How to Use The Chemistry Preparation Resources

The following process is suggested to better ensure your success in general chemistry at CU Boulder.

Step 1: Read "How to be a Successful Chemistry Student"

- This document shares thoughts on learning chemistry and on becoming a successful college student in general.
- Don't miss the flyer on "What Previous Students Have to Say…" Past students have shared their thoughts, insights and all-the-things-they-wish-someone-had-told-them. You can learn from their experience!

Step 2: Complete the Math Proficiency Assessment #1

- Math skills are essential to chemistry! Fortunately we only use algebra so test yourself to see how solid your skills are.
- If you score well on this test, take the second Math Proficiency Assessment.
- If you didn't score well according to the guidelines on the first assessment, follow the "Suggested Actions" at the end of the assessment.

Step 3: Math Tutorial

- Use this tutorial for additional practice, to review weak areas, or to learn concepts/skills you missed over the years.
- You may need to seek out other resources such as online tutorials, friends, a tutor, a text…
- After completing this tutorial, take the first assessment again and see how you've improved!

Step 4: Complete the Math Proficiency Assessment #2

- If you did well on the first assessment, try to do as well if not better on this one! With this assessment you may find a weak skill that didn't show itself on the first assessment.
- If you didn't do well on the first assessment, do your study, review, retake the first assessment, etc. and attempt this assessment as a "final exam" to see if you're ready for the math in chemistry.

Step 5: Complete the Chemistry Review

- The pre-requisite for general chemistry is a full year of high school chem, in addition to math (algebra but ideally pre-calc). It may have been a while since you had HS chemistry so complete this review. It's not expected that you remember everything on this review of selected topics but it should all seem familiar. We'll cover these topics, and more, in gen chem I and it's very helpful if you're familiar with these fundamental concepts.
- If you need to review chemistry turn to one of the many online resources, printed materials, a tutor, or friends.

Math Tutorial

The math skills addressed and illustrated in this tutorial are necessary in any general chemistry course. You should have had all of these concepts and skills in high school but it might be time for a refresher. By the time your general chemistry class begins you need to be comfortable, competent and proficient in each of these math skills areas:

- Scientific notation
- Unit prefixes
- Significant figures
- Writing conversion factors and relationships
- Writing and manipulating equations
- Solving problems using dimensional analysis

This tutorial consists of narrative explanations of these topics, a statement of the skills you must have (offset and in bold) and some practice sets. Look first at the skill statement and the practice set. If you can do the math in that area, move on. If not, read the narrative and try again. If you need more than the narrative provides, find some online resources, printed materials, a tutor, or family/friends to master these skills.

Representing Numbers in Science

Numbers are used a great deal in any of the sciences. Numbers represent the quantitative portion of a measurement and are the result of calculations. While qualitative observations and assessments are also important in the sciences, numbers put the “umph” behind what we do. Watts Humphrey, an influential thinker in software testing, once said that “without facts and figures, you’re just someone else with an opinion”. Numbers put credibility behind what we think is going on.

Expressing very large and very small numbers

Quantities in science are often very large or very small. For example, the recommended daily allowance of vitamin B_{12} for adults is 0.000006 grams while the number of vitamin B_{12} molecules in 1,000 grams (g) (approximate mass) is

602 300 000 000 000 000 000 000

Writing numbers with all of these zeros is tedious, time-consuming and prone to error. Fortunately there are two “shortcuts” we can use: scientific notation and unit prefixes.

1. Scientific Notation

This notation allows numbers to be expressed in an exponential manner and thus avoid writing a lot of the digits in the original number. In scientific notation, a number is written as $A \times 10^x$, where A is a decimal number and x is a whole number. So the number of vitamin B_{12} molecules can be more conveniently written as 6.023×10^{23}. Likewise the recommended daily allowance of vitamin B_{12} can be expressed as 6×10^{-6} g.

Skill 1: Be able to express both large and small numbers in scientific notation and do math operations with numbers expressed with exponents.

You may at times see a shortcut on the shortcut for writing scientific notation. Again, it can become tedious writing the "$\times 10^a$" all the time. So sometimes you'll see numbers expressed as 6.023E23. Here the "E" replaces the "x 10" and the exponent is entered on the same line of text instead of a superscript. Thus the vitamin B_{12} amount could be written as 6E-6 g.

Skill 2: Be able to recognize and use either format for scientific notation.

Practice Set 1

Scientific Notation

(Answers are at the end of this tutorial)

1. Express the following in scientific notation, using both the "$\times 10^a$" and "E" formats:

    a. 5 556 000 000 000 dollars, U.S. national debt as of October 1998

    b. 56 000 000 km, closest approach of Mars to Earth

    c. 0.000 000 000 000 000 000 000 020 g, mass of one carbon atom

    d. 0.000 000 1 m, diameter of the smallest living cells

2. Unit Prefixes

This is a really handy shortcut: use a prefix on the unit to express the exponent. Remember that the recommended daily allowance of vitamin B_{12} for adults is 0.000006 grams or 6×10^{-6} g. This can be written as 6 μg. Here the "μ" stands for "micro" and means 10^{-6}. You could have "micro" of anything: liters, grams, meters, seconds, etc.

While using the unit prefixes makes reading and writing easier when dealing with data, you must convert to the numerical equivalent in order to do math operations with that data. Therefore it's essential to know the exponent that goes with each unit prefix.

Skill 3: Know and be able to use the following prefixes:

Prefix	**Symbol**	**Size**	**Name**
pico	p	10^{-12}	Trillionth
nano	n	10^{-9}	Billionth
micro	μ	10^{-6}	Millionth
milli	m	10^{-3}	Thousandth
centi	c	10^{-2}	Hundreth
deci	d	10^{-1}	Tenth
kilo	k	10^{3}	Thousand
mega	M	10^{6}	Million
giga	G	10^{9}	Billion
tera	T	10^{12}	Trillion

Practice Set 2

Unit Prefixes

(Answers are at the end of this tutorial)

1. Answer the following questions regarding a picometer.

a. What is the unit “pico” equivalent to?

b. A picometer is equivalent to ____________ meters.

c. What portion of a meter is a picometer?

d. How many picometers are in a meter?

e. A meter is equivalent to ____________ picometers.

2. Answer the following questions regarding a nanometer.

a. What is the unit “nano” equivalent to?

b. A nanometer is equivalent to ____________ meters.

c. What portion of a meter is a nanometer?

d. How many nanometers are in a meter?

e. A meter is equivalent to ____________ nanometers.

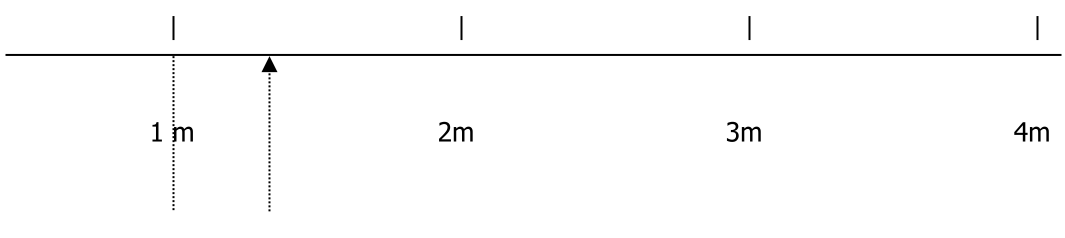
3. Which is the larger unit: a picometer or a nanometer and by how much?

Expressing Measurements Accurately

Whenever measurements are made, there is always a limit to the accuracy with which that measurement is made. Unlike exact numbers, which are found by counting, measurements are made using a measuring device, such as a ruler or measuring cup or a sophisticated instrument like a gas chromatograph. Measurements are limited by the precision of the instrument: we can only measure to the nearest mark on the measuring device and then estimate beyond that mark Therefore, we're certain about all the digits made against the marks on the measuring device and uncertain about the last digit. While all of the figures in a measurement are significant, the last digit, because of the "guesstimation" between marks, is the least significant digit in the measurement.

An illustration will help. If you measure a length of string using a meter stick marked only in 1-meter increments, the length of the string can be measured with certainty to the whole meter; the length of string extending beyond the meter mark must be estimated.

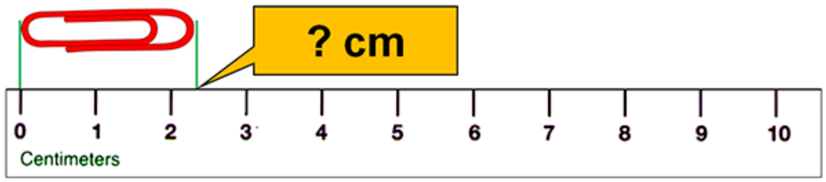
The meter stick (marked in 1-meter increments)



The string to be measured

You can see that the string is 1 meter and a little more but how much more? Half of a meter? Less than half? A little more? Here's where the "quesstimation" comes in: it "looks" like about 0.4 of a meter, give or take 0.1m. So the measurement is reported as 1.4 ± 0.1m. This measurement has one certain digit (the "1") and one uncertain digit (the "4"). But both digits are significant in that they tell you where the certainty, and the uncertainty, lie in the measurement. Therefore this measurement has 2 significant figures. In a correctly reported measurement the last digit is always the uncertain one and thus you can determine the incremental markings on the marking device: if the last digit is where the estimation was made then the digit just prior to it must have been made with certainty.

