

Stoichiometry – Compositions Study Guide

1. Formulas and Subscripts

How many moles of hydrogen atoms are in 1 mole of each of the following compounds?

H₂O 2 CH₃OH 4 (NH₄)₂CO₃ 8

2. Empirical and Molecular Formulas

Give the empirical formula for each compound: (**empirical formula – simplest ratio of elements**)

N₂H₂ NH BH₃ **BH₃** H₂O₂ **HO**

C₆H₁₂O₆ CH₂O B₃N₃H₆ **BNH₂** Fe₂O₃ Fe₂O₃

Most **ionic** compounds are always written as the empirical formula because there are no discrete molecules, just anions and cations packed together in the solid lattice. Most **covalent** compounds come in molecules, and the molecular formula can be either the same as the empirical or an integer multiple thereof.

Find the molecular formula for each compound, given the empirical formula and molar mass: (**with these you can round**)

CHNO, 129.07 g/mol C₃H₃N₃O₃ (C+H+N+O = 12 + 1 + 14 + 16 = 43) how many 43s go into 129?

C₆H₅, 154.21 g/mol C₁₂H₁₀ (C₆ + H₅ = 6*12 + 5*1 = 77) how many 77s in 154? 154/77 = 2

C₃H₆O₂, 222.24 g/mol C₉H₁₈O₆ (C₃ + H₆ + O₂ = 3*12 + 6*1 + 16*2 = 74: 222/74 = 3

3. Empirical Formula from Percentage Composition

A compound is composed of 12.590% hydrogen, 37.404% aluminum, and 50.006% carbon. Please find the empirical formula: **in these, do not round until near the end! Or you get wrong answers all the time!**

ELEMENT	GRAMS	MOLAR MASS	MOLES	MOLES ÷ SMALLEST
H	12.590 g	÷ 1.008 g/mol	= 12.490 mol	÷ 1.386 = 9.011
Al	37.404 g	÷ 26.982 g/mol	= <u>1.386 mol</u>	÷ 1.386 = 1
C	50.006 g	÷ 12.011 g/mol	= 4.163 mol	÷ 1.386 = 3

Empirical Formula: AlC₃H₉ but I will accept any order. The structure is Al(CH₃)₃ so it is called ‘trimethylaluminum’

4. Percent Composition from Empirical Formula

Find the percent composition by mass of ethanol, C₂H₅OH:

ELEMENT	MOLES	MOLAR MASS	GRAMS	MASS %
C	2	× 12.011 g/mol	24.022 g	100×(24.022÷46.070) = 52.1%
H	<u>6</u>	× 1.008 g/mol	6.048 g	100×(6.048÷46.070) = 13.1%
O	<u>1</u>	× 16.000 g/mol	16.000 g	100×(16.000÷46.070) = 34.7 %

TOTAL M.M.:			<u>46.070 g</u>	

5. Hydrate Compounds

You are given a red powder having a mass of 15.50 grams labeled as "CoSO₄". It dissolves in water with an exothermic reaction. After this solution is allowed to slowly evaporate and crystallize, you find pink crystals having a mass of 28.11 g. Find the molecular formula of this hydrate compound.

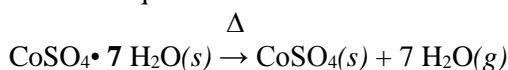
Conservation of mass: 15.50 g + 12.61 g = 28.11 g. mass of CoSO₄ + mass of H₂O = mass of CoSO₄.xH₂O

	MASS		MOLAR MASS		MOLES
CoSO ₄	15.50 g	÷	154.994 g/mol		0.100 mol
H ₂ O	12.61 g	÷	18.02 g/mol		0.699 mol

Mole Ratio: 0.699 mol / 0.100 mol = just about 7

Formula must be CoSO₄•7 H₂O

Upon heating this hydrate compound, it decomposes to water vapor and gives the original red powder. Write a balanced equation for this reaction. Include symbols for state of matter and reaction condition.



6. Honors Example Questions

Sulfur dioxide gas (SO₂) is bubbled through a solution of sodium carbonate (Na₂CO₃). The SO₂ is consumed by the solution, while carbon dioxide gas (CO₂) bubbles off as a product. The solution is then allowed to evaporate and crystallize. These crystals are composed, by mass, of 18.24% Na, 12.71% S, 63.45% O, and 5.60% H.

What is the empirical formula of this compound? Na₂SO₁₀H₁₄

ELEMENT	GRAMS		MOLAR MASS		MOLES	MOLES ÷ SMALLEST
Na	18.24 G	÷	22.990	=	0.79339	2
S	12.71 G	÷	32.065	=	<u>0.39638</u>	1
O	63.45 g	÷	15.999	=	3.96587	10
H	5.60 G	÷	1.0079	=	5.55610	14

This is a hydrate compound. Write the molecular formula using standard dot notation, assuming that all hydrogen present is in the form of bound water. Na₂SO₃•7H₂O

Suppose that you have 100 grams of this hydrate compound and you heat it until all bound water has been driven off. How many grams of anhydrous product do you have left? 49.997 g

Hint: Remember that the moles of anhydrous product are equal to the moles of starting material! Drawing a reaction table is often helpful as shown below. You will need to calculate molar masses of both reactant and anhydrous product.

	<u>Na₂SO₃·7H₂O</u>	→ Na ₂ SO ₃	+ 7 H ₂ O
Grams	<u>100 g of this</u>	answer-> <u>49.997 g</u>	50.016 g
Molar Mass	÷ 252.142 g/mol	126.065 g/mol	_18.016 g/mol
Moles	= 0.3966 mol	= 0.3966 mol	x7 = 2.7762 mol

Steps! Add up from PT to get molar masses of everything.

100 grams / molar mass = 0.3966 mol Na₂SO₃·7H₂O

moles Na₂SO₃ = moles Na₂SO₃·7H₂O. multiply by molar mass

To get grams of Na₂SO₃. *Optional: moles na₂so₃ x 7 = moles h₂o*

Which times 18.02 gives grams h₂o