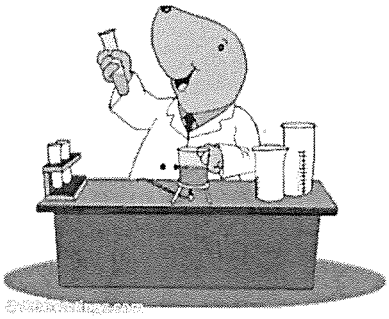
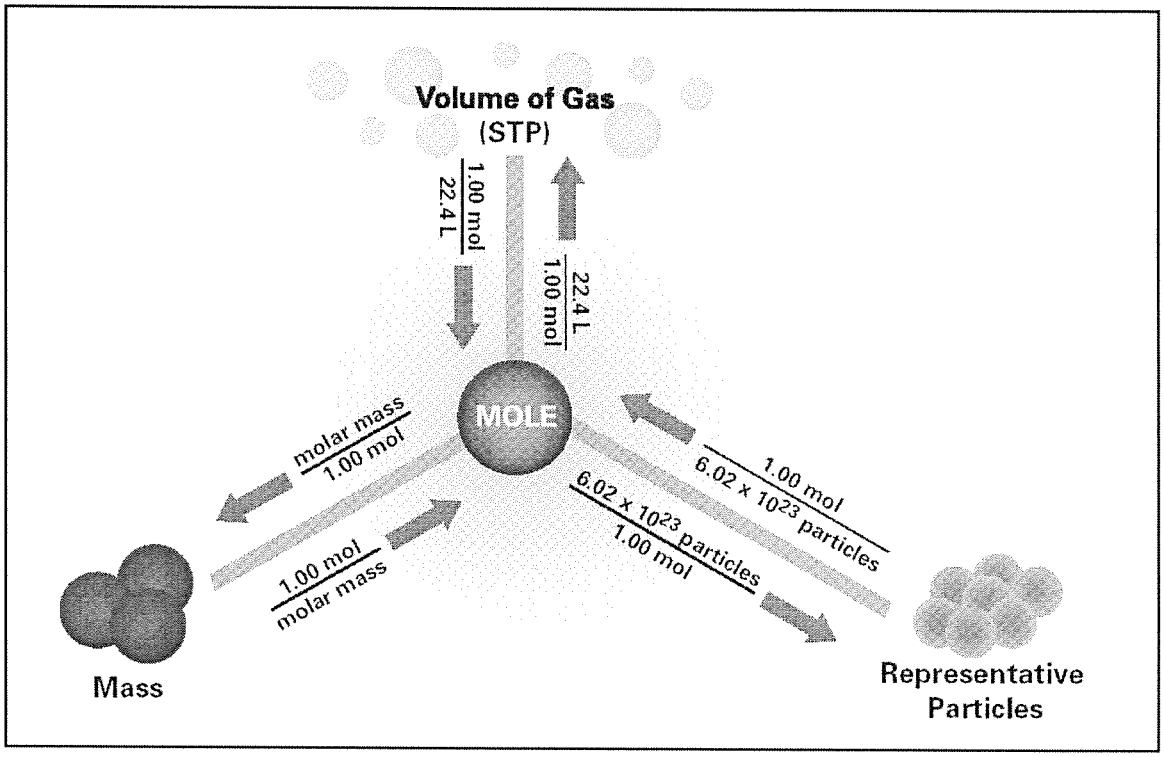
Honors Chemistry – MOLE Packet

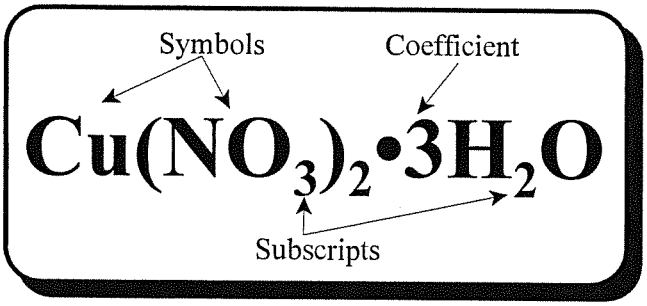




Chemistry: Form WS4.2.0A Name _____

BONDING Date _____ Period _____

Interpreting Chemical Formulas



A chemical formula consists of chemical symbols, subscripts, and, in some cases, a coefficient. The chemical symbols show which elements are present in the compound. Subscripts are small numbers written to the lower right of the symbol to which they refer. In the formula to the right, there are three atoms of oxygen in each nitrate ion (NO_3^-) and two atoms of hydrogen in each molecule of water (H_2O). There is only one atom of copper, but a subscript of one (1) is never written. It is understood. Nitrate is a polyatomic ion. When there is more than one polyatomic ion, it is enclosed in parentheses, and the subscript is written outside to the lower right referring to everything inside. As a result, $Cu(NO_3)_2$ has two nitrogen and six oxygen atoms. Some materials such as copper II nitrate crystallize in such a way that they are attached to a fixed number of water molecules. These are called hydrated crystals. The number of molecules or formula units is shown by a large number called a coefficient. The coefficient is written to the left of the formula, and multiplies everything to the right of it. This means the formula above has a total of 6 hydrogen atoms. The formulas for the copper II nitrate and the water are separated by a dot. The number of atoms in the formula above is 18, because it shows 1 atom of copper, 2 atoms of nitrogen, 9 atoms of oxygen (6 from the nitrate plus 3 from the water), and 6 atoms of hydrogen.

For each of the formulas below, determine the number and type of each of the atoms shown, and the total number of atoms.