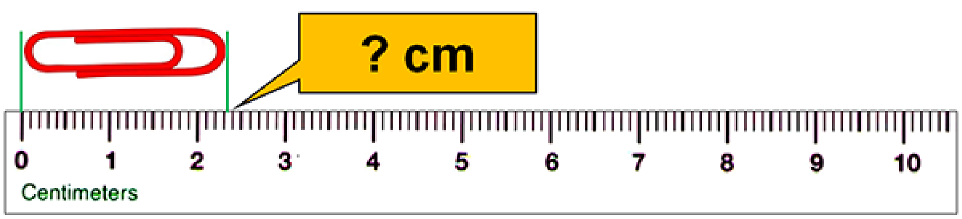
Now, what if the ruler was marked in centimeters, cm, as shown below:



Source: http://getchemistryhelp.com/chemistry-lesson-significant-digits-measurements/

The length of the paperclip is certainty 2 cm long but how much longer? Maybe 0.3 cm? It would be reasonable to report the length of the paperclip at 2.3 ± 0.1cm. (Challenging thought: In terms of meters, the length of the paperclip is certain to the hundredth meters and uncertain in the thousands meters. True or false?)

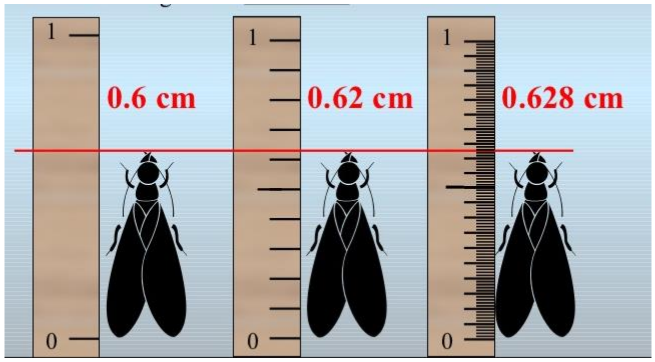
So…the more incremental markings on the measuring device the less uncertain you are about the measurement. The more markings, the smaller the allowed range for the estimate. This is illustrated nicely below:



Source: http://getchemistryhelp.com/chemistry-lesson-significant-digits-measurements/

Now the length of the paperclip is known with certainty as 2.3 cm with an additional length estimated as 0.05 cm. With marking in tenths of centimeters, the length can be estimated in the hundredths place. With a correctly reported length of 2.35 cm, the measurement now has three significant figures: 2 certain and 1 uncertain. But all are significant.

Notice as the incremental markings increase the accuracy and precision of the measurement increases:



Source: https://www.slideshare.net/kendonsmith/chapter-3-notes-chemistry

(If you don't remember the distinction between the terms "precision" and "accuracy", look them up! You can also review the Chemistry Review document on this web site.)

A correctly reported measurement allows you to automatically know the incremental markings on the measuring device. See if you can see how this is true from the above examples.

Skill 4: There are lots of rules for determining the number of significant figures and for handling them in math operations. Refer to a text, past class notes or other resources for these specifics. Bottom line: Remember what significant figures indicate and don't let your calculations run wild with significant figures.

Remember too that the data you report can't be more accurate than it's measurement allows. Always stop and think about the level of accuracy and credibility you're reporting in a measurement or a calculated result. For example if you measure 2 separate pieces of string and then want to know the total length, the calculated length can't be more accurate than the individual string lengths. So if one string was measured at 1.4 m and the other at 1.435 the total length is NOT 2.835, it's only 2.8. The least accurately known measurement was to the tenths; therefore the sum can't be accurate to beyond the tenths place, which is the last common significant digit in both measurements. This guideline holds for addition and subtraction; the rules are slightly different for multiplication and division. Review these!

Practice Set 3

Significant Figures

(Answers are at the end of this tutorial)

1. Using the significant figures (SFs) rules from your source, determine the number of significant figures in each of the following:

a. 2.00 g of silver

b. 0.0023^{o} C

c. 0.002300^{o} C

d. 25 mL

2. In each one of the above measurements, underline the uncertain (estimated) digit.

3. What were the incremental units on each measuring device used, assuming each of these values were correctly reported?

4. Rewrite each of these values in scientific notation using the correct number of significant figures. Does using scientific notation make it easier to "see" the significant figures?

5. Consider the following calculation using several measurements made in the lab:

$$\frac{(0.08206 \text{ g}) \times (273.15 \text{ g} + 1.2 \text{ g})}{1.23 \text{ g} \times 7.004 \text{ g}}$$

a. Which measurement is the most accurate?

b. The least?

c. How many significant figures should there be in the final answer?

Relating Numbers in Science: Writing Equalities and Conversion Factors

There are often many ways to express a measurement made in the sciences. The length of string used to illustrate significant figures could be measured in m, cm, mm, etc. We usually chose a unit (m, or cm, or mm) to best match the size of the thing being measured so that the measurement is reasonable to express. If the string is about a meter, we'd measure in meters. If it's smaller and on the order of centimeters, we'd express the measurement as cm. If the string is 1.2 m, we could also measure in cm or mm but then the measurement would be a little more cumbersome to express. Now the measurement would be 120 cm and 1200 mm respectively. So we pick the measuring device such that the measurement can be written as a number between 1 and 9, preceding the appropriate unit or power of 10 in scientific notation.

But what if you need to know a measurement in another unit? For example, what if you want to put the 2 pieces of string together to find the total length but one string is measured in meters and the other in centimeters. Or what if you want to compare the diameter of the nucleus to that of that atom but each measurement is in different units? Do you have to remeasure one of the items in the same unit as the other one? No, fortunately you can interconvert measurements using conversion factors.

Conversion factors allow you to find the equivalent measurement in another unit. You use conversion factors all the time without realizing it. For example, there are 12 eggs in a dozen. We can quickly compute in our heads that if we have 6 eggs, we also have half a dozen. Six eggs and half-a-dozen are equivalent expressions of the same measurement. And so it is with all measurements in science: we can convert from one measurement system (U.S. or metric) and from unit to another. You can convert a measurement in inches to meters, meters to centimeters, temperature in Celsius to Fahrenheit, pounds to kilograms and so on. There are known relationships between these units – the trick is to find and use the correct conversion factor.

For the egg example, the conversion or relationship factors would be:

- 12 eggs/1 dozen
- 1 dozen/12 eggs
- 1 egg/0.083 of a dozen   (0.083 = 1/12)
- 0.083 of a dozen/1 egg

So there are actually 4 different ways to express the relationship between one unit (a dozen) and the other unit (an egg).

Skill 5: Fundamental to the success in the sciences is to be able to "see" and use these conversion factors. Be able to write conversion factors between different units using any data provided. You do not need to memorize conversion factors between US and metric.

Practice Set 4

Writing Conversion Factors

(Answers are at the end of this tutorial)

1. There are 2.205 lb. in 1.00 kg. Write 2 conversion or relationship factors for these two units.

2. When a gram of protein (or carbohydrate) is burned in the body as food, 4 kcal of energy are released. Another way to state this is that one gram of protein is equal to 4 kcal of energy. What are the 2 conversion factors between mass (grams) and energy (kcal)?

3. For fats, the relationship is 1 gram of fat to 9 kcal of energy. What are the conversion factors between grams of fat and energy?

4. Write 4 conversion factors that relate nanometers and meters.

5. Write the 4 relationship factors between μg and grams.

6. What are 2 possible conversion factors relating millimeters and centimeters?

Determining Relationships between Variables: Writing Equations

Sometimes there are several measurements that together form a relationship. For example, mass and volume are related to the density of a substance. So it's important in the sciences to be able to discern the equation form of the relationship (e.g. $y \alpha x$ or $y = (\text{constant})*x$) from information presented.

> **Skill 6: Be sure you can distill information given in a narrative to a mathematical expression suitable for calculations with actual data and measurements.**

Practice Set 5

Writing Equations

(Answers are at the end of this tutorial)

1. The density of a substance is equal to its mass per volume. Write an equality expression based on this sentence describing density using "d" for density, "m" for mass and "v" for volume.

2. The volume (V) of a gas is directly proportional to its temperature (Kelvin) and inversely proportional to its pressure (P). Write an expression relating these 3 parameters.

3. The mass (m) of a substance divided by its atomic mass (atomic mass) yields the number of moles (n) of a substance. Write an expression showing the relationship between these 3 parameters.

4. The velocity of light (in a vacuum, c) is equal to the product of its wavelength, λ and its frequency, ν. Write the equation relating these 3 variables.

Algebraic Manipulations: Rearranging Equations and Relationships

Once you have an equation, we can use it find other things. From the relationship for density, you can use mass and volume to solve for the density of a substance. Or if you know the density of a substance and its mass, you could find its volume. If there are 3 parameters in a relationship, you need 2 of them to find the third. Likewise, if you have 4 parameters, you need only 3 of them to find the 4th. So in general, if there are *n* variables, *n*-1 variables are needed to solve the relationship.

Quite often, this means rearranging the relationship you have so that the parameter you're looking for can be found. Other times you may know 2 different ways to express something and you need to tie those 2 separate relationships into one. Algebra is the tool required to rearrange and manipulate equations.

> **Skill 7: Be sure your algebra skills are solid so that you can quickly and easily rearrange an expression to isolate, or solve for, any one of the parameters/variables in the equation.**

Practice Set 6

Algebraic Manipulations

(Answers are at the end of this tutorial)

1. Given that d = m/V, where d = density, m=mass and V= volume, rewrite this expression for density in terms of first volume and then in terms of mass.

2. The following equation relates the parameters (variables) characteristic of gases:

$$PV = nRT$$

Solve for P, V, T, and n (moles).

P =

V =

T =

n =

3. Given that n is equal to mass /(atomic mass), substitute for n in PV = nRT and rewrite the expression.

4. Given that density (d) is equal to mass/volume, rewrite PV = nRT in terms of density.

5. A fundamental relation in science is: $E = h\nu$, where E = energy, h = a constant and ν = the velocity of a photon. In Practice Set 5 you saw that for a wave, $c = \lambda\nu$. Write an equation tying these two separate relationships together through their common term, ν.

Solving Problems

A major component in any science course is solving problems. Far too often, problem solving appears to be difficult because you focus on finding the right answer without thinking about what you're doing, what you need, where you're headed, and so on. There's a tendency to throw some numbers into the calculator and hope for the best. But problem solving should not be just number crunching – stop and think about what you have and what you want to do with it first. That will save you trouble in the long run.

