AP Chemistry: Introduction & Stoichiometry
Chapters 1-3

DATE	CLASSWORK	HOMEWORK
Monday, 8/27	Introduction to class, review naming and writing formulas (p.2-4), element quiz	p. 122-128 # 25, 53, 59 Read 2.2 & take notes
Tuesday, 8/28	Assign History of Atom Project Polyatomic ions quiz; Review Empirical Formulas & Hydrates; Mass Spectrometry POGIL (p.14-23)	p. 125 - 128 # 69, 81, 89, 99, 109-115 odd History of Atom Project
Wednesday 8/29	Combustion Analysis Problems (p.5-13)	p. 125 #75 &77 p. 128 #117, 119, 125 History of Atom Project
Thursday, 8/30	p. 129 # 127 AP Problems	pre-lab assignment History of Atom Project
Friday, 8/31	Stoichiometry of Chemical Reactions Lab Week 1 Quiz	Read lab and write a procedure. History of Atom Project
Tuesday, 9/4	Conservation of Mass Inquiry Lab	Begin working on lab write up History of Atom Project
Wednesday, 9/5	Work on Lab Report-- lab report due Monday 9/10 Test Review	Study for Test, Finish & Study History of Atom Project
Thursday, 9/6	Introduction & Stoichiometry Test	Honors Review- States of Matter

Students will be able to: Bolded objectives will NOT be discussed in class; make sure you have completed your summer assignment.

1. **For the metric system, state the basic units of mass, length, and volume, and the common prefixes.**
2. **Define accuracy and precision.**
3. **Use scientific notation and the correct number of significant figures while working mathematical problems.**
4. Design a plan for and use data from a chemical reaction to determine the mole ratio in a chemical reaction.
5. Explain: law of definite proportions, law of multiple proportions, and law of conservation of mass.
6. **Discuss the development of atomic theory through Dalton, Thomson and Rutherford.**
7. **Interpret isotopic symbols.**
8. **Calculate the average atomic mass of an element.**
9. **Locate the special groups of elements on the periodic table**
10. Name and write formulas for compounds
11. **Calculate the moles, volume, mass and number of atoms in a compound.**
12. **Calculate the percent composition of a compound.**
13. Calculate the empirical and molecular formula of a compound.
14. Use combustion analysis to solve problems.
15. Calculate empirical formulas for hydrates using experimental data. (hydrate lab)
16. **Balance a chemical equation.**
17. Solve stoichiometry problems.
18. Interpret mass spectromery graphs.

Mixed NOMENCLATURE Practice
Molecular Compounds, Ionic Compounds, & Acids

NAME THE FOLLOWING COMPOUNDS:

1. $BaSO_3$
2. $(NH_4)_3PO_4$
3. PBr_5
4. $MgSO_4$
5. CaO
6. H_3PO_4
7. $Na_2Cr_2O_7$
8. MgO
9. SO_3
10. $Cu(NO_3)_2$
11. HI
12. N_2O
13. MnO
14. $AgNO_3$
15. As_2O_5
16. Fe_2O_3
17. $HClO$
18. N_2O_3
19. HF
20. $H_2C_2O_4$
21. $NaHCO_3$
22. $SiBr_4$
23. $CuCl_2$
24. HNO_2
25. SnO_2
26. $BaCrO_4$

WRITE FORMULAS FOR THE FOLLOWING COMPOUNDS:

27. hydrobromic acid
28. chromium(III) carbonate
29. magnesium sulfide
30. iodine trichloride
31. lithium hydride
32. ammonium hydroxide
33. calcium chloride
34. hydroselenic acid
35. iron(II) nitride
36. aluminum hydroxide
37. tin(II) fluoride
38. sulfur tetrachloride
39. mercury(II) iodide
40. diphosphorus pentoxide
41. sulfurous acid
42. lead(II) nitrate
43. dihydrogen monoxide
44. sodium oxalate
45. perchloric acid
46. chlorous acid
47. silicon dioxide
48. carbonic acid
49. sodium chlorate
50. xenon hexafluoride
51. nickel nitrate
52. potassium perchlorate