Example

$5(NH_4)_3PO_4$ ..... N = 15, H = 60, P = 5, O = 20, *TOTAL* = 100

1. $4NaHCO_3$ ..... _____
2. $15HCl$ ..... _____
3. $3Al_2O_3$ ..... _____
4. $6KNO_3$ ..... _____
5. $2N_2O_5$ ..... _____
6. $7Sn(NO_2)_4$ ..... _____
7. $4Mn_2(Cr_2O_7)_7$ ..... _____
8. $9Na_2SO_3$ ..... _____
9. $8Ba_3(PO_4)_2$ ..... _____
10. $5MgSO_4 \cdot 7H_2O$ ..... _____

Formula Mass

Compounds are either ionic or molecular. The formulas for ionic substances are always written with subscripts reduced to lowest terms. This is because we know the ratio of ions in a compound, but we don't necessarily know how many ions are in a crystal of the compound. Formulas written in lowest terms are called empirical formulas. Molecular substances can have formulas that are not in lowest terms. For example, the formula of glucose is $C_6H_{12}O_6$. All of the subscripts are divisible by six. This is acceptable, however, because we know exactly how many atoms of each type are in a molecule of glucose. The formula for glucose is called a molecular formula and its mass is called a molecular mass. Regardless of whether a compound has a molecular formula or an empirical formula, the mass of the compound is found the same way. The atomic masses of the elements in the compound and the formula are used to determine the mass. The mass determined from the formula is called a formula mass. A molecular mass is a type of formula mass. The terms are sometimes used interchangeably. Formula masses are determined by following the steps in the box to the right. The results are in *atomic mass units* (amu).

Finding the Formula Mass

Find the formula mass of $CuSO_4$

Step 1: Look up the mass of each element on the *Periodic Table* and round it off.
Step 2: Multiply each element's atomic mass by its subscript to get the product.
Step 3: Add the products together to get the total

Element	Atomic Mass		Subscript		Product
Cu	64	×	1	=	64
S	32	×	1	=	32
O	16	×	4	=	64
			TOTAL		160

Determine the formula masses of each of the substances below.

1. $CaCl_2$

2. NH_4OH

3. $AgCH_3COO$

4. $Ba_3(PO_4)_2$

5. $Al_2(CO_3)_3$

6. $Zn(NO_3)_2$

NAME:_____ DATE:_____SECTION_____LAB_____

What Is Your Weight?

Molecular and Formula Mass

- the **molecular mass** of a molecule is the sum of the atomic masses of all the atoms in a molecular compound
- the **formula mass** of an ionic compound is the sum of the atomic masses of all of the atoms in an ionic compound

Determining Molecular/Formula Masses

1. Determine the number of atoms of every element present in the formula
2. Look up the atomic mass of each element on the periodic table rounded to the nearest whole number
3. Multiply step one by step two for each element
4. Add the products of step three

Example

- Calculate the molecular mass of $C_4H_6O_2$.

Element	Number of Atoms	Atomic Mass of Element	Total Mass of Element in Compound
C	4	12 amu	48 amu
H	6	1 amu	6 amu
O	2	16 amu	32 amu
Molecular Mass of compound			86 amu

Problems:

Calculate the formula/molecular mass for the following compounds.

A. H_2O

B. CO_2

C. H_2SO_4

D. NH_3

E. XeF_6

F. $C_2H_2F_2$

G. $Mg(OH)_2$

H. $Al_2(SO_4)_3$

H. $Al_2(CrO_4)_3$

Refection:

Describe the procedure you used to calculate the molecular/formula mass.

GRAM FORMULA MASS

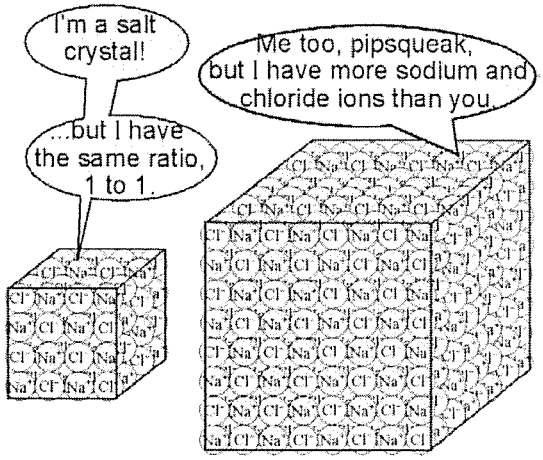
Name _____

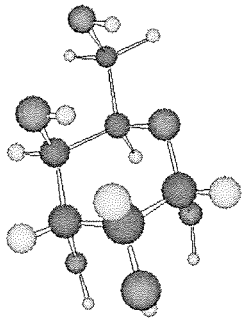
Determine the gram formula mass (the mass of one mole) of each compound below.

1. $KMnO_4$ _____
2. KCl _____
3. Na_2SO_4 _____
4. $Ca(NO_3)_2$ _____
5. $Al_2(SO_4)_3$ _____
6. $(NH_4)_3PO_4$ _____
7. $CuSO_4 \cdot 5H_2O$ _____
8. $Mg_3(PO_4)_2$ _____
9. $Zn(C_2H_3O_2)_2 \cdot 2H_2O$ _____
10. $Zn_3(PO_4)_2 \cdot 4H_2O$ _____
11. H_2CO_3 _____
12. $Hg_2Cr_2O_7$ _____
13. $Ba(ClO_3)_2$ _____
14. $Fe_2(SO_3)_3$ _____
15. $NH_4C_2H_3O_2$ _____

Empirical Formulas

The chemical formula for a molecular compound shows the number and type of atoms present in a molecule. Ionic crystals are a collections of ions. The chemical formula for an ionic compound shows the ratio ions in the compound. The ratio of ions in the formula for an ionic compound is always in lowest terms. A chemical formula in which the ratio of the elements are in lowest terms is called an empirical formula. For example, the formula for table salt, sodium chloride, is NaCl even though a salt crystal may have millions of ions and millions of ionic bonds. A glucose, molecule ($C_6H_{12}O_6$) such as the one pictured to the left, on the other hand, has exactly six carbon atoms, twelve hydrogen atoms, and six oxygen atoms per molecule. The molecular formula for glucose is not an empirical formula. All the subscripts are divisible by six. When the subscripts are divided by six, the empirical formula for glucose, CH_2O, is obtained. Some molecular formulas, such as the one for carbon dioxide, CO_2, are already empirical formulas without being reduced.





There are two skills you need to learn in order to work with empirical formulas. They are finding the empirical formula from the molecular formula and Finding the molecular formula from the empirical formula and the molecular mass:

- to find the empirical formula from the molecular formula
  divide all the subscripts by the greatest common factor

Determine the empirical formula, for each of the following molecular formulas.