At some point it will be time to actually solve the problem. Prior to this step, you will have perhaps identified conversion factors or equations or rearranged relationships. When it does come down to solving the problem, dimensional analysis or factor labeling method is the recommended method for calculating. It's a very structured approach to staying on top of the numbers and units to be dealt with in a problem.

In essence, dimensional analysis says:

1. Draw a line on the LEFT for the "thing" you're looking for – include its units
2. Insert an equal sign
3. Write on the RIGHT the thing that you have
4. Place on the RIGHT any and all conversion factors needed to make the units of the thing on the RIGHT equal to the units of the thing on the LEFT.
5. Do the math operations in the equation to arrive at the final answer. Make sure the appropriate units are left; watch for significant figures.

Sounds wordy but it's really straight forward and will keep you out of trouble. One key point to keep in mind: ALWAYS INCLUDE UNITS AND MAKE SURE THAT THE UNITS THAT NEED TO CANCEL OUT DO INDEED CANCEL OUT!!!!

Here's an example. Let's take an easy one such as "How much do you weigh in kg if you weigh 120 lbs.?" Follow the steps above…

1. Weight in kg
2. Weight in kg =
3. Weight in kg = 120 lbs.
4. Weight in kg = 120 lbs. (1.00 kg/2.205 lbs.)
5. 54 kg

Using this method will keep you out of trouble. By following the units, you'll know which conversion factor to use instead of wondering "Do I need 1.00 kg/2.205 lbs. or 2.205 lbs./1.00 kg?" This method will answer the age-old question of "Do I multiply or divide by 2.205?" And it will help you sort out which conversion factors you'll need; quite often you'll need more than one. You can string them together, watching the units drop away until you're left with the correct one. Following this method will help you successfully solve problems whether in science or every day life. Dimensional analysis is an excellent way to think about any problem.

> **Skill 8: Be able to use the dimensional analysis approach or factor labeling method to correctly solve problems.**

Practice Set 7

Dimensional Analysis

(Answers are at the end of this tutorial)

1. How many pm are in 0.42 m?

2. How many μm are in 88 nm?

3. What portion of a kiloliter (kL) is 25.0 mL?

4. Based on the given relationships, determine the number of Calories per food type in a typical yogurt containing 8 grams of protein, 1 gram of fat and 38 grams of carbohydrates.

1 g protein/4 Cal

1 g fat/9 Cal

1 g carbohydrate/4 Cal

5. Determine the total number of iron atoms in $1 mm^3$ of human blood using the following data:

- Each mm^3 of blood has 5.5×10^6 red blood cells
- There are 2×10^8 hemoglobin units in each red blood cell
- The ratio of iron atoms to hemoglobin units in 4:1

6. The radius of an atom is approximately 2.01×10^{-4} μm and that of the nucleus is 1.0×10^{-12} cm. How many times larger is the atom than its nucleus?

7. The density of balsa wood is 0.16 g/cm^3. What is the mass of a cube of balsa wood having a volume of 1.45 mL?

8. When a piece of metal (mass = 5.21 g) is dropped into a container containing 16.7 mL of water, the water level rises to 18.2 mL. What is the density of the metal?

9. Planck's constant, h, is 6.634×10^{-34} J-s, where J = joules (a unit of energy) and s = seconds. A Joule is equal to 1 kg-m^2/s^2. Express Planck's constant in terms of mass and length.

Math Tutorial Answers

Practice Set 1

1. Express the following in scientific notation, using both the "x 10^a" and "E" formats:

   a. 5 556 000 000 000 dollars: 5.556×10^{12} dollars or 5.556 E12 dollars ($5.556 trillion)

   b. 56 000 000 km: 5.6×10^{7} km or 5.6 E7 km

   c. 0.000 000 000 000 000 000 000 020 g: 2.0×10^{-23} g or 2.0 E-23 g

   d. 0.000 000 1 m: 1×10^{-7} m or 1 E-7 m

Practice Set 2

1. Answer the following questions regarding a picometer.

   a. What is the unit "pico" equivalent to? 10^{-12} of the base unit. One trillionth of the base unit.

   b. A picometer is equivalent to _____10^{-12} ______ meters.

   c. What portion of a meter is a picometer? 10^{-12}

   d. How many picometers are in a meter? 1 trillion or 10^{12}

e. A meter is equivalent to ______10^{12} _______ picometers.

2. Answer the following questions regarding a nanometer.

a. What is the unit "nano" equivalent to? 10^{-9} of the base unit. One millionth of the base unit.

b. A nanometer is equivalent to ______10^{-9} _______ meters.

c. What portion of a meter is a nanometer? 10^{-9}

d. How many nanometers are in a meter? 1 million or 10^{9}

e. A meter is equivalent to ______10^{9} _______ nanometers.

3. Which is the larger unit: a picometer or a nanometer and by how much?

A picometer is a thousand times smaller than a nanometer. A picometer is 1/1000th of a meter.

A nanometer is a thousand times larger than a picometer. A nanometer is equivalent to 1000 picometers.

Practice Set 3

1. Using the significant figures (SFs) rules from your source, determine the number of significant figures in each of the following:

a. 2.0<u>0</u> g of silver: 3 SFs b. 0.002<u>3</u>° C: 2 SFs c. 0.00230<u>0</u>° C: 4 SFs d. 2<u>5</u> mL: 2 SFs

2. In each one of the above measurements, underline the uncertain (estimated) digit.

3. What were the incremental units on each measuring device used, assuming each of these values were correctly reported?

a. Tenths b. Thousandths c. 1/100,000 d. Tens

4. Rewrite each of these values in scientific notation using the correct number of significant figures. Does using scientific notation make it easier to "see" the significant figures?

a. 2.00×10^{0} b. 2.3×10^{-3} c. 2.300×10^{-3} d. 2.5×10^{1}

5. Consider the following calculation using several measurements made in the lab:

$$\frac{(0.08206\ g) \times (273.15\ g + 1.2\ g)}{1.23\ g \times 7.004\ g}$$

a. Which measurement is the most accurate? 0.08206 c. The least? 1.2

c. How many significant figures should there be in the final answer? 2

Practice Set 4

1. There are 2.205 lb. in 1.00 kg. Write 2 conversion or relationship factors for these two units.

1.00 kg/2.205 lb. and 2.205 lb./1.00 kg

2. When a gram of protein (or carbohydrate) is burned in the body as food, 4 kcal of energy are released. Another way to state this is that one gram of protein is equal to 4 kcal of energy. What are the 2 conversion factors between mass (grams) and energy (kcal)?

1 g/4 kcal and 4 kcal /1 g

3. For fats, the relationship is 1 gram of fat to 9 kcal of energy. What are the conversion factors between grams of fat and energy?

1 g/9 kcal and 9 kcal /1 g

4. Write 4 conversion factors that relate nanometers and meters.

10^9 nm/1 m   1 m /10^9 nm   1 nm /10^{-9} m 10^{-9} m /1 nm

5. Write the 4 relationship factors between μg and grams.

10^6 μg/1 g   1 g /10^6 μg   1 μg /10^{-6} □ 10^{-6} □/1 μg

6. What are 2 possible conversion factors relating millimeters and centimeters?

10 mm/1 cm   1 cm /10 mm   0.1 cm /1mm   1 mm /0.1 cm

Practice Set 5

1. The density of a substance is equal to its mass per volume. Write an equality expression based on this sentence describing density using "d" for density, "m" for mass and "v" for volume.

$$d = m/V$$

2. The volume (V) of a gas is directly proportional to its temperature (T, Kelvin) and inversely proportional to its pressure (P). Write an expression relating these 3 parameters.

$$V \quad \alpha \quad T\ (K)/P$$

3. The mass (m) of a substance divided by its atomic mass (atomic mass) yields the number of moles (n) of a substance. Write an expression showing the relationship between these 3 parameters.

Moles, $n = m/\text{atomic mass}$

4. The velocity of light (in a vacuum, c) is equal to the product of its wavelength, λ and its frequency, ν. Write the equation relating these 3 variables.

$$c = \lambda\nu$$

Practice Set 6

1. Given that d = m/V, where d = density, m=mass and V= volume, rewrite this expression for density in terms of first volume and then in terms of mass.

$$V = m/d \qquad m = d * V$$

2. The following equation relates the parameters (variables) characteristic of gases: $PV = nRT$

   Solve for P, V, T, and n (moles).

   $P = nRT/V$ $\quad$ $V = nRT/P$ $\quad$ $T = PV/nR$ $\quad$ $n = PV/RT$

3. Given that n is equal to mass /(atomic mass), substitute for n in PV = nRT and rewrite the expression.

$$PV = nRT = (g/\text{atomic mass})*RT$$

4. Given that density (d) is equal to mass/volume, rewrite PV = nRT in terms of density.

PV = nRT

PV = (g/atomic mass)*RT

P*(atomic mass) = (g/V)*RT

d = P*(atomic mass)/RT

5. A fundamental relation in science is: $E = h\nu$, where E = energy, h = a constant and ν = the velocity of a photon. In Practice Set 5 you saw that for a wave, $c = \lambda\nu$. Write an equation tying these two separate relationships together through their common term, ν.

$E = hc/\lambda$

Practice Set 7

1. How many pm are in 0.42 m? 4.2×10^{11} pm/m

2. How many μm are in 88 nm? 8.8×10^{-2} μm in 88 nm

3. What portion of a kiloliter (kL) is 25.0 mL? 2.5×10^{-2} L

4. Based on the given relationships, determine the number of Calories per food type in a typical yogurt containing 8 grams of protein, 1 gram of fat and 38 grams of carbohydrates.

