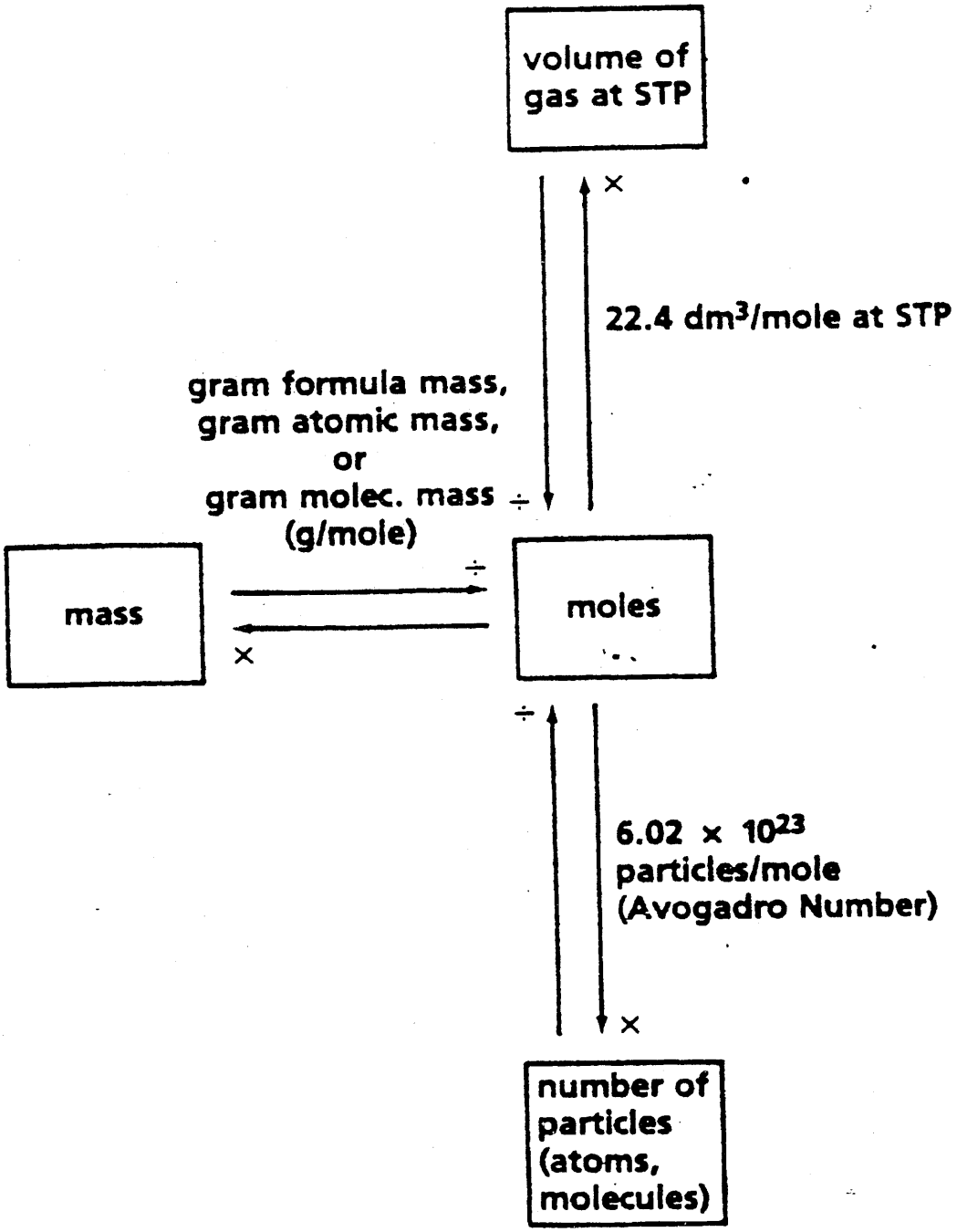
The Mole Diagram



Counting Atoms

The formula for a compound indicates the elements that make up the compound and the number of atoms of each element present in the compound. These numbers of atoms are indicated by the use of small numbers called subscripts. Sometimes groups of atoms act as a single atom. Such a group of atoms is called a *polyatomic ion.* If a polyatomic ion is used in a formula more than once, it is put in parentheses and the subscript appears outside the parentheses. When a subscript appears outside the parentheses, it indicates that *all* the elements inside the parentheses should be multiplied by that subscript. For example, the formula $Fe(OH)_3$ indicates the combination of one atom iron (Fe), three atoms of oxygen (O), and three atoms of hydrogen (H).

Name	***Use***	***Formula***	***# of Atoms x Atomic Mass***	***Gram Formula/ Molecular Mass***
Calcium carbonate	Limestone	$CaCO_3$	Ca = 1 calcium x 40.08 = C = 1 carbon x 12.01 = O = 3 oxygen x 16.00 =	
Aspirin	Pain reliever	$C_9H_8O_4$		
Magnesium	Found in milk of magnesia	$Mg(OH)_2$		
Paradichloro-benzene	Moth crystals	$C_6H_4Cl_2$		
Acetic acid	Found in vinegar	$C_2H_4O_2$		
Silicon dioxide	Sand	SiO_2		
Iron oxide	Rust	Fe_2O_3		
Sulfuric acid	Used in car batteries	H_2SO_4		

*Find the gram formula, or molecular mass, for each compound. Show work.

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. $NH_4C_2H_3O_2$ _____

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? _____

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?

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

1. **What is the empirical formula for a compound if a 5.09 g sample contains 4.09 g of zinc and 1.00 g of oxygen?**

2. **A gaseous compound has a percentage composition of 82.4% nitrogen and 17.6% hydrogen. What is the empirical formula of the gas?**

3. **The molecular mass of the gas in Problem 2 is 17.0 g/mol. What is the molecular formula for the gas?**

4. **What is the molecular formula for a compound with an empirical formula of NO_2 and a molecular mass of 92.0 g/mol?**

5. **What is the empirical formula for a compound if a 32.8 g sample contains 2.00 g of carbon, 22.8 g of barium, and 8.00 g of oxygen?**

Empirical Formula - The smallest whole number ratio of atoms in a compound.
(Simplist formula) examples: CH_2, H_2SO_4, NO_2

Molecular Formulas- Whole number multiple of empirical formula
examples:

C_2H_4 N_2O_4

Find empirical formula of a compound by using ratio of the moles of each atom in the compound.

Find molecular formula by comparing mass given for compound and mass of empirical formula.

Sample Problem- Empirical Formula
A compound is 80.0% carbon and 20.0% hydrogen. (The molecular weight is 30.0g) Find the empirical formula and then the molecular formula.
(assume a 100g sample)

To find mole ratio divide by smallest value.
The empirical formula = CH_3

mass of empirical formula

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?

_____