1. C_8H_{18} ..... _____
2. H_2O_2 ..... _____
3. Hg_2Cl_2 ..... _____
4. $C_3H_6O_3$ ..... _____
5. $Na_2C_2O_4$ .... _____
6. H_2O ..... _____
7. C_4H_8 ..... _____
8. C_4H_6 ..... _____
9. C_7H_{12} ..... _____
10. CH_3COOH .. _____

NEXT PAGE ☞

- to find the molecular formula from the empirical formula and the molecular mass.

Step 1: Determine the empirical formula mass.
Step 2: Divide the molecular mass by the empirical formula mass to determine the multiple..
Step 3: Multiply the empirical formula by the by the multiple to find the molecular formula

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Sample Problem

A compound with an empirical formula of CH_2O has a molecular mass of 90 amu. What is its molecular formula?

Step 1: Determine the empirical formula mass.

CH_2O

C = 12 × 1 = 12
H = 1 × 2 = 2
O = 16 × 1 = 16
30

Step 2: Divide the molecular mass by the empirical formula mass to determine the multiple.

$$\frac{90}{30} = 3$$

Step 3: Multiply the empirical formula by the by the multiple to find the molecular formula

$[CH_2O] \times 3 = C_3H_6O_3$

Determine the molecular formula for each of the following:

11. Find the molecular formula for a compound with a mass of 78 amu and the empirical formula CH.

12. Find the molecular formula for a compound with a mass of 82 amu and the empirical formula C_3H_5.

13. Find the molecular formula for a compound with a mass of 90 amu and the empirical formula HCO_2.

14. Find the molecular formula for a compound with a mass of 112 amu and the empirical formula CH_2.

15. Find the molecular formula for a compound with a mass of 40 amu and the empirical formula C_3H_4.

NAME:_____ DATE:_____SECTION_____LAB_____

What Is Your Formula?

Background:

An empirical formula is the lowest whole number ratio of atoms in a compound. A molecular formula is the exact ratio of atoms in a compound.

Procedure:

Given a substance's gram formula mass and its empirical formula to predict the compound's molecular formula.

1) What is the molecular formula of a compound with an empirical formula of CH_2 and a gram formula mass of 84 g/mol?

2) What is the molecular formula of a compound with an empirical formula of C_2H_3 and a gram formula mass of 54 g/mol?

3) What is the molecular formula of a compound with an empirical formula of CH and a gram formula mass of 78 g/mol?

4) What is the molecular formula of a compound with an empirical formula of CH_2O and a gram formula mass of 180 g/mol?

5) What is the molecular formula of a compound with an empirical formula of C_3H_4 and a gram formula mass of 40 g/mol?

6) What is the molecular formula of a compound with an empirical formula of P_2O_5 and a gram formula mass of 284 g/mol?

7) TATB, or triaminotrinitrobenzene, is an aromatic explosive, based on the benzene ring structure with three nitro functional groups (NO_2) and three amine (NH_2) groups attached, alternating around the ring. TATB is a powerful explosive (more powerful than TNT), but it is extremely insensitive to shock, vibration, fire, or impact. Because it is so difficult to detonate by accident, even under severe conditions, it has become preferred for applications where extreme safety is required, such as the explosives used in nuclear weapons, where accidental detonation during an airplane crash or rocket misfiring would present extreme dangers. Almost all US nuclear weapons are now believed to use TATB based explosives for main explosive charges.

a) What is the molecular formula of TATB, which has an empirical formula of CHNO and a gram formula mass of 258 g/mol?

b) Why is TATB used instead of TNT is situations where safety is of extreme concern?

Reflection:

Describe how to calculate the molecular formula given the formula mass and the empirical formula.

NAME:_____ DATE:_____SECTION_____LAB_____

My Percent is Bigger than Yours!

Background:

There are two different ways to describe the composition of a compound: in terms of the number of its constituent atoms (like C_2H_6) and in terms of the percentages (by mass) of its elements. When showing the constituent atoms of a molecule, you can either show the chemical formula, which shows the real number of atoms in the molecule, like C_2H_6, or show the **empirical formula**, which merely shows their relative amounts in a substance, so the above molecular formula would be expressed as CH_3.

You can describe the composition of a compound in terms of the weights of its constituent elements by determining the percent composition of particular elements in the molecule. To calculate percent compositions, you would find the weight of each constituent atom, then figure out what percent of the total molecular weight it makes up.

$$\% \text{ composition by mass} = \frac{\text{mass of part}}{\text{mass of whole}} \times 100$$

Where mass of part is the mass of the individual constituent and mass of whole is the molecular or formula mass.

Problems:

Find the percent composition of each element in the following substances. Round each percent off to one decimal place.

1) CO_2

2) H_2SO_4

3) XeF_6

4) $C_2H_2F_2$

5) $Zn(ClO_2)_2$

Potassium sulfate (K_2SO_4) (in British English potassium sulphate, also called sulphate of potash, arcanite, or archaically known as potash of sulfur) is a non-flammable white crystalline salt which is soluble in water. The chemical is commonly used in fertilizers, providing both potassium and sulfur.

6) Determine the mass of the sulfate ion.

7) Determine the mass of potassium sulfate.

8) Determine the percent potassium of potassium sulfate.

9) Determine the percent sulfate of potassium sulfate.

Aluminum sulfate, written as $Al_2(SO_4)_3$ Aluminum sulfate is an industrial chemical used as a flocculating agent in the purification of drinking water and waste water treatment plants, and also in paper manufacturing.

Aluminum Sulfate is used in water purification and as a mordant in dyeing and printing textiles. In water purification, it causes impurities to coagulate which are removed as the particulate settles to the bottom of the container or more easily filtered. This process is called coagulation or flocculation.

When dissolved in a large amount of neutral or slightly-alkaline water, aluminum sulfate produces a gelatinous precipitate of aluminum hydroxide. In dyeing and printing cloth, the gelatinous precipitate helps the dye adhere to the clothing fibers by rendering the pigment insoluble.

10) Determine the percent sulfate of aluminum sulfate.

11) Give the formula for aluminum hydroxide._____

12) Determine the percent hydroxide for aluminum hydroxide.

