Learning Objectives

**Molecular composition and formulas**
- Be able to explain the difference between a molecular formula and an empirical formula.
- Know the definition of percent composition.
- Be able to determine the empirical formula given mass percent of components.
- Be able to use percent composition to get mass of a component in a sample.
- Understand the combustion analysis process.
- Interpret the results of a combustion analysis; be able to find the empirical formula of a sample.
- Be able to determine molecular formula when given molecular weight and empirical formula.
- Know the definition of a hydrate and be able to determine the number of atoms in a hydrate given the molecular formula.

**Introduction to Bonding**
- Know what is meant by valence electrons (be able to write the Lewis dot structure for an atom).
- Be able to explain the difference between a molecular formula and an empirical formula.

**Ionic bonding**
- Recognize if a compound will be ionic or molecular.
- Ionic bonding; what is the measure of the strength of an ionic bond?
- What is lattice energy? How can one estimate the relative size of lattice energy of an ionic crystal? What experimental quantity can be used to compare lattice energies?
- How does the size of ions effect lattice energy?
- Be able to write formulas for simple ionic compounds.
- Know how to name ionic compounds.
Homework Problems
Due before the exam on Monday Sept. 23
Get help in the Resource Room (211 Whitmore) as needed.
Free Help available: hours given on course web page
http://courses.chem.psu.edu/chem110fall/help/help.htm#TAs_Office_Hours

1. Estrogen (estriol) is a steroid that has the formula C\textsubscript{18}H\textsubscript{24}O\textsubscript{3}.

   I. What is the mass of carbon in a 50 g sample of estrogen?
   II. How many moles of estrogen are in the 50 g sample?
   III. How many atoms are in a 3.0 mg sample of estrogen?

2. What is the weight percent of silver in silver nitrate, AgNO\textsubscript{3}?
   A. 63%
   B. 20%
   C. 43%
   D. 78%
   E. None of the above is correct to within 5%.

3. What is the empirical formula of a hydrocarbon containing 84.2% C and 15.8% H by weight?
   A. C\textsubscript{8}H\textsubscript{18}
   B. C\textsubscript{16}H\textsubscript{3}
   C. C\textsubscript{3}H\textsubscript{8}
   D. C\textsubscript{5}H\textsubscript{12}
   E. C\textsubscript{4}H\textsubscript{9}

4. Which of the following samples contains the largest total number of atoms?
   A. 0.1 moles of P\textsubscript{4}O\textsubscript{10}
   B. 0.2 moles of P\textsubscript{4}O\textsubscript{6}
   C. 0.3 moles of N\textsubscript{2}O\textsubscript{5}
   D. 0.4 moles of N\textsubscript{2}O\textsubscript{4}
   E. 0.5 moles of BiF\textsubscript{3}

5. What is the percent mass of hydrogen in the following compound?

   A. 5.2%
   B. 7.8%
   C. 8.7%
   D. 7.2%
   E. 8.4%

6. Washing soda is a hydrated version of sodium carbonate. It has the formula \textsubscript{x}Na\textsubscript{2}CO\textsubscript{3} \cdot x\textsubscript{H}2O. If 286 g of washing soda is heated the water of hydration is driven off. The final mass of the remaining solid is 106 g. What is x?

7. One gram of alum, KAl(SO\textsubscript{4})\textsubscript{2} \cdot 12\textsubscript{H}2O, has 1.3 \texttimes 10\textsuperscript{21} Al atoms. How many oxygen atoms are present in 1.0 g of alum?
   A. 1.3 \texttimes 10\textsuperscript{22}
   B. 2.6 \texttimes 10\textsuperscript{22}
   C. 1.6 \texttimes 10\textsuperscript{22}
   D. 1.0 \texttimes 10\textsuperscript{22}
   E. 2.1 \texttimes 10\textsuperscript{22}

8. "X" is an unknown element which forms an acid, HXO\textsubscript{3}. The mass of 0.0133 mol of this acid is 1.123 g. Find the atomic mass of X and identify the element represented by X. The element X is
   A. N
   B. Cl
   C. P
   D. Br
   E. I
9A. A 7.0 g sample of a hydrocarbon (a molecule that has only hydrogen and carbon) is subject to combustion analysis. The mass of CO$_2$ collected is 22.0 g. What is the empirical formula of the compound?