1 g protein/4 Cal   1 g fat/9 Cal   1 g carbohydrate/4 Cal

Protein: 32 Cal   Fat: 9 Cal   Carbohydrate: 152 Cal

5. Determine the total number of iron atoms in 1mm^3 of human blood using the following data:

- Each mm^3 of blood has 5.5×10^6 red blood cells
- There are 2×10^8 hemoglobin units in each red blood cell
- The ratio of iron atoms to hemoglobin units in 4:1

4.4×10^{15} iron atoms

6. The radius of an atom is approximately 2.01×10^{-4} μm and that of the nucleus is 1.0×10^{-12} cm. How many times larger is the atom than its nucleus? ~20,000 times

7. The density of balsa wood is 0.16 g/cm^3. What is the mass of a cube of balsa wood having a volume of 1.45 mL? 0.23 g

8. When a piece of metal (mass = 5.21 g) is dropped into a container containing 16.7 mL of water, the water level rises to 18.2 mL. What is the density of the metal? 3.5 g/mL

9. Planck's constant, h, is 6.634×10^{-34} J•s, where J = joules (a unit of energy) and s = seconds. A Joule is equal to 1 kg-m^2/s^2. Express Planck's constant in terms of mass and length. 6.634×10^{-34} kg•m^2/s

Math Proficiency Assessment #1

The following assessment will allow you to determine your math preparedness for college-level chemistry. Work each of the following calculations, algebraic manipulations or word problems and check your answers with those given at the end of the document. It's best if you work alone and without the aid of any resources, other than a calculator in order to obtain a realistic assessment of your skills.

When you've completed the assessment, score your answers according to the key on the last page. Use the guidelines provided on that page to see what you need to do next.

In all of CU's general chemistry courses only non-programmable calculators are permitted. A simple scientific calculator is sufficient for this course. You should begin using that type of calculator now and for all work once classes start so that you're proficient with the calculator that you'll be using on all chemistry exams.

1. What is the numerical result of each of the following computations? Where possible estimate an answer first and then determine the value expressed to the correct number of significant figures. Express your result in both scientific notation and expanded form.

   a. 236^4
   b. The square root of 6.892
   c. The cube root 9.00
   d. $1025^{1/5}$
   e. The quantity 1.245×10^4 squared
   f. 2.89^{-1}
   g. $(1.5 \times 10^{-3})(1.82 \times 10^{12})$
   h. $\dfrac{(4.2x10^3)^2(0.266)}{\sqrt{5.6}}$
   i. $\{(2.18 \times 10^{-18})/[(6.626 \times 10^{-34})(3.00 \times 10^8)]\}\ (1/2^2 - 1/4^2)$ Note: ½ and ¼ are exact numbers in this case

2. What is the value of x according to $\dfrac{5x}{3} = 10$?

3. When x = 4 and y = 6 what is the value of $\dfrac{5x - 2y}{x + y}$?

4. Express each of the following relationships in terms of the stated variable.

   a. $\dfrac{AB}{C} = D$ in terms of B

b. $\dfrac{a}{b + x} = c$ in terms of x

c. Density is defined as mass per volume. Re-express this relationship with respect to mass and with respect to volume.

d. The van der Waals equation is $(P + n^2a/V^2)(V - nb) = nRT$. Solve for P.

5. Which of the following expressions is equivalent to $\dfrac{T_2 - T_1}{T_1T_2}$?

$T_2(\dfrac{1 - T_1}{T_1})$ $\qquad \dfrac{1}{T_2} - \dfrac{1}{T_1}$ $\qquad T_2/T_1 - T_1/T_2$ $\qquad \dfrac{1}{T_1} - \dfrac{1}{T_2}$

6. The volume (V) of a gas is directly proportional to its temperature (T) and inversely proportional to its pressure (P). Write an expression relating these three parameters.

7. The energy (E) of electromagnetic radiation is given by $h\nu$ where h is a constant and ν is the frequency of the radiation. Also, $c = \lambda\nu$, where c is the speed of light (a constant) and λ is the wavelength of the radiation. Express λ in terms of h, c, and energy.

8. Which one of the following is the smallest volume?
2.25×10^5 mL $\qquad 4.71 \times 10^9$ μL $\qquad 5.29 \times 10^3$ dL.

9. You have P cubic centimeters of a copper block, which has a density of Q (expressed as g/cm^3). What volume of wood would have the same mass as the block of copper given that the density of wood is R g/cm^3?

10. Consider the relation where some physical constant, A, is equal to kT^3/ϕ^4. If k is a constant, by what factor does A change if T is doubled and ϕ is decreased by ½?

11. Photographic film is made with silver bromide, AgBr. One gram of bromine will react with 1.35 g of Ag to produce 2.35 g of AgBr. A photographic studio wishes to recover all the valuable silver from 4.25 kg of AgBr. How much silver will they recover?

12. A mole of ions, molecules, or anything else contains Avogrado's number, 6.022×10^{23}, of these units. A mole of glucose, $C_6H_{12}O_6$, has a mass of 180.0 g. A level teaspoon of glucose has a mass of 5.02 g. How many atoms of oxygen are present in this teaspoonful of glucose?

Assessment Results

Score your assessment using the key below giving yourself 1 point for each answer for a total of 30 points. Then determine your next action according to the table below.

1.a $3.10 \times 10^9 = 3{,}100{,}000{,}000$

1.b 2.625

1.c 2.08

1.d 4.001

1.e $1.550 \times 10^8 = 150{,}000{,}000$

1.f $0.346 = 3.46 \times 10^{-1}$

1.g $2.7 \times 10^9 = 2{,}700{,}000{,}000$

1.h $2.0 \times 10^6 = 2{,}000{,}000$

1.i $2.06 \times 10^6 = 2{,}060{,}000$

2. $x = 6$

3. 8×10^{-1}

4.a $B = CD/A$

4.b $x = (a/c) - b$

4.c Mass = (density)(volume) and Volume = mass/density

4.d $P = [(nRT)/(V - nb)] - (n^2a/V^2)$

5. $1/T_1 - 1/T_2$

6. $V \alpha T/P$

7. $\lambda = hc/E$

8. 2.25×10^5 mL is the smallest volume

9. A volume of wood of QP/R cm^3 has the same mass as the block of copper.

10. A increases by a factor of 128.

11. 2.44 kg Ag

12. 1.01×10^{23} oxygen atoms

Score	**Suggested Action**
>90%	You have good mastery of the algebra skills necessary in general chemistry. You can review the Math Tutorial or go to Assessment #2.
89% - 75%	Identify your weak areas on this assessment and then review those areas in the Math Tutorial. Work the practice problems in those areas of the tutorial, rework the problems that you missed on this assessment and then take Assessment #2.
<75%	Thoroughly study the Math Tutorial and additional resources as needed (friends, tutors, online help, etc.) Retake Assessment #1.

Math Proficiency Assessment #2

Whether you did well on Assessment #1 or had to do some review before being successful on it, treat Assessment #2 like a final exam. As with the first assessment, do all work alone, without any outside resources and using a non-programmable calculator; only with these constraints will you have a realistic assessment your math readiness for general chemistry.

1. Determine the following quantities:

   a. Which one of the following is the longest time?

      1.31×10^7 ms 2.46×10^9 μs 5.29×10^{-1} ks.

   b. Solve for A: $A^2X - BXY = Z$. Solve for X.

   c. Eggs cost A cents per dozen. You purchase B dozen eggs. How many pounds of tomatoes could you purchase for the same amount of money? Tomatoes cost C cents per pound.

2. The kinetic energy of a body is given in terms of its momentum (p) and mass (m) by $E = \frac{p^2}{2m}$

   The mass of Particle B is twice that of Particle A while the momentum of Particle B is 25% less than Particle A.

   By what factor does E for particle B differ from that of A?

3. The radius of a barium atom (Ba) is 0.0000000002220 m. Express this distance in correct scientific notation in meters, nm, and pm, retaining the correct number of significant figures in each case.

4. How many nanometers are in one centimeter?

5. Round off each of the following numbers to the indicated number of significant digits and write the answer in standard scientific notation, retaining the correct number of significant figures in each expression.

   a. 0.00034159 to three digits
   b. 3.363×10^5 to three digits

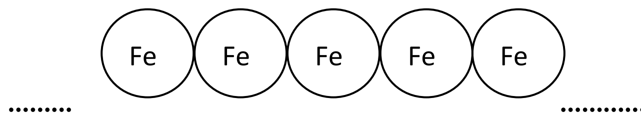
6. Consider the formula for the volume of a sphere, $V = \frac{4}{3} \pi r^3$. By what factor does the volume change if the radius of the sphere is doubled?

7. The relationship between the pressure of a gas and the volume of the gas is an inverse relationship. Sketch a graph of pressure (y) versus volume for a gas (x).

8. The blood circulating in an average adult human body contains about 2E22 iron atoms.

   a. If all of these iron atoms were removed and laid out side by side (see below), what linear distance (in km and miles) would they cover? Assume an atom diameter of 125 pm.

   1 m = 0.62 mi



   b. The mole concept is fundamental to chemistry. One feature of the mole is that there 6.022 x 10^{23} units (atoms, particles, molecules, etc.) per 1 mole of any substance. How many moles of iron are present in the blood of an average adult?

9. In one of the Capped Crusader's many adventures, Batman falls into a vat of concentrated acid. One would think that this would be the end of him but fortunately he carried "Neutralizer-Pellets" in his utility belt. Calculate the following quantities given that 14.3 kg of the neutralizing substance was needed to counter the acid in the vat.

   a. If each Neutralizer-Pellet contained 10 mg of neutralizing substance, how pellets would Batman need to have in his utility belt?

   b. If Batman carried only one pellet, what would the diameter (d) of the pellet be if it was 5 mm thick, a typical height for an aspirin tablet? Assume the density of the neutralizing substance to be 2.13 g/cm^3. $V = \pi r^2 h$ and $d = 2r$. 1 ft. = 0.3048 m

10. If one were to cover the 48 contiguous United States with a mole of M&Ms the thickness of the layer of M&Ms would be closest to: 1 foot, 1 mile, 10 miles or 50 miles. Anticipate an answer then using the data below calculate the actual depth. (JChemEd, Volume 63, Number 62, February 1986, page 125)

V = area x depth

Area of the US = 3.02 x 10^6 mi^2

Volume of 88 M&Ms = 100 mL = 100 cm^3

1 mile = 1.61 x 10^3 m

Source: http://timvandevall.com/blank-united-states-map-with-states/

Assessment Results

Score your assessment using the key below giving yourself 1 point for each answer for a total of 17 points. Then determine your next action according to the table below.

