

AP Chemistry Summer Assignment

Welcome to AP Chemistry! You will quickly notice that things will be different than they were in Honors/Regular Chemistry. For one, there will be a lot more to memorize. For another, you need to manage many more types of calculations. This assignment will help us with some of the memorization, math skills, and basic topics that you will need so that we can hit the ground running when the school year begins. **Start the packet several weeks before school starts at the latest.** If you have questions, you can reach me at mjensen@stpaulsmd.org

As you progress through this assignment use the following sources for help:

- <http://chemwiki.ucdavis.edu/>
- <http://www.kentchemistry.com/>
- <https://www.khanacademy.org/science/chemistry>
- <http://www.chemtutor.com/>
- <http://www.chemteam.info/>
- <http://www.chemguide.com>
- <https://www.youtube.com/user/tdewitt451>

Important Dates

- Due Date: The packet pages 4-16 are due on the first day of school.
- **We will have a quiz on the first day of class.** The quiz will require you to write the chemical formulas of any compound consisting of ions from Tasks 3 and 4 below, and also calculate the molar masses.
- **The second class will also have a quiz.** The topic of this quiz is on metric conversions and mole conversions.
- These are the topics summarized and reviewed in this packet.
 - Nomenclature - Elements, polyatomic ions, and compounds
 - Quantitative Skills - scientific notation, significant figures*, metric conversions, dimensional analysis**
 - Chemical Reactions - balancing equations, writing equations
 - Stoichiometry - Mole conversions from mass, gas at STP, solutions; multi-step mole conversions, empirical formula, full stoichiometry problems (all 3 states), mass percent of compounds**
 - Helpful diagrams, documents, and guides. You will not need to hand this in.

(* = not covered in Regular Chemistry, ** = not covered in Honors or Regular Chemistry)

Task 1: Complete Attached Packet

Task 2: Memorize the names of the elements and their corresponding symbols

- You need to know elements 1-56, plus Pt, Au, Hg, Pb, Rn, Fr, Ra, U, Pu
- Many of these elements you will already know
- Making flashcards is helpful!
- It's important to know these elements because the periodic table you are provided has only the symbols and not the names of the elements.
- You do not need the data of these elements (atomic number, relative atomic mass, etc) but you should be familiar with oxidation states (charges) of these including transition metals.

Task 3: Memorize the ionic charges of the basic ions

- Think about the valence electrons!
- Think about the common elements/ions in that group
 - Group 1 ions = +1
 - Group 2 ions = +2
 - Group 15 (5A) ions (N and P) = -3
 - Group 16 (6A) ions (O and S) = -2
 - Group 17 (7A)/ halogens = -1
 - Zn = +2
 - Ag = +1
 - Cu = +1 or +2
 - Fe = +2 or +3
 - Pb = +2 or +4
 - Sn = +2 or +4

Task 4: Memorize the names, symbols, and charges of Polyatomic ions below:

- Oxyanions - polyatomics containing oxygen, names end in *-ate* or *-ite*
- *-ate* is used for the most common form
- *-ite* is used for the form with the same charge, but one less oxygen
 - Example:
 - NO_3^- = nitrate
 - NO_2^- = nitrite
- Prefixes are also used
 - *Per-* indicates one more oxygen than the *-ate* form
 - *Hypo-* indicates one fewer oxygen than the *-ite* form
 - Example:
 - ClO_4^- = perchlorate (b/c it has one more O than the *-ate* form)
 - ClO_3^- = chlorate (b/c it is the most common)
 - ClO_2^- = chlorite (b/c it has one less oxygen than *-ate* form)
 - ClO^- = hypochlorite (b/c it has one less oxygen than *-ite* form)
 - F, Cl, Br, I all behave the same
 - Therefore, if chlorate is ClO_3^- , the bromate ion is...
 - BrO_3^- !!!!
 - Simply substitute one halogen for the other
 - If you learn the chlorate series, you also automatically know the bromate, iodate, and fluorate series
- Hydrogen can be added to -2 or -3 ions to make a "new ion"
 - HPO_4^{2-} is hydrogen phosphate, $\text{H}_2\text{PO}_4^{1-}$ is dihydrogen phosphate (note the - charge went up 1 for each H^+ added)
 - HCO_3^{1-} is hydrogen carbonate (bicarbonate)
 - HSO_4^{1-} is hydrogen sulfate