NOMENCLATURE REVIEW

Molecular Compounds, Ionic Compounds, & Acids

ANSWER KEY

1. barium sulfite
2. ammonium phosphate
3. phosphorus pentabromide
4. magnesium sulfate
5. calcium oxide
6. phosphoric acid
7. sodium dichromate
8. magnesium oxide
9. sulfur trioxide
10. copper(II) nitrate
11. hydroiodic acid
12. dinitrogen monoxide
13. manganese(II) oxide
14. silver nitrate
15. diarsenic pentoxide
16. iron(III) oxide
17. hypochlorous acid
18. dinitrogen trioxide
19. hydrofluoric acid
20. oxalic acid
21. sodium bicarbonate
22. silicon tetrabromide
23. copper(II) chloride
24. nitrous acid
25. tin(IV) oxide
26. barium chromate
27. HBr
28. $Cr_2(CO_3)_3$
29. MgS
30. ICl_3
31. LiH
32. NH_4OH
33. $CaCl_2$
34. H_2Se
35. Fe_3N_2
36. $Al(OH)_3$
37. SnF_2
38. SCl_4
39. HgI_2
40. P_2O_5
41. H_2SO_3
42. $Pb(NO_3)_2$
43. H_2O
44. $Na_2C_2O_4$
45. $HClO_4$
46. $HClO_2$
47. SiO_2
48. H_2CO_3
49. $NaClO_3$
50. XeF_6
51. $Ni(NO_3)_2$
52. $KClO_4$

Empirical & Molecular Formulas

I. Empirical Vs. Molecular Formulas

- *Molecular Formula* = actual/exact # of atoms in a compound (ex: Glucose = $C_6H_{12}O_6$)

- *Empirical Formula* = lowest whole # ratio of atoms in a compound (ex: Glucose = CH_2O)

II. Determining Empirical Formulas

- You can determine the empirical formula of a compound from % composition information or by knowing the mass of each element present in the whole compound

- Empirical Formula Rhyme (to help you remember the steps):

  Percent to Mass,
  Mass to Mole,
  Divide by small,
  Multiply 'till whole

- **Examples:**

1. *An experiment uses a catalyst that is 23.3 % cobalt, 25.3 % molybdenum, and 51.4 % chlorine. What is the empirical formula of this catalyst?*

Step #1: *Percent to mass* → Assume that you are working with a 100 gram sample, so the % of each element is equal to the mass of each element in grams (show this during step #2)

Step #2: *Mass to mole* → Convert the mass of each element to moles of each element using the molar mass.

Step #3: *Divide by small* → Divide each of the mole quantities by the smallest number of moles. Often, this will result in whole (or practically whole) numbers.

Step #4: *Multiply 'till whole* → If step #3 does not result in whole numbers, find the least common multiple that will achieve all whole numbers. These whole numbers represent the subscripts for each element in the empirical formula.

The empirical formula for this compound is: ______________________________

2. *a) Nicotine is a stimulant and an addictive chemical found in tobacco. An analysis of nicotine produces the following percent composition: 74.03% carbon, 17.27% nitrogen, and 8.70% hydrogen. What is the empirical formula of nicotine?*

b) *Further tests show that the molar mass of nicotine is 162.23 g/mol. Given this information, what is the molecular formula of nicotine?*

3. *An ionic sample with a mass of 0.5000 g is determined to contain the elements indium and chlorine. If the sample has 0.2404 g of chlorine, what is the empirical formula of this ionic compound?*

Determining Empirical and Molecular Formulas

1. a) What is the empirical formula of a molecule containing 65.5% carbon, 5.5% hydrogen, and 29.0% oxygen?

   b) If the molar mass of the compound in part a (above) is 110 grams/mole, what is the molecular formula?

2. a) Find the empirical formula of a molecule containing 18.7% lithium, 16.3% carbon, and 65.0% oxygen.

   b) If the molar mass of the compound in part a (above) is 73.8 grams/mole, what is the molecular formula?

III. Empirical Formulas of Hydrates

- Empirical formulas of hydrates can be determined by essentially calculating the mol-to-mol ratio of the ionic salt-to-water molecules present in a hydrate's solid crystal structure

  - o Recall copper (II) sulfate pentahydrate ($CuSO_4 \bullet 5H_2O$)

    - this hydrate has 5 mols of H_2O for every 1 mol of $CuSO_4$

  - o If you heat a hydrate enough, you can drive out all the water of hydration (water trapped in the hydrate solid leaving behind only the anhydrous ionic salt (in this case, $CuSO_4$)

  - o Given the initial mass of the hydrate and either the mass of anhydrous salt remaining, or the mass of water lost, the empirical formula of the hydrate can be determined

- **Example:**

1. *Washing soda, a compound used to prepare hard water for washing laundry, is a hydrate which means that a certain number of water molecules are included in the solid structure. Its formula can be written $NaCO_3 \bullet xH_2O$ where the x indicates the number of moles of H_2O per mole of $NaCO_3$. When 2.558 g of washing soda is heated so that all the water of hydration is lost, only 0.948 g of $NaCO_3$ remains. What is the value of x? Using chemical nomenclature, how would you name this hydrate compound?*

Step #1: <u>*Mass of H_2O lost*</u> → Use the initial mass of hydrate sample and the mass of anhydrous salt left after heating to determine the mass of H_2O lost (water of hydration trapped in the hydrate)