1. a. 1.31×10^7 ms
   b. $A = (Z + BY)/X)^{½}$
   c. AB/C lbs

2. The kinetic energy of Particle B is 0.28 of Particle A.

3. 2.220×10^{-10} m, 0.2220 nm, 222.0 pm

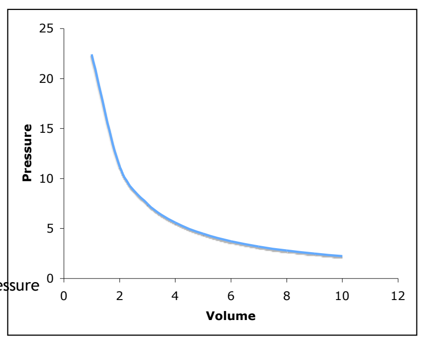
4. 10^7 nm

5. a. 3.42×10^{-4}

   b. 3.36×10^5

6. 8

7.



Pressure

8. a. 2.5×10^9 km and 1.6×10^{12} mi

   b. 0.03 mol Fe atoms

9. a. 1,430,000 pellets or 1.43×10^6 pellets

   b. 131 cm = 4.3 ft.

10. One mole of M&Ms would cover the contiguous US to a depth of 54 miles – inconceivable!

Score	Suggested Action
>90%	You have good mastery of the algebra skills necessary in general chemistry. You should be able to focus on the chemistry concepts rather than the math!
89% - 70%	Continue to review; focus on your weak areas.
<70%	You will most likely have difficulty succeeding in general chemistry because you’ll be so focused on the math aspects of the problems rather than the chemistry. You could consider taking Intro Chem.

Chemistry Review

A full year of high school chemistry is a pre-requisite for general chemistry at CU Boulder. Use this review sheet to see how much you remember! Don't worry if you don't remember everything but hopefully all of it will be familiar. Spend some time brushing up on these basic definitions, concepts and skills and your first semester of chemistry will be much more successful and much less painful! Use any resource you have access to: notes from high school, online tutorials, etc. The Math tutorial and assessments available on this web site will be helpful as well.

Fundamental Definitions and Skills

1. Define the following terms.
   a. Chemistry:
   b. Element:
   c. Substance:
   d. Matter:
   e. Molecule:
   f. Compound:
   g. Ionic Substances:
   h. Molecular Substances:
   i. Accuracy:
   j. Precision:
   k. Uncertainty in measurements:
   l. Significant figures in a measurement:
   m. Density:
   n. Mole:

All About the Numbers

1. Measurements in science are made in the metric system. Fill in the blanks in the table below for the commonly used metric prefixes.

Prefix	Symbol	Word	Conventional Notation	Exponential Notation
Mega			1,000,000	
		Thousand		
--	**--**	**One**	**1**	**1×10^0**
Deci				1×10^{-1}
	c			1×10^{-2}
Milli				
Micro		Millionth		
				1×10^{-9}
Pico			0.000000000001	*1×10^{-12}*

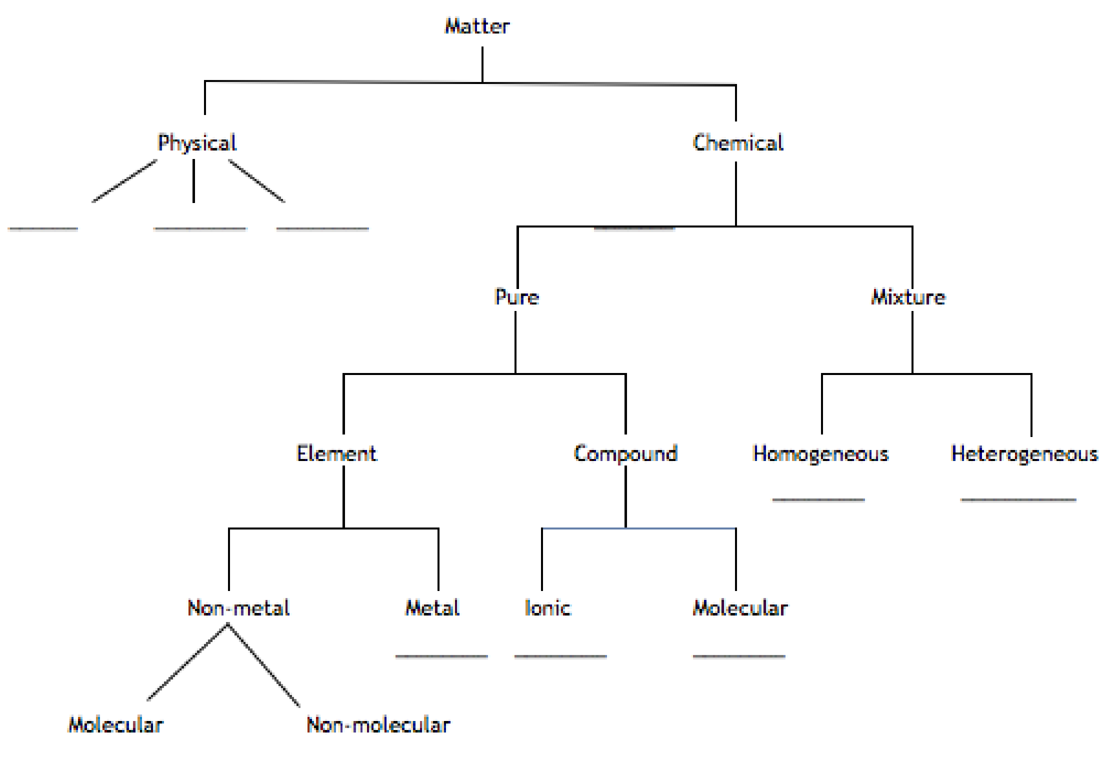
2. Be able to explain why there is always uncertainty in a measure value, no matter how experienced the operator or how expensive/reliable the instrument.
3. Explain how to determine if a zero in a reported value is significant.
4. Examine the mathematical operations below and summarize the rules for significant figures in both addition/subtraction and multiplication/division.

	A	**B**	**C**	**D**
	2.436	356.934	88.30	243.872
	+ 15.3	+ 5.11	+ 294.837	- 241
Calculator shows:	17.736	362.044	383.137	2.872
Should be reported as:	**17.7**	**362.04**	**383.14**	**3**

	E	F	G	H
	2.436	356.934	88.30	243.872
	x 15.3	x 5.11	÷ 294.837	÷ 241
Calculator shows:	37.2708	1823.93274	0.299488	1.01191701
Should be reported as:	**37.3**	**1820**	**0.2995**	**1.01**

Classification of Matter

Here is one possible scheme showing the classification of matter. Place the substances in the box below in the blanks in the scheme. Use each substance only once, placing it in its most appropriate category.



LiBr	NaCl(*s*)	Kr	Pb	$H_2O(g)$	CO_2	Hg(*l*)	O_2

Cup of tea with dissolved sugar   Salad dressing

Atoms: The Basics

1. Describe the fundamental composition of an atom.
2. Explain the terms ions, cations and anions.
3. What is an isotope?
4. The table below gives the number of electrons, protons, and neutrons in an atom or ion of several elements. Evaluate whether each statement below is true or false. Explain your reasoning.

Atom/Ion of Element	**P**	**Q**	**R**	**S**	**T**	**U**	**V**
Number of electrons	9	1	18	18	1	10	82
Number of protons	9	1	19	17	1	8	82
Number of neutrons	10	1	20	18	2	8	125

	T or F?	Explanation
S and **U** are anions		
R is a cation		
Q and **T** are isotopes of each other		
R and **S** are isotopes of each other		

5. Each of the elements in the table above corresponds to an actual element. How can you determine the element is? Give the name and elemental symbol for each of the elements.

Notation	**Symbol**	**Name**
P		
Q		
R		
S		
T		
U		
V		

6. Use a periodic table to determine the symbol or name of each of the following elements. You'll always have access to a periodic table for exams. Note that spelling counts when writing elemental names!

Symbol	Name		Symbol	Name
	Lithium		C	
N				Copper
Ne			Co	
	Potassium		Sn	
	Phosphorus		S	
Ag				Magnesium
	Gold		Mn	
	Bromine			Iron

7. What are the name and the weighted average atomic mass for the following elements?

Symbol	Name	Weighted Average Atomic Mass*
O		
Be		
Ar		
I		
Ca		

* Actual values may differ based on the actual periodic table used. Be sure to include unit!

8. Write the complete electron configuration and the noble gas shorthand notation for each of the following atoms.

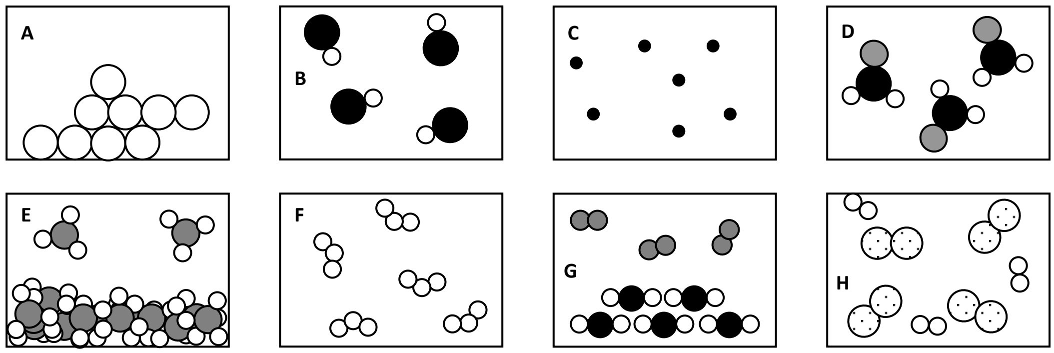
Element	Electron Configurations
N	Complete:
	Shorthand:
S	Complete:
	Shorthand:
Br	Complete:
	Shorthand:
Kr	Complete:
	Shorthand:
Ca	Complete:
	Shorthand:

9. Determine the common ion of each of the following elements and write the shorthand electron configuration for that ion.