13) Define in terms of chemistry:

a) Flocculent

b) Mordant

c) Precipitate

d) Coagulate

Reflection:

Describe your process to calculate percent composition.

Chemistry: Form WS5.1.3A Name _____

CHEMICAL FORMULAS and EQUATIONS Date _____ Period _____

Determining Percent Composition

Percentage composition is determined by finding the formula mass of a compound, multiplying the mass of each element by 100, and dividing the product by the formula mass of the compound. Use the periodic table to find the masses of individual elements. See the ***Sample Problem*** to the right.

Sample Problem: Find the percentage composition of $MgCO_3$.

Formula Mass	Percentage Composition
Mg = 24 × 1 = 24	% Mg = 24 × 100 ÷ 84 = 29
C = 12 × 1 = 12	% C = 12 × 100 ÷ 84 = 14
O = 16 × 3 = 48	% O = 48 × 100 ÷ 84 = 57
84	100

1. What is the percentage composition of: Na, O, and H in the compound NaOH?

   Na _____, O _____, H _____.

2. Calculate the percentage composition of baking soda ($NaHCO_3$).

   Na _____, H _____, C _____, O _____.

3. Calculate the percentage of each of the elements within acetic acid ($HC_2H_3O_2$), the substance found in vinegar.

   H _____, C _____, O _____.

4. What is the percentage composition of a soap ($C_{17}H_{35}COONa$)?

   C _____, H _____, O _____, Na _____.

5. Which of the following has the highest percentage of nitrogen? (✔)

   ___ $Ca(NO_3)_2$ _____ ___ $(NH_4)_2SO_4$ _____

Percentages can refer to different portions of a compound. In hydrated crystals, for example, it is possible to calculate the percentage of water. Find the formula mass of each portion of the compound separately. Add them together to get the mass of the compound. Then multiply the mass of the water by 100, and divide the product by the formula mass of the compound. See the ***Sample Problem*** to the right.

Sample Problem: What is the percentage of water in $CuSO_4 \cdot 5H_2O$?

Formula Mass of $CuSO_4$
Cu = 64 × 1 = 64
S = 32 × 1 = 32
O = 16 × 4 = 64
160

Formula Mass of H_2O
H = 1 × 2 = 2
O = 16 × 1 = 16
18
Mass of Water: 5 × 18 = 90 *TOTAL*: 160 + 90 =250

Percentage
$\%H_2O$ = 90 × 100 ÷ 250 = 36 %

6. Calculate the percentage of water in the compound $CaSO_4 \cdot 6H_2O$.

7. Calculate the percentage of water in the compound $CaCl_2 \cdot 10H_2O$.

Once you know the percentage composition of a compound, you can figure out the mass of any component of the compound in a sample of any mass simply by multiplying the sample mass by the percentage. See the ***Sample Problem*** to the right.

Sample Problem: A 40.0 g sample of $CaCl_2 \cdot 2H_2O$ is heated to dryness. What is the mass of the remaining calcium chloride.

Formula Mass of $CuSO_4$
Ca = 40 × 1 = 40
Cl = 35 × 2 = 70
O = 16 × 4 = 110

Formula Mass of H_2O
H = 1 × 2 = 2
O = 16 × 1 = 16
18
Mass of Water: 2 × 18 = 36 *TOTAL*: 110 + 36 = 146

Percentage
$\%CaCl_2$ = 110 × 100 ÷ 146 = 75 %

Mass
0.75 × 40.0 g = 30. g

8. How many milligrams of iron are delivered from a 250. mg tablet of $FeSO_4 \cdot 7H_2O$?

9. What is the yield of uranium from 2.50 kg U_3O_8?

PERCENTAGE COMPOSITION

Name _____

Determine the percentage composition of each of the compounds below.

1. $KMnO_4$

   K = _____

   Mn = _____

   O = _____

---

2. HCl

   H = _____

   Cl = _____

---

3. $Mg(NO_3)_2$

   Mg = _____

   N = _____

   O = _____

---

4. $(NH_4)_3PO_4$

   N = _____

   H = _____

   P = _____

   O = _____

---

5. $Al_2(SO_4)_3$

   Al = _____

   S = _____

   O = _____

Solve the following problems.

6. How many grams of oxygen can be produced from the decomposition of 100. g of $KClO_3$? _____

7. How much iron can be recovered from 25.0 g of Fe_2O_3? _____

8. How much silver can be produced from 125 g of Ag_2S? _____

Chemistry: Form WS5.9A Name _____

FORMULAS and EQUATIONS Date _____ Period _____

Formulas from Masses

The molecular formula for a compound can be determined from the percentage composition by assuming the sample has a mass of 100 g. Using the percentages, the number of grams out of 100 can be determined for each component. This can be converted to moles by dividing by the GFM. The mole ratio and empirical formula can be determined by dividing each number of moles by the smallest number of moles. The atomic masses are added together to find the empirical formula mass. The empirical formula mass is divided into the molecular weight to find the number of times "n," the formula is repeated. Finally, "n" is multiplied by the empirical formula to find the molecular formula. See the ***Sample Problem*** to the right.

Sample Problem

Find the molecular formula for a compound composed of 5.9% hydrogen and 94.1% oxygen and having a molecular weight of 34 amu.

Step 1: Assume a 100 g sample

Step 2: Find the mass of each element in the sample

mass of H = 5.9 % of 100 g = 5.9 g
mass of O = 94.1 % of 100 g = 94.1 g

Step 3: Convert grams to moles

moles of H = $\frac{5.9g}{1g/mol}$ = 5.9 moles

moles of O = $\frac{94.1g}{16g/mol}$ = 5.9 moles

Step 4: Find the mole ratio by dividing both numbers by the smaller number

5.9 ÷ 5.9 = 1 H
5.9 ÷ 5.9 = 1 O
empirical formula = HO

Step 5: Find the empirical formula mass

atomic mass of H = 1
atomic mass of O = 16
EFM = 17

Step 6: Find the number of times, "n," the empirical formula is repeated and multiply through

$\frac{M.W.}{EFM}$ = n = $\frac{34}{17}$ = 2

molecular formula $(HO)_n$ = $(HO)_2$ = H_2O_2

Answer the questions below.