9B. Using a mass spec, the mass of one molecule of this compound is determined to be 70 amu. What is the molecular formula of the compound?

10. 1.00 g of a compound is combusted in oxygen and found to give 3.14 g of CO$_2$ and 1.29 g of H$_2$O. From these data we can tell that

A. the compound contains C, H, and some other element of unknown identity, so we can’t calculate the empirical formula.
B. the compound contains only C and H and has the empirical formula of C$_x$H$_y$.
C. the compound contains C, H, and O and has the empirical formula of CH$_2$O.
D. the compound contains only C and H and has the empirical formula of CH$_2$.
E. None of the above is a true statement

11. A Chem 110 TA synthesizes a compound composed of carbon, hydrogen, and nitrogen and submits 0.1156 g of it to combustion analysis. The TA recovers 0.3556 g of carbon dioxide and 0.0655 g of water. What is the empirical formula of the compound?

A. C$_{11}$H$_{11}$
B. C$_{20}$H$_{18}$N$_2$
C. C$_5$H$_6$N
D. C$_{10}$H$_{18}$
E. C$_{10}$H$_9$N

12. Atom X is in Group IIA and atom Y is in Group VIIA. A compound formed between these two elements would have the formula

A. X$_2$Y
B. XY$_2$
C. X$_2$Y$_7$
D. X$_7$Y$_2$
E. None of the above

13. If Na forms an ionic compound with element X with the formula Na$_3$X, what will be the formula of the compound that Ca will form with X?

A. CaX$_2$
B. CaX
C. Ca$_2$X$_3$
D. Ca$_3$X$_2$
E. Ca$_2$X

14. Rank the following compounds from smallest to largest lattice energy? (Lowest to highest melting point?)

CaO, CsI, BaS, NaF, NaCl

15. Which of the following ionic crystals would you expect to have the lowest melting point?

A. KF
B. KBr
C. CaO
D. PbS
E. ScN

16. Which of the following chemical formulas is NOT the expected one for the compound named?

A. Ga$_2$O$_3$ – gallium oxide
B. AlCl$_3$ – aluminum chloride
C. Li$_2$O – lithium oxide
D. MgBr – magnesium bromide
E. SrI$_2$ – strontium iodide
Week 4: 18 Sept thru 24 Sept; Lectures 10-12

Reflection After Exam I

Complete the Chem 110 Learning Strategies Questionnaire found in Angel. This is required as part of your recitation grade for this week. It must be completed before recitation on Thursday Sept. 26. After completing the questionnaire, please review the following reflection.

How did you do on exam 1?
Are you happy with your current grade? If so continue to do what you have been doing and you are likely to get similar grades on future Chem 110 exams. Note: if you STOP doing the work you have been doing your grade on the next exam will probably drop.

Do you wish your grade had been better? Do you want to improve? If so you must do something DIFFERENT. If you continue to do what you have been doing you are likely to get similar grades on future Chem 110 exams.

What can you do differently?
There are many things you could do differently, but it is possible to work hard and NOT get grades that are any better. In order to improve, you have to figure out WHY you did not do well in the first place and fix it. If you REALLY want to improve, you have to start by reflecting on what you have done so far, try to discover what has been helpful and what has NOT been helpful. Then adjust your studying in a manner that will fix the problems.

Below is a series of questions and suggestions that can guide this reflection process. If you want to improve your grades in Chem 110, we strongly encourage you to complete this IN WRITING.

1. **Analyze your readiness for this exam:**
   How much time do you estimate you have spent on Chem 110 so far? (Be specific.) Do you think this was enough time and was it spread out wisely?
   
   **Was the time spent effectively?** Were you achieving understanding of the concepts or were you simply memorizing particular problems and then not able to apply concepts to similar problems on the exam?
   
   **Did you get help when you needed it?** Did you use the Resource Room (TA help), the instructor, Guided Study Groups, or other students for help? How helpful were the ones you used?

2a. **Did you get a copy of your exam 1 score report?** (This will be e-mailed to you a few days after the exam.) Use this report to double check your grade and to determine which problems you got wrong.