Element	Electron Configuration of Common Ions
Li	Common ion:
	Configuration:
S	Common ion:
	Configuration:
Br	Common ion:
	Configuration:
Mg	Common ion:
	Configuration:

Molecules and Compounds: Names and Numbers

1. Look at the atomic/molecular views below and identify the illustration or illustrations that correspond to the descriptions below. In these drawings each circle is an atom and it could be that there isn't an illustration for a description. This exercise is adapted from University of New Hampshire PLTL Materials Library (Bauer, Rickert, Langdon)



Description	Figure Notation	If none, draw your own representation
Could contain elemental hydrogen at room temperature.		
Contains a pure substance		
A pure compound		
A mixture of two compounds		

Could represent a gaseous element.		
Could contain two distinct molecular substances.		
Could contain at least one ionic compound.		
Could represent the vaporization of a liquid.		

2. Name the following compounds or give the chemical formula.

$MgCl_2$	Dinitrogen trioxide
P_2O_5	Sodium iodide
NH_3	Phosphorus trifluoride
NH_4F	Silver bromide
CO	Aluminum hydroxide
Na_2CO_3	Zinc sulfide
$Pb(SO_4)_2$	Cobalt(III) oxide
HNO_3	Sulfuric acid

3. The endings of elemental names in chemistry impart key information about a substance. What is the difference between "chlorine" and "chloride"?

4. Which elements exist as diatomic molecules?

5. What is an allotrope? Identify the common allotropic form of oxygen. Which atomic/molecule view in #1 above could represent this allotrope?

6. What do the subscripts in a chemical formula indicate? What is the consequence of changing the subscript in a formula? Give an example.

Now for the quantitative aspects of formulas:

7. The anticancer drug Platinol (aka cisplatin), $Pt(NH_3)_2Cl_2$, reacts with DNA and interferes with its replication and hence cell growth. Determine the following quantities for cisplatin.

   a. How many atoms are in one molecule of cisplatin?
   b. Based on the total number of atoms in a molecule of cisplatin, what is the percent of each atom?
   c. Based on the mass of one molecule of cisplatin, what is the mass percent of each atom?
   d. Why is it important to specify the basis of the percentage calculation? Consider the results from parts b and c.
   e. How many moles of cisplatin are in 3 mg? How many molecules?

   f. How many moles of hydrogen atoms are in 3 mg? How many hydrogen atoms?

8. How many moles of chlorine atoms are in 4×10^{21} elemental chlorine molecules?

9. How many fluorine atoms are there in 19 g of difluoromethane, CH_2F_2?

10. One of the several oxides of tin found in the Earth's crust is 78.77% by mass tin. What is its empirical formula and name?

Reactions

1. Balance the following equations using whole numbers. Name the reactants and the product.

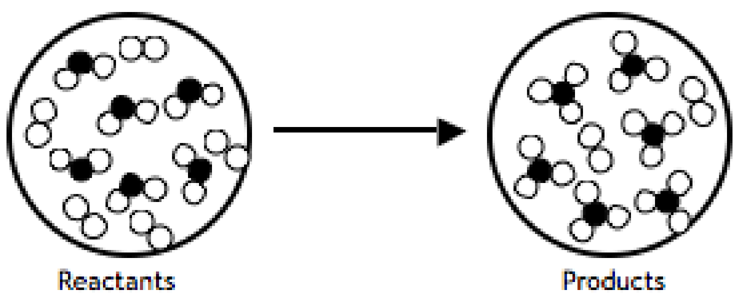
   a. ____ $Al(s)$ + ____ $Br_2(l)$ → ____ $AlBr_3(s)$

   b. ___ $Mg(s)$ + ____ $N_2(g)$ → _____ $Mg_3N_2(s)$

2. Write balanced chemical equations based on the following descriptions.

   a. Liquid N_2O_5 reacts to form dinitrogen tetroxide (liquid) and oxygen.

   b. The formation of AB_3 from AB_2 and B_2 based on the molecular level view below.



3. What do the coefficients in a balanced equation tell you?

4. Calculate the quantity or quantities associated with reactions.

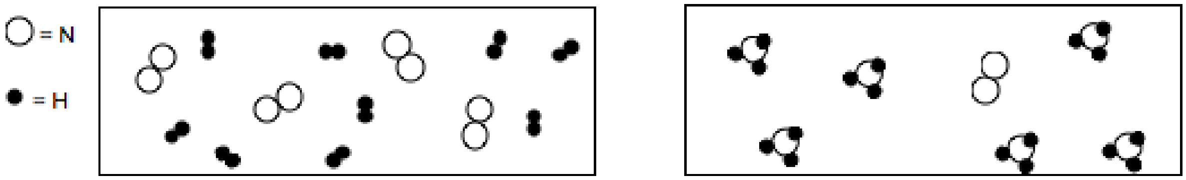
   a. Nitrous oxide (N_2O) is also called "laughing gas". It can be prepared by the thermal decomposition of ammonium nitrate with the release of water vapor. How many grams of nitrous oxide are formed if 0.46 mol of ammonium nitrate is heated? If 15 g of nitrous oxide are actually produced what is the percent yield?

   b. When baking soda ($NaHCO_3$) is heated, it releases carbon dioxide gas, which is responsible for the rising of cookies, cakes, and other baked goods. In addition to carbon dioxide the reaction also produces sodium carbonate. What mass of carbon dioxide is produced when 78.3 g of baking soda is heated?

   c. The mass of iodic acid (HIO_3) formed when 635 g of iodine trichloride reacts with excess of water.

$$ICl_3 + H_2O \rightarrow ICl + HIO_3 + HCl$$

d. Based on the molecular view below, determine the limiting reagent in the formation of ammonia according to: $N_2(g)$ + $3H_2(g)$ → $2\ NH_3(g)$



Before reaction | After reaction

e. The mass of HCl formed when 635 g of iodine trichloride reacts with 282 g of water.

f. The mass of $MgCl_2$ formed when 24.3 mg of magnesium reacts with 10.0 mL of 0.1 M HCl.

$$Mg(s) + HCl(aq) \rightarrow MgCl_2(s)$$

Chemistry Review – Key

Fundamental Definitions and Skills

1. Define the following terms.
   a. Chemistry: ***The study of matter, its transformations and the energy associated with those changes.***
   b. Element: ***A collection of similar, but not identical, atoms.***
   c. Substance: ***A type of matter, either an element or a compound, that has a fixed composition.***
   d. Matter: ***Anything that possesses mass and occupies space (has a volume).***
   e. Molecule: ***A structure consisting of two or more atoms that are bound chemically and behave as an independent unit. The atoms can be the same, as in H_2, or different, as in H_2O.***
   f. Compound: ***A substance composed of two or more different elements that are chemically combined in fixed proportions, for example NaCl and H_2O. Note that NaCl is a compound but not a molecule while water is both a compound and a molecule.***
   g. Ionic Substances: ***A substance containing ionic bonds. All ionic substances are compounds as ionic bonds do not form between identical atoms.***
   h. Molecular Substances: ***A substance containing covalent bonds. Molecular substances can be a molecule or a compound.***
   i. Accuracy: ***Refers to how close the measured result is to the true value.***
   j. Precision: ***Refers to how close together a series of measurements are.***
   k. Uncertainty in measurements: ***The uncertainty in a measurement is in the last digit of the measurement. It represents how much you had to estimate that last digit when making your measurement.***
   l. Significant figures in a measurement: ***The digits recorded in a measurement, both the certain and uncertain (estimated) ones, are called significant figures.***
   m. Density: ***The mass to volume ratio for a substance.***
   n. Mole: ***A mole of any substance contains 6.022×10^{23} units (atoms, particles, molecules, etc) in 1 mole of any substance. The mass of one mole of a chemical substance is its atomic mass or molecular mass expressed in grams. Thus molar mass is the mass of one mole of a substance, g/mol***

All About the Numbers

1. Measurements in science are made in the metric system. Fill in the blanks in the table below for the commonly used metric prefixes.

Prefix	Symbol	Word	Conventional Notation	Exponential Notation
Mega	***M***	***Million***	1,000,000	***1×10^{6}***
Kilo	***K***	Thousand	***1,000***	***1×10^{3}***
--	**--**	**One**	**1**	**1×10^{0}**
Deci	***d***	***Tenth***	***0.1***	1×10^{-1}
Centi	c	***Hundreth***	***0.01***	1×10^{-2}
Milli	***m***	***Thousandth***	***0.001***	***1×10^{-3}***
Micro	***μ***	Millionth	***0.000001***	***1×10^{-6}***
Nano	***n***	***Billionth***	***0.000000001***	1×10^{-9}
Pico	***p***	***Trillionth***	0.000000000001	***$1 \quad \times 10^{-12}$***

2. Be able to explain why there is always uncertainty in a measure value, no matter how experienced the operator or how expensive/reliable the instrument.

   See the explanation in the Math Tutorial found in the General Chemistry Preparation Resources folder in the course D2L.

3. Explain how to determine if a zero in a reported value is significant.

   Zeroes between non-zero numbers are ALWAYS significant.

   Zeroes which are SIMULTANEOUSLY to the right of the decimal point AND at the end of the number are ALWAYS significant.