1. What is the percentage composition of each of the elements in the following compounds?

   a) NaOH

   b) $KHCO_3$

   c) $(NH_4)_2SO_4$

   d) $CuSO_4$

2. Calculate the percentage of water in each of the following hydrates.

   a) $CaCl_2 \cdot 10H_2O$ b) $CaSO_4 \cdot 6H_2O$

3. A strip if copper weighing 6.4 grams is heated in a stream of oxygen until it is converted to an oxide. The mass of the oxide is 8.0 g.
   a) What is the percentage composition of this compound?

   b) Is the formula of this compound CuO or is it Cu_2O ?(show work)

4. Find the empirical formula for the following compounds(use the percentage composition given for each).
a) Na = 43.4 %; C = 11.3 %; O = 45.3 %

b) Cu = 34.0 %; N = 14.9 %; O = 51.1 %

c) Al = 18.4 %; S = 32.7 %; O = 48.9 %

5. Find the molecular formula of each of the following compounds.
a) C = 82.8 %; H = 17.2 %; M.W. = 58

b) H = 5.9 %; O = 94.1 %; M.W. = 34

c) C = 93.75 %; H = 6.25 %; M.W. = 128

DETERMINING EMPIRICAL FORMULAS

Name _____

What is the empirical formula (lowest whole number ratio) of the compounds below?

1. 75% carbon, 25% hydrogen

_____

2. 52.7% potassium, 47.3% chlorine

_____

3. 22.1% aluminum, 25.4% phosphorus, 52.5% oxygen

_____

4. 13% magnesium, 87% bromine

_____

5. 32.4% sodium, 22.5% sulfur, 45.1% oxygen

_____

6. 25.3% copper, 12.9% sulfur, 25.7% oxygen, 36.1% water

_____

DETERMINING MOLECULAR FORMULAS (TRUE FORMULAS)

Name _____

Solve the problems below.

1. The empirical formula of a compound is NO_2. Its molecular mass is 92 g/mol. What is its molecular formula?

_____

2. The empirical formula of a compound is CH_2. Its molecular mass is 70 g/mol. What is its molecular formula?

_____

3. A compound is found to be 40.0% carbon, 6.7% hydrogen and 53.5% oxygen. Its molecular mass is 60. g/mol. What is its molecular formula?

_____

4. A compound is 64.9% carbon, 13.5% hydrogen and 21.6% oxygen. Its molecular mass is 74 g/mol. What is its molecular formula?

_____

5. A compound is 54.5% carbon, 9.1% hydrogen and 36.4% oxygen. Its molecular mass is 88 g/mol. What is its molecular formula?

_____

COMPOSITION OF HYDRATES

Name _____

A hydrate is an ionic compound with water molecules loosely bonded to its crystal structure. The water is in a specific ratio to each formula unit of the salt. For example, the formula $CuSO_4 \bullet 5H_2O$ indicates that there are five water molecules for every one formula unit of $CuSO_4$. Answer the questions below.

1. What percentage of water is found in $CuSO_4 \bullet 5H_2O$?

_____

2. What percentage of water is found in $Na_2S \bullet 9H_2O$?

_____

3. A 5.0 g sample of a hydrate of $BaCl_2$ was heated, and only 4.3 g of the anhydrous salt remained. What percentage of water was in the hydrate?

_____

4. A 2.5 g sample of a hydrate of $Ca(NO_3)_2$ was heated, and only 1.7 g of the anhydrous salt remained. What percentage of water was in the hydrate?

_____

5. A 3.0 g sample of $Na_2CO_3 \bullet H_2O$ is heated to constant mass. How much anhydrous salt remains?

_____

6. A 5.0 g sample of $Cu(NO_3)_2 \bullet nH_2O$ is heated, and 3.9 g of the anhydrous salt remains. What is the value of n?

_____

Analyzing Chemical Formulas

Aim

- to perform calculations based on the information in a chemical formula

Notes

Determining Formula Mass

★ add up the product of the subscript and the mass from the periodic table for each element shown in the formula

☆ Examples

★ silver nitrate

$AgNO_3$

Ag =	1 × 108 =	108
N =	1 × 14 =	14
O =	3 × 16 =	48
		170

★ sodium chloride

NaCl

Na =	1 × 23 =	23
Cl =	1 × 35 =	35
		58

Empirical Formulas

★ Definition: Empirical Formula = The simplest ratio of the atoms present in a molecule

★ Determining empirical formulas from molecular formulas – reduce subscripts to lowest terms

☆ Examples

★ glucose: Molecular formula = $C_6H_{12}O_6$; Empirical formula = CH_2O

★ hydrogen peroxide: Molecular formula = H_2O_2; Empirical formula = HO

★ Determining molecular formulas from empirical formulas and formula mass

☆ Procedure – molecular formulas are always some multiple of empirical formulas

★ determine the empirical formula mass as described above

★ divide the empirical formula mass into the molecular mass to determine the multiple

★ multiply the empirical formula by the multiple

CONTINUE ☞

☆ Example

Sample Problem

A compound with an empirical formula of CH_2 has a molecular mass of 42 amu. What is its molecular formula.

Step 1: Determine the empirical formula mass.

CH_2

C = 12 × 1 = 12

H = 1 × 2 = 2

14

Step 2: Divide the molecular mass by the empirical formula mass to determine the multiple..

$$\frac{42}{14} = 3$$

Step 3: Multiply the formula by the by the multiple to find the molecular formula

$[CH_2] \times 3 = C_3H_6$

Determining Percent Composition

★ Procedure - determine the formula mass and divide the mass of each element by the mass of the compound

Sample Problem

What is the percent composition of $Ca(OH)_2$?

