$ cobalt (III) hydrogen sulfate

h) $\text{CuHPO}_4$ copper (II) hydrogen phosphate

i) $\text{ScCl}_3$ scandium chloride

j) $\text{Mg(OH)}_2$ magnesium hydroxide

k) $\text{Fe}_2\text{S}_3$ iron (III) sulfide

l) $\text{Bi}_2\text{O}_5$ bismuth (V) oxide

m) $\text{Au}_3\text{P}$ gold (I) phosphide

n) $\text{AlF}_3$ aluminum fluoride

10. Use electron dot diagrams to show the formation of the ionic compounds between the following elements. Show three steps, write the chemical formula and name of each compound.

a) nitrogen and cesium

$$\begin{align*}
\text{Cs} & \quad \text{N} \\
\text{Cs} & \quad \text{Cs} \\
\text{Cs} &
\end{align*}$$

$$\text{Cs}^+ \quad \left[\text{N}^-\right] \quad \text{Cs}^+ \quad \rightarrow \quad \text{Cs}_3\text{N} \quad \text{cesium nitride}$$

b) phosphorus and calcium

$$\begin{align*}
\text{Ca} & \quad \text{P} \\
\text{Ca} & \quad \text{Ca} \\
\text{Ca} &
\end{align*}$$

$$\text{Ca}^{2+} \quad \left[\text{P}^-\right] \quad \text{Ca}^{2+} \quad \rightarrow \quad \text{Ca}_3\text{P}_2 \quad \text{calcium phosphide}$$

c) magnesium and carbon

$$\begin{align*}
\text{Mg} & \quad \text{C} \\
\text{Mg} & \quad \text{Mg} \\
\text{Mg} &
\end{align*}$$

$$\text{Mg}^{2+} \quad \left[\text{C}^{4-}\right] \quad \text{Mg}^{2+} \quad \rightarrow \quad \text{Mg}_2\text{C} \quad \text{magnesium carbide}$$
11. Complete the following chart:

<table>
<thead>
<tr>
<th>Compound</th>
<th>Formula</th>
<th>Ionic or Covalent</th>
<th>Number of each type of atom in one “unit”</th>
</tr>
</thead>
<tbody>
<tr>
<td>calcium hydroxide</td>
<td>Ca(OH)₂</td>
<td>ionic</td>
<td>1 (Ca) + 2 (O) + 2 (H)</td>
</tr>
<tr>
<td>bismuth (V) chlorate</td>
<td>Bi(ClO₃)₅</td>
<td>ionic</td>
<td>1 (Bi) + 5 (Cl) + 15 (O)</td>
</tr>
<tr>
<td>iron (III) hydrogen carbonate</td>
<td>Fe(HCO₃)₃</td>
<td>ionic</td>
<td>1 (Fe) + 3 (H) + 3 (C) + 9 (O)</td>
</tr>
<tr>
<td>glycerol</td>
<td>C₃H₈O₃</td>
<td>covalent</td>
<td>3 (C) + 8 (H) + 3 (O)</td>
</tr>
<tr>
<td>cobalt (III) hydrogen phosphate</td>
<td>Co₂(HPO₄)₃</td>
<td>ionic</td>
<td>2 (Co) + 3 (H) + 3 (P) + 12 (O)</td>
</tr>
<tr>
<td>pyridine carbonate</td>
<td>(N₂H₅)₂CO₃</td>
<td>covalent</td>
<td>4 (N) + 10 (H) + 1 (C) + 3 (O)</td>
</tr>
<tr>
<td>creatine</td>
<td>C₄(NH₃)₃O₂</td>
<td>covalent</td>
<td>4 (C) + 3 (N) + 9 (H) + 2 (O)</td>
</tr>
</tbody>
</table>

12. Write the chemical formulas of the following covalent (molecular) compounds:

- sulfur trichloride \( \text{SCl}_3 \)
- dichlorine heptoxide \( \text{Cl}_2\text{O}_7 \)
- diphosphorus trioxide \( \text{P}_2\text{O}_3 \)
- nitrogen monoxide \( \text{NO} \)
- carbon tetrabromide \( \text{CBr}_4 \)
- oxygen difluoride \( \text{OF}_2 \)
- tricarbon octahydride \( \text{C}_3\text{H}_8 \)
- phosphorus pentabromide \( \text{PBr}_5 \)
- xenon hexachloride \( \text{XeCl}_6 \)
- nitrogen triiodide \( \text{NI}_3 \)

13. Are the compounds in question #12 binary compounds? Explain why or why not.

Yes, these compounds are all binary compounds – they each contain only two TYPES of atoms.