   Zeroes which are to the left of a written decimal point and are in a number >= 10 are ALWAYS significant.

   A helpful way to check these last two statements is to write the number in scientific notation. If you can/must get rid of the zeroes, then they are NOT significant.

4. Examine the mathematical operations below and summarize the rules for significant figures in both addition/subtraction and multiplication/division.

	A	B	C	D
	2.436	356.934	88.30	243.872
	+ 15.3	+ 5.11	+ 294.837	- 241
Calculator shows:	17.736	362.044	383.137	2.872
Should be reported as:	**17.7**	**362.04**	**383.14**	**3**

	E	F	G	H
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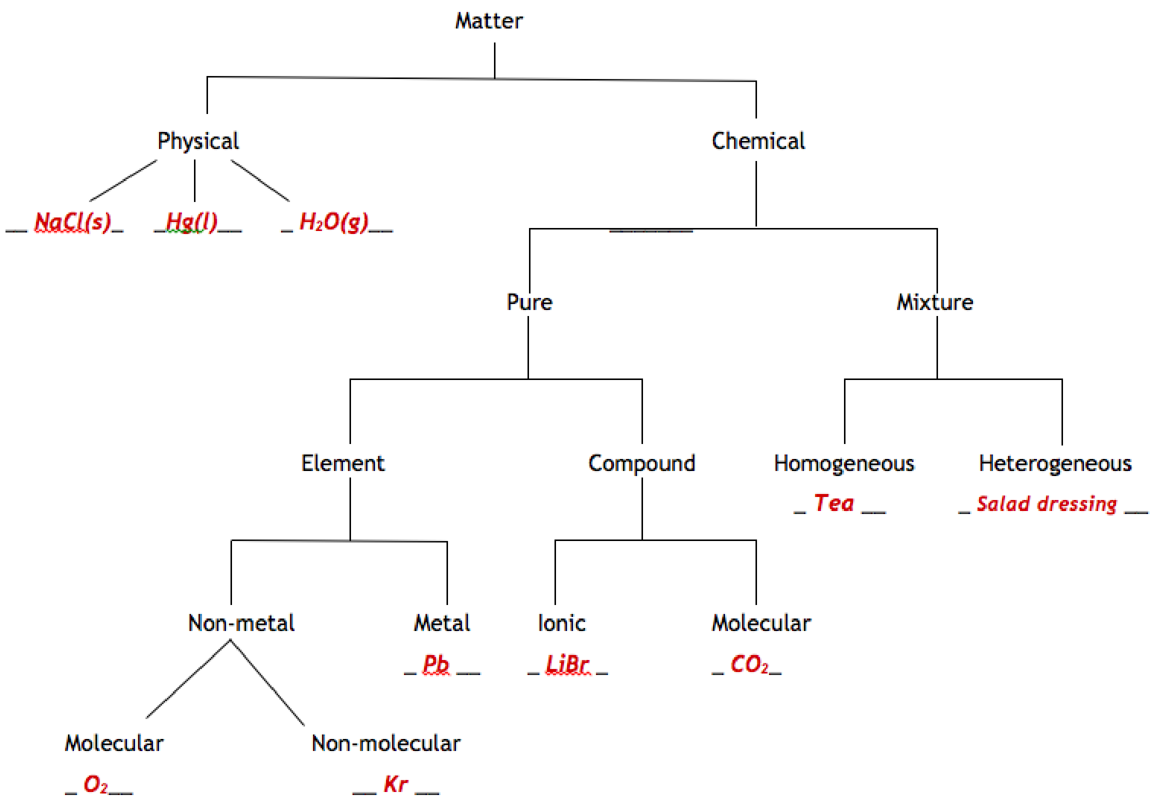
	x 15.3	x 5.11	÷ 294.837	÷ 241
Calculator shows:	37.2708	1823.93274	0.299488	1.01191701
Should be reported as:	**37.3**	**1820**	**0.2995**	**1.01**

In addition and subtraction, the answer should have the same number of decimal places as the number added or subtracted containing the least number of decimal places.

For multiplication and division, the answer should have the same number of significant figures as the number multiplied or divided containing the least number of significant figures.

Classification of Matter

Here is one possible scheme showing the classification of matter. Place the substances in the box below in the blanks in the scheme. Use each substance only once, placing it in its most appropriate category.



Atoms: The Basics

1. Describe the fundamental composition of an atom.

The atom is comprised of a centralized nucleus surrounded by electrons. The nucleus contains both protons, which are positively charged, and neutrons, which carry no charge. Therefore the nucleus is positive. The electrons are negatively charged and when the number of electrons equals the number of protons the overall charge on the atom is zero, it's neutral with respect to charge. The electrons are often represented as residing in orbits (the Bohr model) but a more accurate representation is that there are regions of space where there is a high probability of finding an electron; these regions are known as orbitals.

2. Explain the terms ions, cations and anions. *An ion is an atom that carries an overall non-zero charge due to an imbalance in the number of protons and electrons. Cations are positive*

due to having more protons than electrons; anions carry an overall negative charge due to excess electrons.

3. What is an isotope? ***All atoms of an element have the same number of protons; it is this number that uniquely identifies the element. However, the atoms within the element can have different numbers of neturons. These are isotopes.***

4. The table below gives the number of electrons, protons, and neutrons in an atom or ion of several elements. Evaluate whether each statement below is true or false. Explain your reasoning.

Atom/Ion of Element	**P**	**Q**	**R**	**S**	**T**	**U**	**V**
Number of electrons	9	1	18	18	1	10	82
Number of protons	9	1	19	17	1	8	82
Number of neutrons	10	1	20	18	2	8	125

	T or F?	Explanation
S and **U** are anions	*T*	**Each has more electrons than protons**
R is a cation	*T*	**It has fewer electrons than protons**
Q and **T** are isotopes of each other	*T*	**Each has the same number of protons but different number of neutrons**
R and **S** are isotopes of each other	*F*	**They don't have the same number of protons so they are not the same element**

5. Each of the elements in the table above corresponds to an actual element. How can you determine the element is? Give the name and elemental symbol for each of the elements.
The number of protons uniquely identifies the element. Use the periodic table to find the element associated with each Z-number, the number of protons.

Notation	**Symbol**	**Name**
P	***F***	***Fluorine***
Q	***H***	***Hydrogen***
R	***K***	***Potassium***
S	***Cl***	***Chlorine***
T	***H***	***Hydrogen***
U	***O***	***Oxygen***
V	***Pb***	***Lead***

6. Use a periodic table to determine the symbol or name of each of the following elements. You'll always have access to a periodic table for exams. Note that spelling counts when writing elemental names!

Symbol	**Name**		**Symbol**	**Name**
Li	Lithium		C	***Carbon***
N	***Nitrogen***		***Cu***	Copper
Ne	***Neon***		Co	***Cobalt***
K	Potassium		Sn	***Tin***
P	Phosphorus		S	***Sulfur***
Ag	***Silver***		***Mg***	Magnesium
Au	Gold		Mn	***Manganese***
Br	Bromine		***Fe***	Iron

7. What are the name and the weighted average atomic mass for the following elements?

Symbol	**Name**	**Weighted Average Atomic Mass***
O	***Oxygen***	***16.00 amu/atom or 16.00 g/mole***
Be	***Beryllium***	***9.012 amu/atom or 9.012 g/mole***
Ar	***Argon***	***39.95 amu/atom or 39.95 g/mole***
I	***Iodine***	***126.9 amu/atom or 126.9 g/mole***
Ca	***Calcium***	***40.08 amu/atom or 40.08 g/mole***

* Actual values may differ based on the actual periodic table used. Be sure to include unit!

8. Write the complete electron configuration and the noble gas shorthand notation for each of the following atoms.

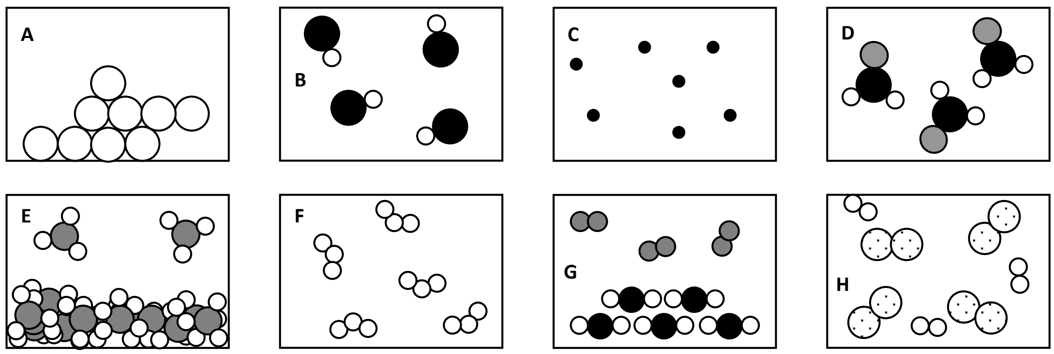
Element	**Electron Configurations**
N	Complete: *$1s^22s^22p^3$*
	Shorthand: *[He] $2s^22p^3$*
S	Complete: *$1s^22s^22p^63s^23p^4$*
	Shorthand: *[Ne]$3s^23p^4$*
Br	Complete: *$1s^22s^22p^63s^23p^63d^{10}4s^24p^5$*
	Shorthand: *[Ar]$4s^23p^5$*
Kr	Complete: *$1s^22s^22p^63s^23p^63d^{10}4s^24p^6$*
	Shorthand: *[Kr]*
Ca	Complete: *$1s^22s^22p^63s^23p^64s^2$*
	Shorthand: *[Ar]$4s^2$*

9. Determine the common ion of each of the following elements and write the shorthand electron configuration for that ion.