Step 1: Determine the formula mass

$Ca(OH)_2$

Ca = 40 × 1 = 40

O = 16 × 2 = 32

H = 1 × 2 = 2

74

Step 2: Divide the mass of each element in the compound by the mass of the compound and multiply by 100.

$$\%Ca = \frac{40}{74} \times 100 = 54;\ \%O = \frac{32}{74} \times 100 = 43;\ \textit{and}$$

$$\%H = \frac{2}{74} \times 100 = 3$$

Answer the questions below by circling the number of the correct response

1. An example of an empirical formula is (1) C_2H_2, (2) H_2O_2, (3) C_2Cl_2, (4) $CaCl_2$

2. A 10.0 gram sample of a hydrate was heated until all the water of hydration was driven off. The mass of anhydrous product remaining was 8.00 grams What is the percent of water in the hydrate? (1) 12.5% (2) 20.0% (3) 25.0% (4) 80.0%

3. A compound has the empirical formula NO_2. Its molecular formula could be (1) NO_2, (2) N_2O, (3) N_4O_2, (4) N_4O_4.

4. The percent by mass of oxygen in $Ca(OH)_2$ (formula mass = 74) is closest to (1) 16, (2) 22, (3) 43, (4) 74.

5. The empirical formula of a compound is CH. Its molecular mass could be (1) 21, (2) 40, (3) 51, (4) 78.

6. What is the percent by mass of oxygen in NaOH (formula mass = 40.)? (1) 80. (2) 40. (3) 32 (4) 16

7. A compound whose empirical formula is CH_2O could be (1) HCOOH, (2) CH_3OH, (3) CH_3COOH, (4) CH_3CH_2OH.

8. The percent by mass of oxygen in CO is approximately (1) 73%, (2) 57%, (3) 43%, (4) 17%.

9. A compound has an empirical formula of CH_2 and a molecular mass of 56. Its molecular formula is (1) C_2H_4, (2) C_3H_6, (3) C_4H_8, (4) C_5H_{10}.

10. What is the percent by mass of hydrogen in NH_3 (formula mass = 17.0)? (1) 5.9% (2) 17.6% (3) 21.4% (4) 82.4%

11. The empirical formula of a compound is CH_2 and its molecular mass is 70. What is the molecular formula of the compound? (1) C_2H_2 (2) C_2H_4 (3) C_4H_{10} (4) C_5H_{10}

12. The percent by mass of nitrogen in $Mg(CN)_2$ is equal to (1) $^{14}/_{76} \times 100$, (2) $^{14}/_{50} \times 100$, (3) $^{28}/_{76} \times 100$, (4) $^{28}/_{50} \times 100$.

13. What is the percent by mass of oxygen in Fe_2O_3 (formula mass = 160)? (1) 16% (2) 30.% (3) 56% (4) 70.%

14. Which formulas could represent the empirical formula and the molecular formula of a given compound? (1) CH_2O, $C_4H_6O_4$ (2) CHO $C_6H_{12}O_6$ (3) CH_4, C_3H_{12} (4) CH_2, C_3H_6

15. The percent by mass of carbon in CO_2 is equal to (1) $^{44}/_{12} \times 100$, (2) $^{12}/_{44} \times 100$, (3) $^{28}/_{12} \times 100$, (4) $^{12}/_{28} \times 100$

16. The percentage by mass of hydrogen in NH_3 is equal to (1) $^{1}/_{17} \times 100$ (2) $^{3}/_{17} \times 100$ (3) $^{17}/_{3} \times 100$ (4) $^{6}/_{17} \times 100$

17. The empirical formula of a compound is CH_4. The molecular formula of the compound could be (1) CH_4, (2) C_2H_6, (3) C_3H_8, (4) C_4H_{10}

18. A hydrocarbon has the empirical formula CH_3. The most probable molecular formula for this compound is (1) CH_3, (2) C_2H_6, (3) C_3H_8, (4) C_4H_6

19. A compound with an empirical formula of CH_2 has a molecular mass of 70. What is the molecular formula? (1) CH_2 (2) C_2H_4 (3) C_4H_8 (4) C_5H_{10}

20. What is the percent by mass of oxygen in CH_3OH? (1) 50.0 (2) 44.4 (3) 32.0 (4) 16.0

21. The approximate percent by mass of potassium in $KHCO_3$ is (1) 19 %, (2) 24 %, (3) 39 %, (4) 61 %

22. A compound has an empirical formula of CH_2 and a molecular mass of 56. What is its molecular formula?
(1) CH_2 (3) C_3H_6
(2) C_2H_4 (4) C_4H_8

23. What is the percent by mass of hydrogen in CH_3COOH (formula mass = 60.)?
(1) 1.7% (3) 6.7%
(2) 5.0% (4) 7.1%

24. What is the percentage by mass of oxygen in CuO?
(1) 16% (3) 25%
(2) 20% (4) 50%

25. What is the approximate percent composition by mass of $CaBr_2$ (formula mass = 200)? (1) 20% calcium and 80% bromine (2) 25% calcium and 75% bromine (3) 30% calcium and 70% bromine (4) 35% calcium and 65% bromine

26. A 60. gram sample of $LiCl \cdot H_2O$ is heated in an open crucible until all of the water has been driven off. What is the total mass of LiCl remaining in the crucible?
(1) 18 g. (3) 42 g.
(2) 24 g. (4) 60 g.

27. Which compound contains the greatest percentage of oxygen by mass?
(1) BaO (3) MgO
(2) CaO (4) SrO

28. The precent by mass of oxygen in MgO (formula mass = 40) is closest to
(1) 16% (3) 40%
(2) 24% (4) 60%

NAME:_____ DATE:_____SECTION_____LAB_____

We got the whole mole!

Moles are a unit of measurement for chemicals, just as meters are measurement units for length and grams are measurement units for mass. When a chemist or engineer wants to make a chemical reaction happen, he or she wants to make sure there is the right amount of each kind of chemical. Moles are used so that chemists, scientists or engineers know how much of different kinds of chemicals to use to have reactions that work out right.

A chemical can be atoms of a single element or atoms of many elements combined into molecules, so a single molecule of a chemical can weigh three or four times what a single molecule of another chemical weighs. For this reason, chemists can't just measure the weight of different chemicals to have the right proportions of reactants.

When chemists want to have a chemical reaction come out they need to know how many molecules of each kind of chemical they have, so they measure the chemicals in moles. A mole is the atomic mass of a molecule of the chemical in grams. So a mole of a molecule like hydrogen (H) with an atomic weight of 1 is one gram. Meanwhile, a complex molecule like glucose ($C_6H_{12}O_6$) has an molecular mass of 180, so one mole is 180 grams. But even though the weight is different, the two moles contain the exact same number of molecules, 6.02×10^{23}.