2b. **Go over your Chem 110 exam and redo all the questions you got wrong.** For each question, make note of why you got that question wrong. From this, analyze what prevented you from achieving a higher exam grade. Consider the following as well as any others you feel are appropriate to your situation:
   
   Didn't understand the question. (Didn't know what was being asked.)
   Misinterpretation of questions on exam
   Careless errors
   Poor mental condition due to stress
   
   **Note:** If you do not find your weak points now, you may make similar mistakes on the next exams.

3. After you have finished part 2, add a short summary stating what action you can take that might help you to avoid these problems in the future. What do you plan to do differently for the next Chem 110 exam in order to do better? Your answer should be concrete and specific. For example, "I will study more" is not specific enough; where, when, and how you will study is specific. Review your answers to the Chem 110 Learning Strategies Questionnaire to give you ideas for what you can do that might help you improve.
RULES FOR WRITING LEWIS STRUCTURES
1. Count up the number of valence electrons.
2. Write the atom symbols and connect bonded atoms with single bonds.
3. Distribute electrons (in pairs) to complete octets of atoms.
4. Not enough electrons? Make multiple bonds to complete octets if necessary.

1. Draw a Lewis structure for
   A. SiH$_4$
   B. BrF$_3$
   C. H$_2$CO

2. Which of the following compounds would you expect to possess a multiple bond?
   A. SbH$_3$
   B. AlCl$_3$
   C. CBr$_4$
   D. C$_2$H$_4$
   E. SiF$_4$

3. A reasonable Lewis structure for the molecule CH$_2$O is
   A. \( \text{H} \equiv \text{C} \equiv \text{O} \equiv \text{H} \)
   B. \( \text{H} \text{C} = \text{O} \text{H} \)
   C. \( \text{H} \text{C} = \text{O} \text{H} \)
   D. \( \text{H} \equiv \text{C} \equiv \text{O} \equiv \text{H} \)
   E. \( \text{N} \equiv \text{C} \equiv \text{C} \equiv \text{N} \)

4. What is a reasonable Lewis structure for cyanogen, C$_2$N$_2$?
   A. \( \text{C} \equiv \text{N} \equiv \text{C} \equiv \text{N} \)
   B. \( \text{C} \equiv \text{N} \equiv \text{N} \equiv \text{C} \)
   C. \( \text{N} \equiv \text{C} \equiv \text{C} \equiv \text{N} \)
   D. \( \text{C} \equiv \text{N} \)
   E. \( \text{N} \equiv \text{C} \equiv \text{C} \equiv \text{N} \)

5. Nitrogen–nitrogen bond lengths of 1.10, 1.25 and 1.45 Å have been measured for different molecules.
   Match the molecules N$_2$F$_2$, N$_2$, N$_2$F$_4$ with appropriate N–N bond length.

<table>
<thead>
<tr>
<th>1.10 Å</th>
<th>1.25 Å</th>
<th>1.45 Å</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. N$_2$</td>
<td>N$_2$F$_4$</td>
<td>N$_2$F$_2$</td>
</tr>
<tr>
<td>B. N$_2$</td>
<td>N$_2$F$_2$</td>
<td>N$_2$F$_4$</td>
</tr>
<tr>
<td>C. N$_2$F$_4$</td>
<td>N$_2$</td>
<td>N$_2$F$_2$</td>
</tr>
<tr>
<td>D. N$_2$F$_2$</td>
<td>N$_2$</td>
<td>N$_2$F$_4$</td>
</tr>
<tr>
<td>E. N$_2$F$_4$</td>
<td>N$_2$F$_2$</td>
<td>N$_2$</td>
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</tbody>
</table>
Formal Charge: \( FC = VE − LSE \)

\( VE = \) number of valence electrons in an isolated atom

\( LSE = \) number of electrons on the atom in the Lewis structure

\( = \) lone pair electrons + \( \frac{1}{2} \) shared electrons

The most stable structure is the one in which the atoms bear the smallest formal charge (using absolute values).

6. Find the formal charge for the atoms in the Lewis structure of \( \text{SO}_4^{2−} \). (Complete octets on all atoms without using expanded octets if possible.) Show that the sum of the formal charges of the atoms equals the charge of the species (ion).