| | | |
|---|--|--|
| <u>+1</u> ammonium, NH_4^+ | | |
| <u>-1</u> acetate, $\text{C}_2\text{H}_3\text{O}^-$ or CH_3COO^- bromate, BrO_3^- perchlorate, ClO_4^- chlorate, ClO_3^- chlorite, ClO_2^- hypochlorite, ClO^- cyanide, CN^- hydrogen carbonate/bicarbonate, HCO_3^- hydroxide, OH^- iodate, IO_3^- nitrate, NO_3^- nitrite, NO_2^- permanganate, MnO_4^- thiocyanate, SCN^- | <u>-2</u> carbonate, CO_3^{2-} chromate, CrO_4^{2-} dichromate, $\text{Cr}_2\text{O}_7^{2-}$ oxalate, $\text{C}_2\text{O}_4^{2-}$ peroxide, O_2^{2-} sulfate, SO_4^{2-} sulfite, SO_3^{2-} | <u>-3</u> phosphate, PO_4^{3-} phosphite, PO_3^{3-} arsenate, AsO_4^{3-} |

Be able to name polyatomic ions using the rules above such as these below:

HPO_4^{2-} _____

HSO_3^{-1} _____

FO_3^{-1} _____

HCO_3^{-1} _____

Be able to write formulae for polyatomic ions using the rules above such as these below:

Bromite _____

periodate _____

Dihydrogen phosphite _____

hydrogen chromate _____

Name: _____

Date: _____

AP Chemistry Summer Assignment

Quantitative Skills

Significant Figures (Sig Figs)* (Confused? Watch this:

<https://www.youtube.com/watch?v=7b60RZqut0U&t=22s> AND See pages 17-18)

1. How many sig figs are in the following numbers?

a. 790 _____

b. 0.0450 _____

c. 32.10 _____

d. 1001 _____

e. 0.0006 _____

f. 300. _____

2. Solve the following problems. Round your answer to the correct number of sig figs (and use the correct unit on your answer) (Check pages 17-18).

a) $825 \text{ cm} \times 32 \text{ cm} \times 0.248 \text{ cm}$ _____

b) $\frac{15.68 \text{ g}}{2.885 \text{ mL}}$ _____

c) $1.20 \text{ g} + 13.0 \text{ g} + 10. \text{ g}$ _____

d) $\frac{(1.01 \text{ g} + 1.01 \text{ g} + 16.00 \text{ g})}{1.0 \text{ mL}}$ _____

Density* (round your answers to correct number of sig figs and show all work with units)

3. A cube of ruthenium metal 1.5 cm on a side has a mass of 42.0 g. What is the density in g/cm^3 ? Will ruthenium metal float on water?

4. The density of bismuth metal is 9.8 g/cm^3 . What is the mass of a sample of bismuth that displaces 65.8 mL of water?

Metric Conversions (round answers correctly and show work with units). You are responsible for the following prefixes: nano- (10^{-9} , n-), micro- (10^{-6} , μ -), milli- (10^{-3} , m-), kilo- (10^3 , k-), Mega- (10^6 , M-). Use scientific notation for any answers ≥ 1000 or ≤ 0.01 . Use the correct number of significant figures.

5. Perform conversions to fill in all of the empty boxes. The first row is filled out.

| n- | μ - | m- | Base Unit | k- | M- |
|--------------------------|----------------------------|-----------------------|-----------|-----------|--------------------------|
| 1.62×10^{10} nm | 1.62×10^7 μ m | 1.62×10^4 ms | 16.2 m | 0.0162 km | 1.62×10^{-5} Mm |
| | | | | 12 ks | |
| 5.44 nL | | | | | |
| | | | 2.0 L | | |
| | | 0.3100 ms | | | |
| | | | | | 0.056 Mg |
| | 20.1 μ m | | | | |

Dimensional Analysis*

See packet pages 19-21.