Element	**Electron Configuration of Common Ions**
Li	Common ion: Li^{+1}
	Configuration: *[He]*
S	Common ion: *S^{2-}*
	Configuration: *[Ar]*
Br	Common ion: *Br^{-1}*
	Configuration: *[Kr]*
Mg	Common ion: *Mg^{2+}* Configuration: *[Ne]*

Molecules and Compounds: Names and Numbers

1. Look at the atomic/molecular views below and identify the illustration or illustrations that correspond to the descriptions below. In these drawings each circle is an atom and it could be that there isn't an illustration for a description. This exercise is adapted from University of New Hampshire PLTL Materials Library (Bauer, Rickert, Langdon)



Description	Figure Notation	If none, draw your own representation
Could contain elemental hydrogen at room temperature.	***G H***	
Contains a pure substance	***A B C D E F***	
A pure compound	***B D E G***	
A mixture of two compounds	***None***	***Putting B and D together would result in a mixture of two compounds.***

Could represent a gaseous element.	*C F*	
Could contain two distinct molecular substances.	*G H*	
Could contain at least one ionic compound.	*B D E G*	
Could represent the vaporization of a liquid.	*E*	

2. Name the following compounds or give the chemical formula.

$MgCl_2$	*magnesium chloride*	Dinitrogen trioxide	N_2O_3
P_2O_5	*diphosphorus pentaoxide*	Sodium iodide	*NaI*
NH_3	*ammonia*	Phosphorus trifluoride	PF_3
NH_4F	*ammonium fluoride*	Silver bromide	*AgBr*
CO	*carbon monoxide*	Aluminum hydroxide	$Al(OH)_3$
Na_2CO_3	*sodium carbonate*	Zinc sulfide	*ZnS*
$Pb(SO_4)_2$	*lead(IV) sulfate*	Cobalt(III) oxide	Co_2O_3
HNO_3	*nitric acid*	Sulfuric acid	H_2SO_4

3. The endings of elemental names in chemistry impart key information about a substance. What is the difference between “chlorine” and “chloride”?

The “ine” ending indicates the elemental form while the “ide” ending indicates the ion.

4. Which elements exist as diatomic molecules? ***Br_2, I_2, N_2, Cl_2, H_2, O_2, F_2***

5. What is an allotrope? Identify the common allotropic form of oxygen. Which atomic/molecular view in #1 above could represent this allotrope?

An allotrope is a different physical form of an element. For example, elemental oxygen exists as O2 but another form of oxygen is O_3, or ozone. This is represented in figure “F”.

6. What do the subscripts in a chemical formula indicate? What is the consequence of changing the subscript in a formula? Give an example.

   The subscripts indicate the ratio of atoms to each other. For example, in water there are 2 hydrogen atoms for each oxygen atom. Changing the subscript changes the substance. For example H2O is water but H_2O_2 is hydrogen peroxide.

7. The anticancer drug Platinol (aka cisplatin), $Pt(NH_3)_2Cl_2$, reacts with the cancer cell's DNA and interferes with its growth. Determine the following quantities for cisplatin.

   g. How many atoms are in one molecule of cisplatin? *11*

   h. Based on the total number of atoms in a molecule of cisplatin, what is the percent of each atom?

   Pt = 9%, N = 18%, H = 55%, Cl = 18%

   i. Based on the mass of one molecule of cisplatin, what is the mass percent of each atom?

   Pt = 65%, N = 9%, H = 2%, Cl = 24%

   j. Why is it important to specify the basis of the percentage calculation? Consider the results from parts b and c.

   Based on the total number of atoms in a molecule of cisplatin (11) only one of them is Pt and therefore itS percent representation in the molecule is small. But based on mass, Pt contributes to the majority of the mass since it is a far heavier element than any of the others.

   k. How many moles of cisplatin are in 3 mg? How many molecules?

   1×10^{-5} mole or 10 μmoles, 6×10^{18} molecules

   l. How many moles of hydrogen atoms are in 3 mg? How many hydrogen atoms?

   6×10^{-5} mole or 60 μmoles, 4×10^{19} atoms

8. How many moles of chlorine atoms are in 4×10^{21} elemental chlorine molecules?

   0.01 mole Cl atoms

9. How many fluorine atoms are there in 19 g of difluoromethane, CH_2F_2?

   4.4×10^{23} F atoms

10. One of the several oxides of tin found in the Earth's crust is 78.77% by mass tin. What is its empirical formula and name?

    SnO_2 Tin(IV) oxide

Reactions

1. Balance the following equations using whole numbers. Name the reactants and the product.

   a. __*2*__ $Al(s)$ + __*3*__ $Br_2(l)$ → __*2*__ $AlBr_3(s)$

   Elemental aluminum + Elemental bromide → Aluminum bromide

   b. __*3*__ $Mg(s)$ + ____ $N_2(g)$ → _____ $Mg_3N_2(s)$

   Elemental magnesium + Elemental nitrogen → Magnesium nitride

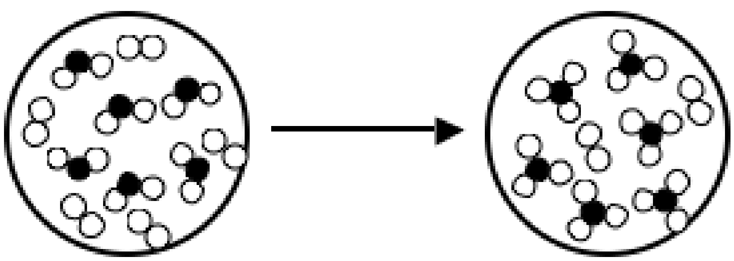
2. Write balanced chemical equations based on the following descriptions.

   c. Liquid N_2O_5 reacts to form dinitrogen tetroxide (liquid) and oxygen.

   $$2\ N_2O_5(l) \rightarrow 2\ N_2O_4(l) + O_2(g)$$

   d. The formation of AB_3 from AB_2 and B_2 based on the molecular level view below.

   $$2\ AB_2 + B_2 \rightarrow 2\ AB_3$$



3. What do the coefficients in a balanced equation tell you?

The coefficients relate the number of atoms or molecules that react or the moles of atoms/molecules that react.

In 1.a above, 2 aluminum atoms react with 3 molecules of elemental bromine to form 2 units of aluminum bromide. OR….2 moles o faluminum react with 3 moles of elemental bromine to form 2 moles of aluminum bromide.

4. Calculate the quantity or quantities associated with reactions.

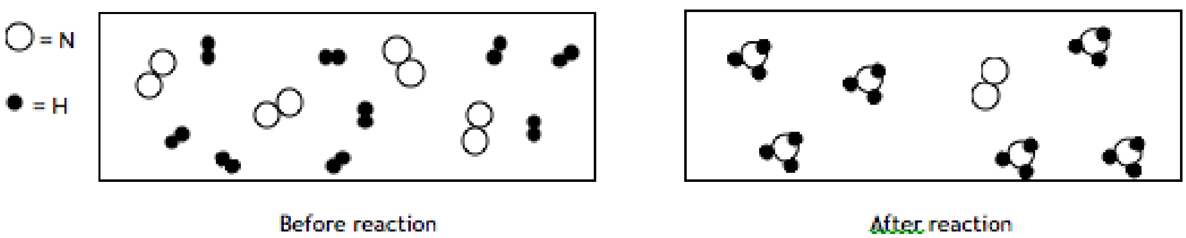
   a. Nitrous oxide (N_2O) is also called "laughing gas". It can be prepared by the thermal decomposition of ammonium nitrate with the release of water vapor. How many grams of nitrous oxide are formed if 0.46 mol of ammonium nitrate is heated? If 15 g of nitrous oxide are actually produced what is the percent yield? ***2.0×10^1 g, 75%***

   b. When baking soda ($NaHCO_3$) is heated, it releases carbon dioxide gas, which is responsible for the rising of cookies, cakes, and other baked goods. In addition to carbon dioxide the reaction also produces sodium carbonate. What mass of carbon dioxide is produced when 78.3 g of baking soda is heated? ***20.5 g***

c. The mass of iodic acid (HIO_3) formed when 635 g of iodine trichloride reacts with excess of water.

$$\mathbf{2}ICl_3 + \mathbf{3}H_2O \rightarrow ICl + HIO_3 + \mathbf{5}HCl \qquad \textbf{239 g}$$

d. Based on the molecular view below, determine the limiting reagent in the formation of ammonia according to: $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ ***H_2 is limiting***



e. The mass of HCl formed when 635 g of iodine trichloride reacts with 282 g of water. ***248 g***

f. The mass of $MgCl_2$ formed when 24.3 mg of magnesium reacts with 10.0 mL of 0.1 M HCl. ***5 mg***

$$Mg(s) + \mathbf{2}HCl(aq) \rightarrow MgCl_2(s)$$

What Previous Students Have to Say About Being Successful in General Chemistry

Read the book (before and after class), print the slides, take notes and do every practice question you're given regardless of how trivial it seems. Retention is greater when you come to class prepared.

Attend every class and keep up! Don't just study right before a test, rather study after class every day (or at the end of the week) and go over what you learned and practice it. Don't cram! Make summary sheets and you'll have a study guide when test time comes.

Do the practice problems (End-of-chapter, Connect, within the PowerPoint). Do them and you will benefit in the long run.

Use your resources – instructor, TAs, classmates! Don't be afraid to ask for help. Help each other and everyone will benefit. Go to office hours.

Always use units!

Take recitation seriously – it will help you to have the repetition for the test.

Make sure you know the fundamentals.

Practice doing multiple choice questions.

Don't overly rely on a tutor – they tend to do the work for you. Realize that talking to a tutor can be helpful as you explain what you know or what you don't understand.

Don't over-complicate a problem in your head. If you relax and take each problem step at a time and recognize that it is simple algebra you'll probably do alright.

IT ALL GOES BY SO QUICKLY… DON'T WASTE ANY OF THE EXPERIENCE OR THE OPPORTUNITIES! IT'S ALL WORTH IT IN THE END.