Problems:

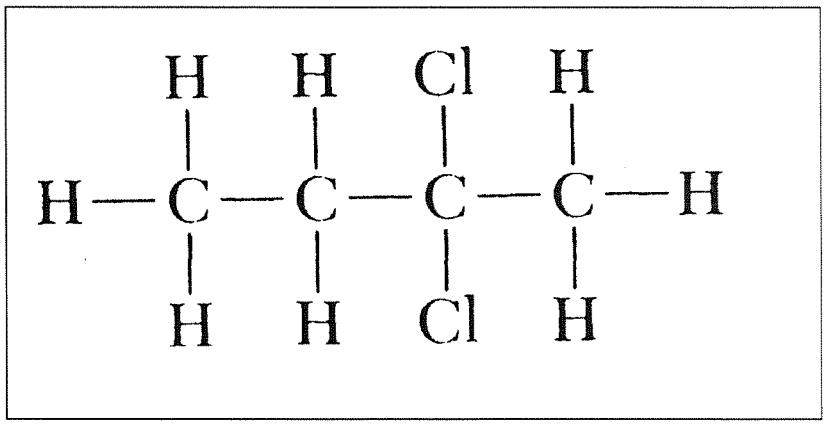
1) Determine the mass of 3.0 moles of NH_3 (GFM = 17 g/mol).

2) Determine the number of moles of NH_3 in 93.5 grams.

3) Determine the mass of 0.20 moles of SO_2 (GFM = 64 g/mol).

4) Determine the number of moles of SO_2 in 168 g

5) Use the molecule of dichlorobutane to answer the following questions:



a) Determine dichlorobutane's molecular formula.

b) Determine the gram formula mass of the molecule.

c) Determine the mass of 5.5 moles of the molecule.

d) Determine the number of moles of dichlorobutane found in 127 grams.

6) Copper (II) Sulfate is also used to test blood for anemia. A drop of the patient's blood is dropped into a container of copper (II) sulfate, if it sinks within a certain time, then the patient has sufficient hemoglobin levels and is not anemic. If the blood floats or sinks too slowly, then the patient is iron-deficient and may be anemic.

a) Determine the formula for copper (II) sulfate. _____

b) Calculate copper (II) sulfate's gram formula mass to the nearest 10^{th} of a decimal place.

c) Determine the mass of 3.53 moles of copper (II) sulfate.

d) Determine the number of moles of copper (II) sulfate found in 2500. Grams.

7) In household bleach form, sodium hypochlorite is used for removal of stains from laundry. It is particularly effective on cotton fiber, which stains easily but bleaches well. 50 to 250 ml per load is usually recommended for a standard-size washer. Hot water increases the activity of the bleach, owing to the thermal decomposition of hypochlorite which ultimately generates environmentally-undesirable chlorate.

   a) Determine the formula for sodium hypochlorite._____

   b) Calculate the gram formula mass for sodium hypochlorite to the nearest 10^{th} of a decimal place.

   c) Determine the mass of 0.62 moles of sodium hypochlorite.

   d) Determine the number of moles of sodium hypochlorite found in 11.2 grams.

8) Your group has the molecular model for 1-Chloro 2-Propanol.

   a) Give the structural formula of 1-Choro 2-Propanol.

   b) Determine the molecular formula of 1-Chloro 2-Propanol.

   c) Calculate the gram formula mass for 1-Chloro 2-Propanol.

   d) Determine the mass of 0.0025 moles of 1-Chloro 2-Propanol.

   e) Determine the number of moles found in 5.6×10^3 grams of 1-Chloro 2-Propanol.

Reflection: Describe your method to convert from moles to grams. Describe your method to convert from grams to moles.

Name _____

Date _____ Period _____

The Mole Concept

★ Mole = number of particles in a molecular or atomic mass expressed in grams

☆ Gram atomic mass or gram-atom - the mass of 1 mole of atoms

✯ numerically equal to the atomic mass of the atom on the periodic table expressed in grams

✯ examples

Element	Atomic Mass	Gram Atomic Mass
carbon	12 amu	12 g
sodium	23 amu	23 g
bromine	80 amu	80 g

☆ Gram molecular mass (GMM) or mole mass - mass of 1 mole of molecules

✯ found by adding the atomic masses of all the atoms in a molecule

✯ example

Sample Problem

Find the mass of one mole of table sugar ($C_{12}H_{22}O_{11}$)

Element	Gram Atomic Mass		Subscript	Product
C	12 g	×	12	144 g
H	1 g	×	22	22 g
O	16 g	×	11	176 g
			TOTAL	342 g

☆ Gram formula mass (GFM) - formula mass expressed in grams or the mass of 1 mole of an ionic substance

✯ formula mass - sum of the masses of the ions in the empirical formula of an ionic substance

✯ example

Sample Problem

Find the gram formula mass of silver nitrate ($AgNO_3$)

Element	Gram Atomic Mass		Subscript	Product
Ag	108 g	×	1	108 g
N	14 g	×	1	14 g
O	16 g	×	3	48 g
			TOTAL	170 g

✯ Calculations involving the mole definition

✯ $GFM = \frac{g}{mole}$ ∴

✯ g = GFM × mole *and*

✯ $mole = \frac{g}{GFM}$

Examples

1. What is the mass of 2 mole of sodium sulfate?

Na_2SO_4

Na = 23 × 2 = 46

S = 32 × 1 = 32

O = 16 × 4 = 64

142

$g = \frac{GFM}{142} \times \frac{moles}{2}$

g = 284 g

2. How many moles are in 145g of sodium chloride?

NaCl

Na = 23 × 1 = 23

Cl = 35 × 1 = 35

58

moles = g / GFM

145 / 58

moles = 2.5 moles

Answer the questions below by circling the number of the correct response

1. The gram molecular mass of CO_2 is the same as the gram molecular mass of (1) CO (2) SO_2 (3) C_2H_6 (4) C_3H_8

2. The number of molecules in 1.0 mole of SO_2 is the same as the number of molecules in
   (1) 1.0 mole of N_2 (3) 0.25 mole of NO_2
   (2) 2.0 moles of Ne (4) 0.50 mole of NH_3