6. Make the following conversions, with correct number of significant figures in the answer:

a) Convert 45.7 mL/s to kL/hr

b) Convert 1.000 yr to seconds

c) Convert 5 km to miles (1 km = 0.621 mi)

d) Convert 80.0 km/hr to mm/s

e) Convert 300. Atoms/s to moles/yr ($N_A = 6.022 \times 10^{23}$ atoms/mole)

- f) I have 470 milligrams of table salt, which is the chemical compound NaCl. How many liters of NaCl solution can I make if I want the solution to be 0.90% NaCl? (9 grams of salt per 1000 grams of solution).

The density of the NaCl solution is 1.0 g solution/mL solution.

- g) I have a bar of gold that is 7.0 in x 4.0 in x 3.0 in. The density of gold is 19.3 g/cm³. The price of gold currently is \$1,884.30 per ounce. How much is my gold bar worth?

- h) The roof of a building is 0.2 km². During a rainstorm, 5.5 cm of rain was measured to be sitting on the roof. What is the mass in kg of the water on the roof after the rainstorm? (Density of rainwater = 1g/mL).

- i) The bromine content of the ocean is about 65 g of bromine per million g of sea water. How many mL of ocean must be processed to recover 500. mg of bromine, if the density of sea water is 1.0x10³ kg/m³?

- j) Light travels 186,000 miles / second. How long is a light year in meters? (1 light year is the distance light travels in one year)

Moles, Reactions, and Stoichiometry

Percent Composition*

8. Calculate the percent composition of Na_2SO_4 .

9. Calculate the percent composition of $\text{C}_{12}\text{H}_{22}\text{O}_{11}$ (sugar). (Give Percent of each element.) Show all work.

10. Calculate the percent composition the elements of hydroxyapatite, $\text{Ca}_5(\text{PO}_4)_3\text{OH}$. Show all work.

Mole Conversions

11. Complete the following conversions: (SHOW WORK, use correct # of sig figs)
 - a) 42.8 g of KNO_3 to moles

 - b) 4.1 g NH_4OH to moles

 - c) 155.7 L of CO_2 at STP to moles

 - d) 89.1 L of Ne at STP to moles

 - e) 0.018 L of a 3.0 M ($M = \text{mol/L}$ or mol/dm^3) solution of HCl to moles HCl

 - f) 25 L of a 0.08 M solution of NaOH to moles NaOH

- g) 1.21×10^{25} molecules of CH_4 to moles CH_4
- h) 9.25×10^{26} formula units of CaCl_2 to moles CaCl_2
- i) 0.051 moles of Na_2SO_4 to mass of Na_2SO_4
- j) 1.52 moles of KNO_3 to mass KNO_3
- k) 1.08×10^{-3} moles of H_2CO_3 to mass H_2CO_3
- l) 6.41 moles of H_2 gas to volume at STP
- m) 0.08 moles of Ne gas to volume at STP
- n) 4.0 moles of NaCl in 2.0 L, to molarity
- o) 0.71 moles of KBr in 810 mL, to molarity

Multi-Step Mole Conversions

12. Complete the following conversions: (SHOW WORK, use correct # of sig figs)
- a) If a 300 mL solution is desired at a concentration of 1.2×10^{-3} M, how many grams of CaBr_2 is needed?

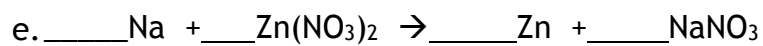
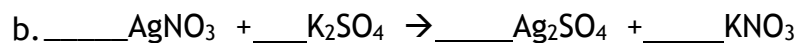
- b) You are preparing a solution of K_2CO_3 . The desired volume and concentration is 1.5 L and 60 L. What is the mass of K_2CO_3 needed?
- c) A balloon of He at STP takes up 300. L. How many He atoms are inside the balloon?
- d) A bell jar at STP has a volume of 44.8 L, and contains an elemental gas with a mass of 64.0 g. What is the molar mass and identity of the gas?
- e) 11.2 L of CO_2 at STP is pressurized into a soda bottle containing 2 L of soda. How many molecules of CO_2 are dissolved in the soda?
- f) A student is hoping to collect 40.0 g of NaCl crystals from a 4.0 M stock solution. How much of the solution should they evaporate to get the desired quantity of crystals?
- g) You notice that a tray of ice cubes left in the freezer has partially sublimated. It started out with 300.0 g of ice, and only 250.0 g of ice remains. What is the expected volume of sublimated H_2O vapor at STP from this tray of ice?