14. Study the summary chart from Q10 on Lab #2, comparing the properties of ionic and covalent compounds.

** identifying a compound as ionic or covalent, or stating the types of elements they are made from are NOT properties. Properties are characteristics of substances that can be observed.

<table>
<thead>
<tr>
<th>Property</th>
<th>Ionic Compound</th>
<th>Covalent Compound</th>
</tr>
</thead>
<tbody>
<tr>
<td>State at room temperature</td>
<td>always solid</td>
<td>can be solid, liquid or gas</td>
</tr>
<tr>
<td>Texture</td>
<td>usually hard, crystalline solids</td>
<td>solids are soft or waxy</td>
</tr>
<tr>
<td>Presence of an odour</td>
<td>usually odourless</td>
<td>often have odours</td>
</tr>
<tr>
<td>Melting point</td>
<td>usually high or very high</td>
<td>usually low or very low</td>
</tr>
<tr>
<td>Conductivity of pure substance</td>
<td>can not conduct in pure form</td>
<td>can not conduct in pure form</td>
</tr>
<tr>
<td>Solubility in water</td>
<td>usually soluble in water</td>
<td>sometimes soluble in water</td>
</tr>
<tr>
<td>Conductivity of solution</td>
<td>conduct in solution</td>
<td>do not conduct in solution</td>
</tr>
</tbody>
</table>

15. Predict five properties of \( \text{CS}_2 \). You can include any five of the following:

- a distinctive odour
- low melting point
- may be solid, liquid or gas at room temp (it is a liquid)
- soft or waxy in solid form
- does not dissolve well in water
- does not conduct electricity in pure form
- does not conduct electricity in solution
16. Given the following substances in their pure form:
   i) mercury ii) liquid C₆H₆ iii) bromine (Br₂) iv) solid silver chlorate v) solid P₂O₅

   a) Which substance will be the most soluble in water? **silver chlorate (it is ionic)**
   b) Which substance(s) will conduct electricity in their pure form? **mercury (it is a metal)**
   c) Which substance has the lowest melting point? **argon gas (it is gas at room conditions)**
   d) Which substance(s) have shared valence electrons? **liquid C₆H₆, liquid Br₂ and solid P₂O₅ (covalents)**
   e) Which substance(s) are held together by electrostatic attraction? **only silver chlorate (ionic)**
   f) Which substance will be the best conductor in solution? **only silver chlorate (ionic)**
   g) Which substance is chemically inert? **argon gas (it’s a Noble gas so it is unreactive, or inert)**
   h) Which substance(s) are binary? **C₆H₆ and P₂O₅ (because they contain 2 types of atoms)**

   i) Silver chloride and white sugar are both crystalline, white solids at room temperature. If you were given one of these solids, but you didn’t know which one, what is **ONE** experiment you could do to determine whether it was silver chloride or white sugar? Be specific.
   - the best test to distinguish between ionic and covalent compounds is to see if they conduct electricity in a solution (all ionic compounds conduct in solution or are ‘electrolytes’)
   - try to dissolve the substance in **DISTILLED** water, and then check the conductivity of the solution
   - if the solution conducts, the solid is silver chloride. If the solution does not conduct, the solid is sugar
   - you could also check their melting points – but this is not always a reliable test (some ionic compounds can have low or medium melting points). Hold a small sample of each solid on a scoopula above the flame of a bunsen burner. Gradually lower the scoopula toward the tip of the blue cone and observe where it melts. Whichever compound melts higher in the flame (at a lower temperature) is white sugar.

17. Name the following covalent compounds using the prefix system. Use electron dot diagrams to draw the stick diagrams of each molecule. Remember to include all unshared (unbonded) pairs of electrons.

   a) SiO₂ silicon dioxide
      \[ \cdot\cdot\cdot O \equiv Si \equiv \cdot\cdot\cdot O \]

   b) PH₃ phosphorus trihydride
      \[ H \cdot \cdot P \cdot \cdot H \]

   c) CS₂ carbon disulfide
      \[ \cdot\cdot S \equiv C \equiv \cdot\cdot S \]

   d) P₂O₂ diphosphorus dioxide
      \[ \cdot\cdot O \equiv P \cdot \cdot P \equiv \cdot\cdot O \]

   e) N₂H₂ dinitrogen dihydride
      \[ H \cdot N \equiv \cdot N \equiv H \]

   f) N₂Cl₄ dinitrogen tetrachloride
      \[ \cdot\cdot Cl \equiv N \cdot \cdot N \cdot \cdot Cl \]

   g) C₂H₄ dicarbon tetrahydride
      \[ \cdot\cdot O \equiv \cdot\cdot S \]
      \[ H \cdot C \equiv C \cdot H \]

   h) SO sulfur monoxide
      \[ \cdot\cdot O \equiv \cdot\cdot S \]