3. What is the gram formula mass of $Ca(HCO_3)_2$?
   (1) 101 (3) 202
   (2) 162 (4) 324

4. What is the total mass of iron in 1.0 mole of Fe_2O_3?
   (1) 160 g (3) 72 g
   (2) 112 g (4) 56 g

5. What is the mass, in grams, of 1.0 mole of $(NH_4)_2S$?
   (1) 50 (3) 64
   (2) 54 (4) 68

6. The mass of two moles of sulfuric acid, expressed in grams, is equal to
   (1) $\frac{98}{2}$ (3) $\frac{6.02 \times 10^{23}}{2}$
   (2) 2×98 (4) $2 \times (6.02 \times 10^{23})$

7. Which quantity is equivalent to 39 grams of LiF?
   (1) 1.0 mole (3) 0.30 mole
   (2) 2.0 moles (4) 1.5 moles

8. What is the total number of moles contained in115 grams of C_2H_5OH?
   (1) 1.00 (3) 3.00
   (2) 1.50 (4) 2.50

9. How many moles of water are contained in 0.250 mole of $CuSO_4 \cdot 5H_2O$?
   (1) 1.25 (3) 40.0
   (2) 4.50 (4) 62.5

10. Which represents the greatest mass of chlorine
    (1) 1 mole of chlorine (2) 1 atom of chlorine
    (3) 1 gram of chlorine (4) 1 molecule of chlorine

11. What is the total mass of iron in 1.0 mole of Fe_2O_3?
    (1) 160 g (3) 72 g
    (2) 112 g (4) 56 g

12. What is the mass, in grams, of 1.0 mole of $(NH_4)_2S$?
    (1) 50. (3) 64
    (2) 54 (4) 68

13. What is the gram atomic mass of the element chlorine?
    (1) 17 g (3) 52 g
    (2) 35 g (4) 70. g

14. The mass in grams of 1.00 mole of $CaSO_4 \cdot 2H_2O$ is
    (1) 172 g (3) 136 g
    (2) 154 g (4) 118 g

MOLES AND MASS

Name _____

Determine the number of moles in each of the quantities below.

1. 25 g of NaCl _____
2. 125 g of H_2SO_4 _____
3. 100. g of $KMnO_4$ _____
4. 74 g of KCl _____
5. 35 g of $CuSO_4 \cdot 5H_2O$ _____

Determine the number of grams in each of the quantities below.

1. 2.5 moles of NaCl _____
2. 0.50 moles of H_2SO_4 _____
3. 1.70 moles of $KMnO_4$ _____
4. 0.25 moles of KCl _____
5. 3.2 moles of $CuSO_4 \cdot 5H_2O$ _____

THE MOLE AND VOLUME

Name _____

For gases at STP (273 K and 1 atm pressure), one mole occupies a volume of 22.4 L. What volume will the following quantities of gases occupy at STP?

1. 1.00 mole of H_2
2. 3.20 moles of O_2
3. 0.750 mole of N_2
4. 1.75 moles of CO_2
5. 0.50 mole of NH_3
6. 5.0 g of H_2
7. 100. g of O_2
8. 28.0 g of N_2
9. 60. g of CO_2
10. 10. g of NH_3

THE MOLE AND AVOGADRO'S NUMBER

Name _____

One mole of a substance contains Avogadro's Number (6.02×10^{23}) of molecules.

How many molecules are in the quantities below?

1. 2.0 moles
2. 1.5 moles
3. 0.75 mole
4. 15 moles
5. 0.35 mole

How many moles are in the number of molecules below?

1. 6.02×10^{23}
2. 1.204×10^{24}
3. 1.5×10^{20}
4. 3.4×10^{26}
5. 7.5×10^{19}

MIXED MOLE PROBLEMS

Name _____

Solve the following problems.

1. How many grams are there in 1.5×10^{25} molecules of CO_2?

_____

2. What volume would the CO_2 in Problem 1 occupy at STP?

_____

3. A sample of NH_3 gas occupies 75.0 liters at STP. How many molecules is this?

_____

4. What is the mass of the sample of NH_3 in Problem 3?

_____

5. How many atoms are there in 1.3×10^{22} molecules of NO_2?

_____

6. A 5.0 g sample of O_2 is in a container at STP. What volume is the container?

_____

7. How many molecules of O_2 are in the container in Problem 6? How many atoms of oxygen?

_____

_____

Solve each of the following problems. In the space below each problem, show a labeled setup. Do any necessary arithmetic on scrap paper. Write your answers in the spaces at the right.

4. A sample of H_2SO_4 has a mass of 15.0 grams.
   a. Calculate the number of moles of H_2SO_4 molecules in the sample. 4. a. _____

   b. What is the number of molecules of H_2SO_4 in the sample? b. _____

   c. How many atoms are there in the sample? c. _____

   d. Find the number of oxygen atoms in the sample. d. _____

5. A sample of $C_6H_4Cl_2$ contains 4.80×10^{22} molecules.
   a. How many moles of $C_6H_4Cl_2$ molecules are there in the sample? 5. a. _____

   b. What is the mass of the sample? b. _____

   c. How many atoms of chlorine are there in the sample? c. _____

   d. How many atoms of carbon are there in the sample? d. _____

6. A sample of $(NH_4)_2SO_4$ contains 0.750 mole of $(NH_4)_2SO_4$ formula units.
   a. What is the mass of this sample? 6. a. _____

   b. How many moles of NH_4^+ ions are there in this sample? b. _____

   c. Find the number of $(NH_4)_2SO_4$ formula units in this sample. c. _____

   d. How many hydrogen atoms are there in this sample? d. _____

7. A sample of $Ba(ClO_3)_2$ has a mass of 15.5 grams.
   a. How many moles of $Ba(ClO_3)_2$ are there in this sample? 7. a. _____

   b. How many moles of oxygen atoms are there in this sample? b. _____

   c. How many Ba^{2+} ions are there in this sample? c. _____

   d. What is the mass of Ba^{2+} in this sample? (Note that one mole of Ba^{2+} has the same atomic mass as one mole of barium atoms). d. _____