Empirical Formula (see pages 21-22)

13. A compound contains, by mass, 40.0% C, 6.7% H, 53.3% O. Determine the empirical formula of the compound.
14. A compound contains, by mass, 42.9% C, 2.4% H, 16.7% N, and 38.1% O. Determine the empirical formula of the compound.
15. The mass of a sample of hydrated copper (II) chloride is 0.996 g before being heated, and 0.790 g after all water is driven off by heat. Determine the empirical formula of the hydrate. (This type of calculation will be in our first lab).
- Determine the mass of water in the hydrate sample.
 - Determine the number of moles of CuCl_2 and H_2O .
 - Compare the number of moles to estimate the mole ratio and determine the empirical formula.

Chemical Reactions - Balancing

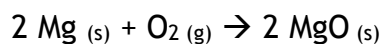
16. Balance the following and equations.



17. What are diatomic molecules? List the 7 diatomic elements.

18. Write a balanced chemical equation using correct chemical formulas and indicating states of matter (s, l, g, or aq) that describe the following observations. The first example is done for you:

- a) A strip of magnesium metal is burned in the presence of oxygen to make a white ionic solid.



- b) Aqueous solutions of lead (II) nitrate and sodium iodide are mixed, resulting in a yellow precipitate of lead (II) iodide.

- c) Potassium metal is added to water, resulting in the formation of a basic solution and a flammable gas.

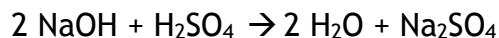
- d) Aluminum wire is added to an aqueous solution of copper (II) chloride, resulting in the formation of copper metal on the surface of the wire. The blue copper (II) chloride solution turns from blue to colorless.

- e) Magnesium carbonate is heated and decomposes, leaving behind a metal oxide and gas that causes lime water to turn cloudy.

- f) Butane (C_4H_{10}) from a lighter ignites in the presence of air.

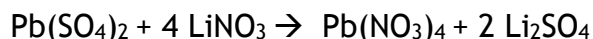
Stoichiometry

19. Using the following equation:



How many grams of sodium sulfate will be formed if you start with 200 grams of sodium hydroxide and you have an excess of sulfuric acid?

20. Using the following equation:



How many grams of lithium nitrate will be needed to make 250 grams of lithium sulfate, assuming that you have an adequate amount of lead (IV) sulfate to do the reaction?

21. Using the following equation: $\text{Fe}_2\text{O}_3 + 3 \text{H}_2 \rightarrow 2 \text{Fe} + 3 \text{H}_2\text{O}$

Calculate the volume of H_2 gas at STP needed to fully react with 16.5 grams of Fe_2O_3 . (hint: find the amount of moles of H_2 gas, then find the volume at STP this corresponds to)

22. Using the following equation: $\text{HCl} + \text{NaOH} \rightarrow \text{H}_2\text{O} + \text{NaCl}$

Determine the volume of 0.100 M NaOH needed to neutralize 100 mL 0.300 M HCl. (hint: find moles of HCl, then use stoich. to determine moles of NaOH)

Practice Naming Compounds

1. Provide names for the following ionic compounds:

- a. AlF_3 _____
- b. $\text{Fe}(\text{OH})_2$ _____
- c. $\text{Cu}(\text{NO}_3)_2$ _____
- d. $\text{Ba}(\text{ClO}_4)_2$ _____
- e. Li_3PO_4 _____
- f. Hg_2S _____
- g. $\text{Cr}_2(\text{CO}_3)_3$ _____
- h. $(\text{NH}_4)_2\text{SO}_4$ _____