Step #2: <u>*Grams of ionic salt & H_2O*</u> → Use the mass of H_2O and its molar mass as well as the mass of the ionic salt and its molar mass to determine the moles of each present in the hydrate. Then divide by small (smaller should always be the moles of ionic salt) to determine the # of moles H_2O per 1 mole of ionic salt present in the hydrate

Empirical and Molecular Formulas: Hydrates

1. Epsom salts, a strong laxative used in veterinary medicine, is a hydrate. The formula for Epsom salts can be written as $MgSO_4 \bullet xH_2O$ where the x indicates the number of moles of H_2O per mole of $MgSO_4$. When 13.52 g of this hydrate is heated and all the water of hydration is lost, only 6.60 grams of the anhydrous salt remains.

    a. What is the value of x?

    b. Using chemical nomenclature, how would you name this hydrate compound?

2. When 8.00 g of $Pb(C_2H_3O_2)_2 \bullet xH_2O$ are heated, 1.14 g of H_2O are driven off. Determine the chemical formula and name of this hydrate.

IV. Empirical Formulas by Combustion Analysis

- Empirical formulas of compounds containing carbon, hydrogen, and oxygen can also be determined if given the results of hydrocarbon combustion

$$C_XH_YO_Z\ (?) + O_2\ (g) \rightarrow CO_2\ (g) + H_2O\ (g)$$

  - Recall that the carbon in the hydrocarbon compound is converted to CO_2 and the hydrogen in the compound is converted to H_2O.

  - From the masses of CO_2 and H_2O produced, we can calculate the number of moles of C and H in the original compound.

  - If oxygen is also present in the compound, its mass can be determined by subtracting the masses of C and H from the compounds original mass

- **Example:**

2. *Isopropyl alcohol, a substance sold as rubbing alcohol, is composed of C, H, and O. Combustion of 0.255 g of isopropyl alcohol produces 0.561 g of CO_2 and 0.306 g of H_2O. Determine the empirical formula of isopropyl alcohol.*

Step #1: *Grams C* → Use the mass of CO_2, carbon dioxide's molar mass, and that fact that in 1 mole CO_2 there is 1 mole of C, to determine the grams of carbon in the original compound.

Step #2: *Grams H* → Use the mass of H_2O, water's molar mass, and that fact that in 1 mole H_2O there are 2 moles of H, to determine the grams of hydrogen in the original compound.

Step #3: *Grams O*→ Use the total mass of the original sample and subtract the determined masses of C and H to find the mass of just oxygen in the original compound.

Step #4: *Find moles of C, H, and O*→ Use the masses (in grams) and molar masses of C, H, and O respectively to determine the number of moles of each present. Next divide by small and multiply 'till whole to determine the empirical formula of the compound.

Empirical & Molecular Formulas: Combustion Analysis

1. A hydrocarbon fuel is fully combusted with 18.214 g of oxygen to yield 23.118 g of carbon dioxide and 4.729 g of water. Find the empirical formula for the hydrocarbon.

2. After combustion with excess oxygen, a 12.501 g of a petroleum compound produced 38.196 g of carbon dioxide and 18.752 of water. A previous analysis determined that the compound does not contain oxygen. Establish the empirical formula of the compound.

3. In the course of the combustion analysis of an unknown compound, 12.923 g of carbon dioxide, 6.608 g of water and 2.057 g of nitrogen was measured. The complete combustion of 11.014 g of the compound needed 10.573 g of oxygen. What the compound's empirical formula?

4. 12.915 g of a biochemical substance was burned in an atmosphere of 50.123 g of oxygen. Subsequent analysis of the gaseous result yielded 18.942 g carbon dioxide, 7.749 g of water and 36.347 g of oxygen. Determine the empirical formula of the substance.

5. 33.658 g of oxygen was used to completely react with a sample of a hydrocarbon in a combustion reaction. The reaction products were 33.057 g of carbon dioxide and 10.816 g of water. Ascertain the empirical formula of the compound.

6. Combustion analysis of toluene, a common organic solvent, gives 5.86 ***mg*** of CO_2 and 1.37 ***mg*** of H_2O. If the compound contains only carbon and hydrogen, what is the empirical formula of toluene?

7. a) Menthol, the substance we can smell in mentholated cough drops, is composed of C, H, and O. A 0.1005 g sample of menthol is combusted producing 0.2829 g CO_2 and 0.1159 g H_2O. What is the empirical formula of menthol?

b) If the compound from part a (above) has a molar mass of 156 g/mol, what is its molecular formula?

8. a) Caproic acid, which is responsible for the foul odor of dirty socks, is composed on C, H, and O atoms. Combustion of a 0.225 g sample of this acid produces 0.512 g CO_2 and 0.209 g H_2O. What is the empirical formula of caproic acid?

b) If caproic acid from part a (above) has a molar mass of 116 g/mol, what is its molecular formula?