2. Write the chemical formulas for the following compounds:

- a. Copper(I) oxide _____
- b. Potassium peroxide _____
- c. Iron(III) carbonate _____
- d. Zinc nitrate _____
- e. Sodium hypobromite _____
- f. Aluminum hydroxide _____

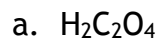
3. Give the name or chemical formula for each of the following molecular substances:

- a. SF_6 _____
- b. XeO_3 _____
- c. Dinitrogen tetroxide _____
- d. Hydrogen cyanide _____
- e. IF_5 _____
- f. Dihydrogen monoxide _____
- g. Tetraphosphorous hexasulfide _____

4. Give the name or chemical formula for the following compounds:

- a. Ammonium oxalate _____
- b. Manganese(III) dichromate _____
- c. $\text{Ti}(\text{OH})_4$ _____
- d. $\text{Ni}(\text{ClO}_2)_3$ _____
- e. Dinitrogen pentoxide _____
- f. Aluminum oxide _____
- g. Fe_2S_3 _____

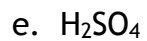
5. Name the following acids













6. Write formulas for the following acids.

a. hydrochloric acid

b. sulfuric acid

c. nitric acid

d. phosphoric acid

e. carbonic acid

f. acetic acid

1. Exact Numbers:

Counted numbers and definitions do not involve any measurement and are considered as exact numbers with an infinite number of significant figures. Do not consider them when determining significant figures for your final answer.

Definitions: 1 week = 7 days.

1 mile = 5,280 feet

1 yard = 3 feet

Counted: 5 Players on the basketball court.

23 students in a room

25 pennies used by a class in an experiment.

2. Measured Numbers:

All *measured numbers* have some degree of uncertainty.

When recording measurements, *record only the significant figures*. Record measurements to include one decimal estimate beyond the smallest increment on the measuring device.

Examples (consider a measuring instrument like a ruler):

- If smallest increment = 1m, then record measurement to 0.1m (i.e. 3.1 *m*)
- If smallest increment = 0.1m, then record measurement to 0.01m (i.e. 5.67 *m*)
- If smallest increment = 0.01m, then record measurement to 0.001m (i.e. 12.675 *m*)

c. Unless otherwise stated the uncertainty in the last significant figure (*the uncertain digit*) is assumed to be ± 1 unit. Modern digital instruments and many types of volumetric glassware will state the level of uncertainty.

3. Rules for counting Significant Figures.

- a. *Non-Zero Numbers:* Non-zero numbers are always significant.
- b. *Zeros:*

1. Leading zeros that come before the first non-zero number are *never* significant
2. Captive zeros (*sandwich zeros*) that fall between two non-zero digits are *always* significant.
3. Ending zeros that appear after the last non-zero digit are significant only when a decimal point appears somewhere in the number.

Examples:

| | | | | | |
|-----------------|--------------|-------------|----------------|-------------|---------------|
| Number | 0.005 | 5005 | 5005.00 | 500. | 0.0050 |
| Sig Figs | 1 | 4 | 6 | 3 | 2 |

c. **Scientific Notation:** Significant figures are recorded in the mantissa (number $1 \leq x < 10$)

Examples:

| | | | | |
|-----------------|-------------------|---------------------|---------------------------|-------------------|
| Number | 3.0×10^3 | 5.998×10^5 | 6.00000×10^{-23} | 0.5×10^4 |
| Sig Figs | 2 | 4 | 6 | 1 |

4. Rules for Using Significant Figures in Calculations

(a) Multiplication, Division, Powers and Roots: - “**LEAST SIG.FIG RULE**”

1. The result should be reported to the same number of significant figures as the measured number having the *least number of significant figures*.
2. Only consider the number of significant figures in each of the *measured numbers!* (not constants)

Example 1:
 $2.3 \times 5.78 =$ Calculator returns 13.294
 2.3 has 2 sig.fig
 5.78 has 3 sig.fig.
 $2.3 \times 5.78 = 13$ The answer must be rounded to show 2 sig.fig

Example 2.
 $\frac{1.67 \times 10^5 \times 0.00045}{2 \times 10^{-23}} =$ calculator returns $2.505000000 \times 10^{24}$
 1.67×10^5 has 3 sig.figs
 0.00045 has 2 sig.figs
 2×10^{-23} has 1 sig.fig
 $\frac{1.67 \times 10^5 \times 0.00045}{2 \times 10^{-23}} = 3 \times 10^{24}$ (rounded to 1 sig.fig)

Example 3
 $\sqrt{2.3} =$ calculator returns 1.516575089
 2.3 has 2 sig.figs
 $\sqrt{2.3} = 1.5$ round answer to 2 sig.figs

(b) Addition and Subtraction: “**LEAST PRECISE DECIMAL RULE**”

1. The result should be reported with the same decimal precision as the measured number having the uncertain digit in the *least precise decimal place*.
2. Only consider the decimal precision in each of the *measured numbers!* (not constants)

Example 5: Watch for numbers ending with zero!
 $10 + 0.0110 =$ calculator returns 10.0110
 10: the uncertain digit appears in the 10^1 place
 0.0110: the uncertain digit appears in the 10^{-4} place
 $10 + 0.0110 = 10$ round answer to the 10^1 place

Example 4: a - c
 a. $123\text{cm} + 5.35\text{cm} = 128\text{cm}$ (rounded to 10^0)
 b. $1.0001\text{m} + 0.0003\text{m} = 1.0004\text{m}$ (rounded to 10^{-4})
 c. $1.002\text{s} - 0.998\text{s} = 0.004\text{s}$ (rounded to 10^{-3})

Rationale: The uncertainty in the measured number 10 is ± 1 . The uncertainty alone in the first number (10) is greater than the entire second number (0.0110).

Unit Multiplication - Dimensional Analysis - Factor Labeling

Units:

In the world of mathematics numbers often exist as abstract and unit-less entities. However, in the world of physics and chemistry where numbers are based upon experimentation and measurement all numbers are based in a physical reality. *As a result, every number consists of two important parts.* The first is a **magnitude** and the second equally important part is a **unit**. It is the unit that gives physical, real-world meaning to the number. We never write one without the other!

Examples: Note that these are all “equivalence statements”!

12 *inches* in one *foot*
365 *days* in one *year*
7 days in one *week*
 1.0×10^9 *bytes* in one *gigabyte*

Derived Units and Calculations

Many of the common units we use are actually derived units that result from performing mathematical operations on the basic units. *When performing mathematical operations the units are treated and manipulated as if they were algebraic variables.* Here are a few examples:

$$\underline{\text{Area}} = (\text{length} - \text{m}) \times (\text{width} - \text{m}) = \text{m}^2$$

$$\underline{\text{Volume}} = (\text{length} - \text{m}) \times (\text{width} - \text{m}) \times (\text{height} - \text{m}) = \text{m}^3$$

$$\underline{\text{Velocity}} = (\text{distance traveled} - \text{m}) / (\text{time} - \text{s}) = \text{m/s}$$

$$\underline{\text{Density}} = (\text{mass} - \text{g}) / (\text{volume} - \text{mL}) = \text{g/mL}$$

Unit Conversions

It is often necessary to convert from one system of units to another. The most efficient way to do this using a process known as “*unit multiplication*”, “*factor labeling*” or “*dimensional analysis*”.

“goal posting”

One useful version of this method is called “goal posting”. **Step 1:** Draw a “goal post” with the horizontal bar extending on each side. **Step 2:** Place the original number and unit to the left. Place the final unit on the right. **Step 3:** Move the original unit (cm) from the top left (*numerator*) to the bottom of the conversion factor (*denominator*). Now there is no confusion about which form of the conversion factor you will use. If you have done this correctly the original units on the top (*cm*) will be cancelled by the same unit in the denominator of the conversion factor.

Example: Consider a car traveling at *35 m/s* in the metric system. What would be the corresponding length in the English system (*miles / hour*)?

Solution: Note that velocity is a derived unit and has two units that must be converted: Length (Meters → miles) and Time (seconds → Hours).

Step 1: The derived unit has consists of two different units - one in the numerator and one in the denominator. Place the numerator unit *together with the number* on the “top” of the goalpost. Place the denominator units on the “bottom” of the goal post.

Step 2: The top unit will be moved down and to the right, the bottom unit will be moved up and to the right.

| | | | | | |
|----------|------------------|-----------------|----------|-----------|-----------------|
| 35 m | 1.094 yds | 1 mile | 60 s | 60 minute | 78 miles |
| s | 1 m | 1760 yds | 1 minute | 1 hour | hour |

Note that the only unit not cancelled in the numerator is miles. The only unit not cancelled in the denominator is hours. This gives us the final unit of miles/hour which the correct unit for the result.

If you need additional support in the form of video tutorials, check out the following:

<https://www.youtube.com/watch?v=7N0lRjLwpPI>

<https://www.youtube.com/watch?v=LdZ000FAfaQ>

<https://www.youtube.com/watch?v=BKsPi-VXp5U>

Steps to Find Empirical & Molecular Formulas

Remember this:

“Percent to mass, Mass to mole,

Divide by small, Make it whole”

1. Determine the mass in grams of each element present in the sample. **“Percent to mass”**

If the information in the problem is in terms of percent composition of each element □

a) assume you have 100 g of the sample to start with

b) The grams of each element (out of the 100 g sample) will just be the numerical value of its percent composition.

EXAMPLE: You have a sample that is 40.0% carbon, 6.73% hydrogen and the rest oxygen. Find the empirical and molecular formulas.

Step 1: $40.0\% + 6.73\% = 46.73\%$. The percentage of oxygen is $100\% - 46.73\% =$

53.27% If I have 100 g of sample to start with, I have:

40.0 grams Carbon, 6.73 grams Hydrogen and 53.27 grams Oxygen

2. Calculate the number of *moles* of each element. **“Mass to mole”**

Step 2: Moles of Carbon = $40.0\text{g C} \times 1\text{ mol C} / 12.01\text{g C} = 3.331\text{ mol C}$

Moles Hydrogen = $6.73\text{g H} \times 1\text{ mol H} / 1.01\text{g} = 6.663\text{ mol H}$

Mole Oxygen = $53.27\text{ g O} \times 1\text{ mol O} / 16.0\text{ g} = 3.33\text{ mol O}$

DO NOT ROUND THESE NUMBERS. KEEP SEVERAL DECIMAL PLACES!

3. Divide each by the smallest number of moles to obtain the *simplest whole number ratio*.

“Divide by small”

Step 3: The molar ratio of the elements in my compound is $C_{3.331}H_{6.663}O_{3.33}$. I want a whole number ratio, so I will divide all the subscripts by the smallest number of moles (3.331) to get:

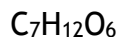


If your number after dividing are values like 2.07, 1.1 etc. then round to the nearest whole number. If they are values like 3.5, 2.333 etc., then go to step 4.

4. If whole numbers are not obtained* in step 3), multiply through by the smallest integer that will give all whole numbers

“Make it whole”

Let's say that my empirical formula turned out to be $C_{2.333}H_4O_2$. 2.333 is not close enough to 2 to round down to 2. But I can multiply my formula through by 3 to get this:



Finding molecular formula: If the molar mass of your empirical formula matches the molar mass of the final compound (as stated in the problem) □ Hooray! You are done: your empirical formula IS your molecular formula.

5. For my example in step 1, it says that the molecular weight (molar mass) of my compound is 180.18 g/mol

My empirical formula is CH_2O from step 3 has a molar mass of $(12.01 + 2 \times 1.01 + 16) \text{ g/mol} = 30.03 \text{ g/mol}$. ***So my empirical formula is not my molecular formula.***

Now, divide molar mass of compound / molar mass of empirical formula:

$$180.18 \text{ g/mol} \div 30.03 \text{ g/mol} = 6$$

The molar mass of my compound is 6 times the molar mass of my empirical formula. Multiply the empirical formula subscripts by 6 to get the final molecular formula:



