Mathematics Review AP Chemistry

Although the mathematics on the AP chemistry exam is not difficult, students find it to be challenging because most of it requires basic arithmetic skills that you have not used since middle school (or even elementary school). Students generally have a good sense of how to use a calculator, but lack the skills of doing math without a calculator. Most math classes stress the use of calculators to solve problems and on the AP chemistry exam **seventy-five percent** of it is to be done **without** calculators. You will need to practice the basic math skills that you already know (just haven't used much in the past) to develop your thinking to solve the problems that you will encounter.

Format of the AP Chemistry Exam

The AP exam consists of two parts: multiple choice and free-response questions. Each part of the exam will count 50% of the overall grade.

- **Format of Multiple Choice AP test:**
  - 50% of overall grade
  - Directly tied to the Learning Objectives (and there are 117 LO in the framework)
  - 90 minutes on the section
    - 60 multiple choice questions
    - Average time is 90 seconds per question
  - **NO CALCULATORS ARE TO BE USED**
  - Multiple Choice questions
    - "Hard" questions are generally in the middle of the test.
      - This is designed to "separate the students out" – find a break between the fours and fives, the threes and the fours, etc.
    - Choices go from the
      - lowest number to the highest number
      - they are generally lined up by decimal points, even though this does not make the number list "straight"
        - Allows you to see decimal points easier.
        - Allows you to see significant figures easier.
    - Look for the word approximate in the question, if there, you can use estimation to help arrive at the answer.
    - Format of questions will be
      - Non-calculator
      - Four choice question (A, B, C and D)
      - Can use periodic table and equation sheets
      - Will have discrete items (stand-alone questions)
      - Will have "sets of assessments"
        - Sets will be between 1/3 and ½ of the test (i.e. between 20 and 30 MC questions)
        - Sets will cover multiple topics of chemistry using the same stem.
    - Interpreting diagrams
    - simple math problems
    - **No penalty for guessing**
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Format of Free Response Questions

- 50% of overall grade
    - Seven Free Response Questions
        - 3 "LONG" problems
            - Multi-part problems
            - designed to be 20 to 25 minutes each
        - 4 "SHORT" problems
            - Generally single-part or two-part questions
            - designed to be 3 to 7 minutes each
- Format of Free-response
    - Can use periodic table and equation sheets
    - Calculator can be used on all questions
    - On **<u>each</u>** test, there will be the following question types (may be combined into a single question – long problem with multiple parts):
        - Lab 1: Experimental design
            - Students will have to design a lab
            - think scientific method
        - Lab 2: Patterns/analysis of data/selection of authentic data to explain observations
            - Take a data table and find the results of the lab.
        - Representations 1: Translation between representations
        - Representations 2: Atomic/molecular view to explain observation
        - Quantitative: Following a logical/analytical pathway

Note on grading

The free-response problems are graded on an "internally consistent" basis. That means that if you need the answer from part (a) to do part (b) and made a mistake in part (a) you can still get full credit for part (b), **PROVIDED** that the reader (the person who grades your test) can see your work and follow what you did. That means "***<u>SHOW YOUR WORK</u>***". Remember:

NO WORK ➔ NO CREDIT

Source of the problems

Each problem of the following practice problems are directly related to released AP chemistry exam questions. There will be nothing in this packet that does not directly relate to developing the skills and abilities that students need to be successful on the AP chemistry exam.

How to do the math

What follows are the notes and the "meat" of this packet. The intent of this packet is to cover the math necessary to be successful on the AP Chemistry exam. If it seems to be overly basic in its approach, the underlying principle in writing this packet is to assume that you (the students) do not remember anything, so we will start at beginning.

Conversion Factors and Dimensional Analysis

There are two guiding mathematical principles when working with conversion factors.

1. When the numerator (the top of a fraction) and the denominator (bottom of the fraction) are the same, then the fraction equals one.
2. When any number is multiplied by one, you do not change the number at all.

A conversion factor is a fraction that equals one, since the top and the bottom are the same thing, just expressed in different units. Examples of conversion factors are:

$$\frac{1\,\text{dollar}}{10\,\text{dimes}},\quad \frac{12\,\text{inches}}{1\,\text{foot}},\quad \frac{365\,\text{days}}{1\,\text{year}},\quad \frac{5280\,\text{feet}}{1\,\text{mile}},\quad \frac{12\,\text{eggs}}{1\,\text{dozen}},\quad \frac{1760\,\text{yards}}{5280\,\text{feet}},\quad \frac{5280\,\text{feet}}{1760\,\text{yards}}.$$

For the last two, how do you know which one to use? You let the units guide you. You ask yourself a series of questions as you do the problem.

1. What unit has to go on the bottom to cancel?
2. What can I change that unit into?
3. What numbers will make them equal?

Using the units to guide you in the problem is called "dimensional analysis". This method only works if you put your units in the problem and cancel them. Here is the trick…you have to think about them canceling. Don't just make your teacher happy by canceling units. If you do not get the units to work out and give you what you are asked to find, then you have 100% of getting the problem wrong. If the units do work out, your final unit is what you are asked to find, then you have a 90% chance of getting the problem right (the other 10% is making dumb mistakes or math errors in your calculations).

Say you are 16 years old and you want to know how old you are in minutes. So you start out with 16 years.

$$16\ \cancel{\text{years}} \times \frac{365\ \cancel{\text{days}}}{1\ \cancel{\text{year}}} \times \frac{24\ \cancel{\text{hours}}}{1\ \cancel{\text{day}}} \times \frac{60\ \text{minutes}}{1\ \cancel{\text{hour}}} = 8\,409\,600\ \text{minutes}$$

- What unit has to go on the bottom to cancel? Answer: years
- What can I change that unit into? Answer: days (you could have picked months or weeks)
- What numbers will make them equal? Answer: 1 year is 365 days, so 1 is on the bottom and 365 is on the top.

Notice that the top and the bottom of the fraction measure the same thing, so this conversion factor equals one.

- What unit has to go on the bottom to cancel? Answer: days
- What can I change that unit into? Answer: hours
- What numbers will make them equal? Answer: 1 day is 24 hours, so 1 is on the bottom and 24 is on the top.

Notice that the top and the bottom of the fraction measure the same thing, so this conversion factor equals one.

- What unit has to go on the bottom to cancel? Answer: hours
- What can I change that unit into? Answer: minutes
- What numbers will make them equal? Answer: 1 day is 60 minutes, so 1 is on the bottom and 60 is on the top.

Notice that the top and the bottom of the fraction measure the same thing, so this conversion factor equals one.

You want to make sure that you cancel as you go. If the units don't cancel, you made a mistake. Notice also that all that this problem did was to multiple 16 years by 1, 1 and 1. Anytime that you multiple by one, you do not change the number.

A common mistake is that students put the number from the start at the bottom of the first conversion factor, making the problem look like this $16\ \text{years} \times \dfrac{5840\ \text{days}}{16\ \text{year}}$. You should never have to reach for a calculator to put the numbers in a conversion factor – you should know what the numbers are and where the numbers come from!

You were asked for your age in minutes but were given years, so you have to convert the units. If the final unit is minutes then you have a 90% chance that you got the problem correct.

Another method to set up the problem involves "railroad tracks" which is shown below. This method is the same thing; it is just set up differently. Either setup will get you credit on the AP exam and earn you the point for showing your work.

$$\begin{array}{l|l|l|l|l} 16\ \cancel{\text{years}} & 365\ \cancel{\text{days}} & 24\ \cancel{\text{hours}} & 60\ \text{minutes} & = 8\ 409\ 600\ \text{minutes} \\ \hline & 1\ \cancel{\text{year}} & 1\ \cancel{\text{day}} & 1\ \cancel{\text{hour}} & \end{array}$$

Note on using calculators

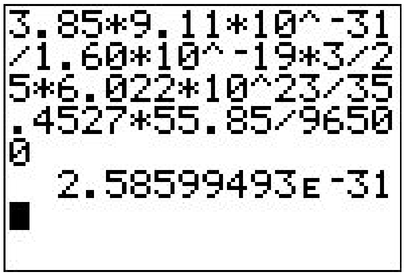
Solve this problem:

$$3.85 \times \frac{9.11 \times 10^{-31}}{1.60 \times 10^{-19}} \times \frac{3}{25} \times \frac{6.022 \times 10^{23}}{35.4527} \times \frac{55.85}{96500} = \underline{\qquad\qquad\qquad}$$

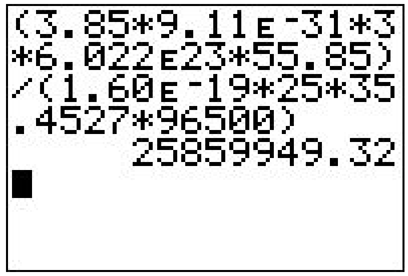
Students commit two common errors when they reach for their calculator to solve problems like the ones above. First, the calculator cannot read your mind and will do exactly what you tell it to. If students are not careful, order of operations will cause you grief. Many students set up these problems correctly on the free response and then do not earn points because they cannot use their calculator correctly.

The second problem is entering scientific notation into your calculators. Take the most common number in scientific notation used in chemistry, 6.022 x 10^{23}. The "6.022" can be called the *coefficient*, *digit term* or the *significand* while the "x 10^{23}" is called the *base* or the *exponential term*. If you use the buttons "10^" or "^" to enter scientific notation, you SHOULD (and in some problems MUST) use parenthesis around the numbers to "glue" the coefficient to the base, if you do not, you may get the wrong answer (depends on the type of problem you are solving). A much better method to enter this information into your calculator is to use the "EE" key (graphing calculators), "EXP" key (generally on non-graphing calculators, but some may have the "EE" key), "E" key (not generally seen) and the "x10" (not generally seen). By using this key, the calculator automatically "glues" the coefficient with the base.

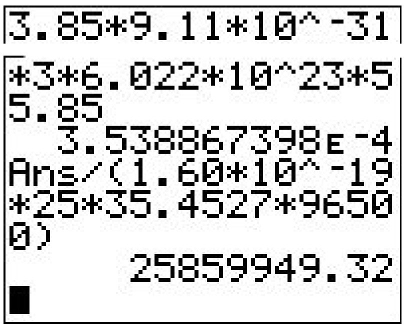
When doing this type of problem, there are two things you want to do…use the EE key and use parenthesis around the top numbers (3.85, 9.11x10^{-31}, 3, 6.022x10^{23} and 55.85), hit the divide key, and then use parenthesis around the bottom numbers (1.60x10^{-19}, 25, 35.4527 and 96500). This will save you many keystrokes on the calculator. Reducing the number of keystrokes reduces the number of chances that you have to make a mistake.



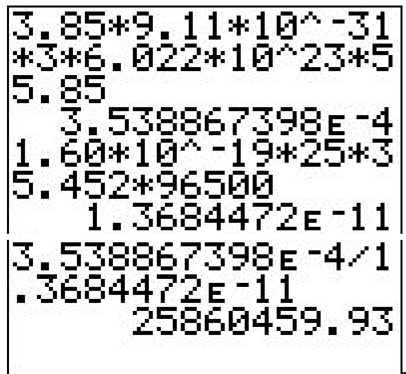
Version One



Version Two



Version Three



Version Four

DID YOU KNOW

That a horizontal line in mathematics is called a **vinculum?** Its name comes from the Latin and it means "bond" or "tied". It is used in a mathematical expression to indicate that the group is to be considered "tied" together. The vinculum can be used to express division. The numerator appears above the vinculum and the denominator beneath it.

Because the vinculum means to group together, we have to use the parenthesis and the "EE" key to glue the correct parts together so the calculator can do the problem correctly.

Version one is wrong. The student did not use the parenthesis to "glue" the coefficient to the base.

Version two is correct. Version three and four are also correct, however, version two only required 60 keystrokes, while version three required 70 and version four 91. The fewer keystrokes, the less likely it is that you will make a mistake. The slight difference in the answers for version two/three and version four is due to the fact that the numbers in two and three were carried in the memory of the calculator and not entered by the student.

Note on Canceling

As problems are done in this packet, when numbers or units are canceled, not only will the units cancel, but how the units are canceled, will cancel. The ways to show units canceling are "/", "\", "—" and "|". The "/" was done with the years above, "\" canceled the days and the "—" canceled the hours. This is done so that it is easier for students to follow what was canceled in the example problems.

Cross Canceling of Numbers

Cross canceling refers to canceling a numerator with a denominator, or a factor that is in each of them. It is one of the most important skills you need to remember for dealing with the multiple choice problems on the AP chemistry exam. In the first example, the numbers that cancel are side by side, however, on the exam, the numbers may not be side by side. Just remember to cancel numerator with denominator.

Example: $\frac{12}{5} \text{ x } \frac{5}{3} \rightarrow \frac{12}{\cancel{5}_{1}} \text{ x } \frac{\cancel{5}^{1}}{3} \rightarrow \frac{\cancel{12}^{4}}{\cancel{5}_{1}} \text{ x } \frac{\cancel{5}^{1}}{\cancel{3}_{1}} = 4$

the fives cancel

3 goes into 3, once and the 3 goes into 12 four times.

Example: $7 \text{ x } \frac{3}{2} \text{ x } \frac{4}{8} \text{ x } \frac{3}{9} \text{ x } \frac{4}{14} \text{ x } \frac{1}{3} = \rightarrow \cancel{7}^{1} \text{ x } \frac{\cancel{3}^{1}}{\cancel{2}_{1}} \text{ x } \frac{\cancel{4}^{\cancel{2}^{1}}}{\cancel{8}_{\cancel{2}_{1}}} \text{ x } \frac{\cancel{3}^{1}}{\cancel{9}_{3}} \text{ x } \frac{\cancel{4}^{1}}{\cancel{14}_{2}} \text{ x } \frac{1}{\cancel{3}_{1}} = \frac{1}{3 \times 2} = \frac{1}{6}$

Memorization

Although this is AP chemistry, you must remember some basic math and arithmetic information. What you have to memorize (and apply) is kept to a minimum; but you **MUST** know it to be successful on the AP chemistry exam.

The first thing to remember is:

- Divided by ten, decimal point moves to the left one place.
- Multiple by ten, decimal point moves to the right one place.
- Divide by powers of ten ($100 = 10^2$, $1000 = 10^3$, etc) move the decimal point to the left the same number of spaces as the power of ten.
- Multiple by powers of ten ($100 = 10^2$, $1000 = 10^3$, etc) move the decimal point to the right the same number of spaces as the power of ten.

Another common mathematic problem is division by a fraction. Remember, find the main division bar and rewrite as a multiplication problem by multiplying by the reciprocal of the fraction on the denominator:

$$\frac{a}{\frac{b}{c}} = a \times \frac{c}{b} = \frac{ac}{b}$$

To make problems easier, it is generally better to write a mixed fraction as an improper fraction. Remember $a\frac{b}{c} = \frac{(ac)+b}{c}$ example is $3\frac{5}{8} = \frac{(3 \text{ x } 8)+5}{8} = \frac{29}{8}$

A common approach for a problem might be to have you solve the following problem, $\frac{3.00}{1.20}$ which can be done "long hand" or you can use the fraction information and division by a fraction to make the problem a little easier.

$$\frac{3.00}{1.20}=\frac{3.00}{1\frac{1}{5}}=\frac{3.00}{\frac{6}{5}}=3.00\times\frac{5}{6}=\frac{3.00}{6}\times5=\frac{1}{2}\times5=2.50$$

The following fractions, their decimal equivalence and their percentages must be memorized.

$\frac{1}{5}=0.20=20.0\%$	$\frac{2}{5}=0.40=40.0\%$	$\frac{3}{5}=0.60=60.0\%$	$\frac{4}{5}=0.80=80.0\%$
$\frac{1}{8}=0.125=12.5\%$	$\frac{3}{8}=0.375=37.5\%$	$\frac{5}{8}=0.625=62.5\%$	$\frac{7}{8}=0.875=87.5\%$
$\frac{1}{3}=0.33=33\%$	$\frac{2}{3}=0.67=67\%$	$\frac{1}{4}=0.25=25\%$	$\frac{3}{4}=0.75=75\%$
$\frac{1}{2}=0.50=50\%$			

Once you know these fractions, you can use them to determine other fractions.

Example: What is $\frac{1}{6}$ as a decimal?

Think of $\frac{1}{6}$ as $\frac{1}{2}$ of $\frac{1}{3}$ ➔ ½ of 0.333 = 0.1667

Likewise, you can think of $\frac{1}{8}$ as ½ of ¼, which gives you ½ x ¼ or ½ x 0.25 = 0.125. You can think of $\frac{5}{8}$ as $\frac{4}{8}+\frac{1}{8}=\frac{1}{2}+\frac{1}{8}$ = 0.5 + 0.125 = 0.625, so as long as you have the basic list memorized, you should be able to do problems that appear on the test.

Example: What is 0.025 as a fraction?

First thing is to recognize that the fraction is really based on 0.25, or ¼. But you want 0.025, so that is done like this:

$$0.025=\frac{0.25}{10}=\frac{1/4}{10}=\frac{1/4}{10/1}=\frac{1}{4}\text{ x }\frac{1}{10}=\frac{1}{40}$$

This type of problem often appears when the question is dealing with stoichiometry or titration problems where you are given molarities like 0.025 M, 0.0125 M and 0.020 M.

If you are given a decimal number like 0.150 M or 0.120 M and it does not fit any of the fractions above, you can also write it as a fraction by moving the decimal to the right until it is behind the last non-zero number, and then put it over the appropriate power of 10, which would be $10^{(\text{number of decimal places moved})}$. So if you move a decimal 3 places to the right, then it the denominator will become 10^3, or 1000.

So, 0.150 M would become $\frac{15}{100}$ and 0.120 M becomes $\frac{12}{100}$. If you have a problem that involves molarities like these, work the problem with the fractions; the problem is designed for you to do that.

Example is from the 1994 AP test question #55.

What volume of 0.150-molar HCl is required to neutralize 25.0 millilters of 0.120-molar $Ba(OH)_2$?

(A) 20.0 mL
(B) 30 0 mL
(C) 40.0 mL
(D) 60.0 mL
(E) 80.0 mL

First step is to write out the balance equation.

$$Ba(OH)_2 + 2\ HCl \rightarrow 2\ HOH + BaCl_2$$

The second step is to place your information so you can do the problem.

$$Ba(OH)_2 + 2\ HCl \rightarrow 2\ HOH + BaCl_2$$

25.0 mL ? mL
0.120 M 0.150 M

Since the problem said “neutralize” we know that the moles of acid and the moles of base are stoichiometrically equal.

So, the first thing to do is to rewrite the molarities as fractions, $\frac{15}{100}$ and $\frac{12}{100}$.
Next, find the moles of $Ba(OH)_2$, moles = molarity x volume.

$$\text{moles} = \text{molarity} \times \text{volume} = \left(\frac{12}{100}\right)\frac{\text{moles}}{\cancel{\text{liter}}} \times 25.0\,\text{milli}\cancel{\text{liters}} = \left(\frac{12}{\cancel{100}_{4}}\right)\left(\frac{\cancel{25}^{1}}{1}\right) = \frac{12}{4} = 3\ \text{millimoles}$$

Notice that I only cancelled the “liters” part of the milliliters. This would leave a “milli” and that will be multiplied by the moles to get millimoles. You can “track” the “milli” through the problem.

Next find the number of moles HCl.

$$3.0\ \text{millimoles}\ Ba(OH)_2 \times \frac{2\ \text{moles HCl}}{1\ \text{mole}\ Ba(OH)_2} = 6\ \text{millimoles HCl}$$

Last step is to find the volume of HCl used. Volume equals $\frac{moles}{molarity}$.

$$\text{volume} = \frac{\text{moles}}{\text{molarity}} = \frac{6\text{ millimoles HCl}}{\left(\frac{15}{100}\right)\left(\frac{\text{moles}}{\text{liters}}\right)} = \overset{2}{\cancel{6}}\text{ milli}\cancel{\text{moles}}\text{ HCl} \times \left(\frac{\overset{20}{\cancel{100}}}{\underset{\underset{1}{\cancel{5}}}{\cancel{15}}}\right)\left(\frac{\text{liters}}{\cancel{\text{moles}}}\right) = 40.0\text{ milliliters}$$

A common type of problem will require you to use scientific notation and to use the following exponent laws (which need to be memorized):

$$a^m \times a^n = a^{m+n} \qquad a^m \div a^n = a^{m-n} \qquad \left(a^m\right)^n = a^{m\times n} \qquad \left(ab\right)^m = a^m b^m$$

$$a^0 = 1 \qquad a^{-n} = \frac{1}{a^n}\left(a \neq 0\right)$$

Example: A problem gives you the Keq value of 2.0×10^7 and would like the Keq value for the reverse reaction, which is the reciprocal of the given Keq value.

Answer: $$\frac{1}{2.0\times10^7} = \frac{1\times10^0}{2.0\times10^7} = \frac{1}{2}\times10^{0-7} = 0.5\times10^{-7} = 5\times10^{-8}$$

Another way to do this problem is to rewrite 1 as 10×10^{-1}. Doing this, you will have:

$$\frac{1}{2.0\times10^7} = \frac{10\times10^{-1}}{2.0\times10^7} = \frac{10}{2.0}\times10^{-1-7} = 5\times10^{-8}$$

This trick is very helpful when you have to do division. It allows you to get a whole number directly from the problem and not have to try to move the decimal point in scientific notation (like the first method does).

The last exponent rule is commonly used on the AP exam with units (both on the formula charts and in problems). The exponent law that says $a^{-n} = \frac{1}{a^n}$ will often show up on the test with units like sec^{-1} (which means $sec^{-1} = \frac{1}{sec^1} = \frac{1}{sec}$) or mol^{-1} ($\frac{1}{mol}$) or K^{-1} ($\frac{1}{K}$). When you are doing kinetic problems, you will see units like, M^{-2} ($M^{-2} = \frac{1}{M^2} = \frac{1}{\frac{mol^2}{liter^2}} = 1 \text{ x } \frac{liters^2}{mol^2} = \frac{liters^2}{mol^2}$).

You will also need to remember your "perfect squares" from 1 to 12.

$1^2 = 1$	$2^2 = 4$	$3^2 = 9$	$4^2 = 16$	$5^2 = 25$	$6^2 = 36$
$7^2 = 49$	$8^2 = 64$	$9^2 = 81$	$10^2 = 100$	$11^2 = 121$	$12^2 = 144$

Scientific Notation

In science, the numbers are characteristically very large (a mole is 602 214 179 000 000 000 000 000) or very small (the charge carried by an electron is 0.000 000 000 000 000 000 160 217 653 coulombs). Scientific notation is used to conveniently write the numbers using powers of ten. So 1,650,000 can be written (with four significant figures) as 1.650×10^6 (which generally will be written as 1.650×10^6 ~ it makes it easier for people to see the exponent). This can be thought of as 1.650 x 10 x 10 x 10 x 10 x 10 x 10 (six sets of 10, since the exponent was 6).

Notice that

$$\begin{aligned} &1.650 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \\ &= 16.50 \times 10 \times 10 \times 10 \times 10 \times 10 \\ &= 165.0 \times 10 \times 10 \times 10 \times 10 \\ &= 1650. \times 10 \times 10 \times 10 \\ &= 16500. \times 10 \times 10 \\ &= 165000. \times 10 \\ &= 1{,}650{,}000 \end{aligned}$$

> A note about commas and numbers: Most textbooks will not use commas to separate numbers into groups of three. They will add a space instead, so 1,650,000 will be written as 1 650 000 – this is because in other countries, a comma in a number is read as a decimal point and you can't have two decimal points in a number!

So by multiplying by 10, we are moving the decimal place over to the right that many times and get a number bigger than one.

1.650×10^6 is equal to 1. 6 5 0 0 0 0

Likewise, if we have a number that is smaller than one, we should divide by powers of 10 and move the decimal point to the left. So 0.000321 can be thought of as:

$$\frac{3.21}{10 \times 10 \times 10 \times 10} = \frac{3.21}{10^4} = \frac{3.21 \times 10^0}{10^4} = 3.21 \times 10^{0-4} = 3.21 \times 10^{-4}$$

Remember that 10^0 is 1 and anything multiplied by one is still itself.

Students have a problem sometimes in remembering if the exponent is positive or negative. The easiest way to remember this is to ask yourself "is the original number less than one?" The answer to this question will determine if your exponent is positive or negative.

Is the original number less than one?	Exponent will be	Examples
Yes	Negative	$0.0025 = 2.5 \times 10^{-3}$
No	Positive (or zero)	$320500 = 3.205 \times 10^5$

Powers and Roots

Just as operations of addition and subtraction and the operations of multiplication and division are related to each other (in math terms they are inverse operations of each other), so are exponents and roots. When $\sqrt[2]{9}$ is written, the 2 is called the "index", the 9 is called the "base" or "radicand" and the $\sqrt{\ }$ is called the "radical" or "root". When the index is "2", we often call it "square root".

Fractional exponents can be used to represent taking the "root" of a number, thus $\sqrt[2]{9}$ can also be written as $9^{1/2}$, likewise $8^{1/3}$ is another way to write the third root of eight, $\sqrt[3]{8}$, which equals 2. We will use this idea to solve problems like $x^2 = 2.5 \times 10^{-9}$. The idea here is to write the scientific notation in a non-traditional form so that it will be easier to take the square root.

$$x^2 = 2.5 \times 10^{-9} \rightarrow x^2 = 25 \times 10^{-10} \rightarrow x = \sqrt{25\times10^{-10}} \rightarrow x = \left(25\times10^{-10}\right)^{1/2} \rightarrow x = (25)^{1/2}\times\left(10^{-10}\right)^{1/2}$$

Since we went from 2.5 to 25 (we want a whole number that is a perfect square), we moved the decimal point to the right; we will need to move it back one extra space to the left, so the exponent will have to become -10.

$25^{1/2}$ is the square root of 25, which is 5 and the $\left(10^{-10}\right)^{1/2} = 10^{-5}$ since a power to a power is multiplied and $-10 \times 1/2 = -5$. So the final answer is $x = 5 \times 10^{-5}$.

Logarithms

Another type of math problem that you will be expected to be able to do is simple logarithms. Remember a logarithm is just another way to write an exponent problem. Remember that logarithms are just a "circular" way of writing exponents. Take for example $2^x = 8$ can be written as $\log_2 8$.

$$2^x = 8 \rightarrow \log_2 8 = 3$$

Remember that $-\log_{10} 1.0\times10^{-B} = B$, so when given a question that says "determine the approximate range that an indicator would be appropriate for?" – you are looking for the pKa value; you will need to know how to find the approximate answer. The exponent will always give you the characteristic of the number…unless the number in front of the "x" sign is 1, then your answer (when you take the log) will be (exponent – 1) – in this case B - 1.

Look at the following chart and look at the pattern of the numbers:

Number	$\log_{10}$ of number
1.00 x 10^{-5}	5.00
1.78 x 10^{-5}	4.75
3.16 x 10^{-5}	4.50
5.62 x 10^{-5}	4.25
10.0 x 10^{-5}	4.00

The logarithmic scale is not linear. The half-way point for the log (a mantissa of ".5") will be determined by 3.16 x $10^{-??}$; an easy way to remember this is π x $10^{-??}$ will give you the mantissa of ".5" and the exponent determines the characteristic of the your answer.

When you see things like pH, pOH, pK_a, pK_b or pK_w, what does the little "p" represent? The little "p" in front of a term means "$-\log_{10}$", so pH = $-\log_{10}[H^+]$, likewise $pK_a = \log_{10}K_a$ and so on.

Manipulation of Equations

In chemistry, just as in other science classes, students will have to manipulate equations. The equations are not hard and there are not too many that appear on the test. The most common equations and where they are used are given below.

Equation	Where is it used
$D = \frac{m}{V}$	Density problems – usually multiple choice
PV=nRT	Ideal Gas Law – gas law problems, usually on the free response
$M = \frac{moles_{solute}}{liters_{solution}}$	Molarity – determine the concentrations of solutions, usually multiple choice
$q = mc\Delta T$	Thermochemistry/specific heat problem – both multiple choice and free response problems
$\Delta G = \Delta H - T\Delta S$	Thermodynamics problems – both multiple choice and free response problems
$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$	Combined Gas Law – gas law problems, multiple choice usually

When solving an equation…use the algebra that you already know. You want to solve for a term, (meaning you want that term by itself) your equation should look like "term = variables".

Remember to solve for a variable, look at the other variables and you want to use the operation that "undoes" whatever you have in the problem.

- division undoes multiplication
- multiplication undoes division
- addition undoes subtraction
-

subtraction undoes addition

- power undoes a logarithm
- logarithm undoes a power

Examples:

$$D = \frac{m}{V}$$
$$VD = \frac{m}{V} \times V$$
$$VD = m$$

Solve for "m"

$$q = mc\,\Delta T$$
$$\frac{q}{c\,\Delta T} = \frac{mc\,\Delta T}{c\,\Delta T}$$
$$\frac{q}{c\,\Delta T} = m$$

Solve for "m"

$$M = \frac{\text{moles}_{\text{solute}}}{\text{liters}_{\text{solution}}} \Rightarrow$$
$$M = \frac{\text{mol}}{\text{vol}}$$
$$M \times \text{vol} = \frac{\text{mol}}{\text{vol}} \times \text{vol}$$
$$M \times \text{vol} = \text{mol}$$
$$\frac{M \times \text{vol}}{M} = \frac{\text{mol}}{M}$$
$$\text{vol} = \frac{\text{mol}}{M}$$

Solve for "volume"

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$
$$\frac{T_2P_1V_1}{T_1} = \frac{T_2P_2V_2}{T_2}$$
$$\frac{T_2P_1V_1}{T_1} = P_2V_2$$
$$\left(\frac{T_1}{P_1V_1}\right)\left(\frac{T_2P_1V_1}{T_1}\right) = \left(P_2V_2\right)\left(\frac{T_1}{P_1V_1}\right)$$
$$T_2 = \frac{P_2V_2T_1}{P_1V_1}$$

Solve for "T_2"

The last two are the hardest for students to do, since the problem asked for you to solve for a variable in the denominator. Your first task is to get the term out of the denominator, i.e. multiple both sides by that term and have them cancel. Then use algebra to solve for that term.

When you have the equation solved and are substituting (plugging in) your values, please don't forget the units. The units will tell you if you have the equation correct. If the units don't work out, you know that you made a mistake in solving the equation. Say that you are using the density equation to solve for volume and did the following work:

$$D = \frac{m}{V}$$
$$\left(\frac{1}{m}\right)(D) = \left(\frac{m}{V}\right)\left(\frac{1}{m}\right)$$
$$\frac{D}{m} = V$$

and then substituted the numbers with units and got this:

$$\frac{D}{m} = V \rightarrow \frac{\frac{\text{grams}}{\text{milliliters}}}{\text{grams}} = \frac{\frac{\text{grams}}{\text{milliliters}}}{\frac{\text{grams}}{1}} = \left(\frac{\text{grams}}{\text{milliliters}}\right)\left(\frac{1}{\text{grams}}\right) = \frac{1}{\text{milliliters}}$$

You are looking for volume and should get the units of “milliliters” and when you solved the problem, you got the units “ $\frac{1}{\text{milliliters}}$ ” which should tell you that your equation is wrong! Not only that, but getting the units “ $\frac{1}{\text{milliliters}}$ ” tells you how to fix your equation. You want “milliliters” and you got the reciprocal of that unit, so all you need to do is to take the reciprocal of your equation (flip the equation) and you will have $V = \frac{m}{D}$.

Some math tricks

- If you don’t like to work with numbers like 0.025, move the decimal point three places to the right and think of the number as 25 – just remember to move the decimal point three places back to the left when done with the problem.
- Anytime that you have a number that has 25 in it…think of it as money. You are dealing with a quarter. If the problem is 0.25x = 1.25 → that is the same as asking how many quarters does it take to make $1.25?
- If you are a “music person” – then think of “25” as a quarter note, so 0.25x = 1.25 is the same as asking, “How many quarter notes does it take to make a whole and quarter note?” – make it relevant to your interests.
- If you are squaring a number that ends in 5, like 35. This is what you can do.
    - Take the number in front of the 5 – in this case it is 3.
    - Add one to the number – in this example that would be 1 + 3 = 4
    - Take this number and multiple by the original number; here we get 4 x 3 = 12.
    - Take this number and put 25 at the end. Here we would get 1225.

- Use the skills that you learned in algebra for factoring.
    - $(a + b)(a - b) = a^2 – b^2$ is one of the most common factoring methods used in algebra. How does it relate to doing problems? Let’s say that you have the following problem: 47 x 43 = ? You can think of that as:

$$(45 + 2)(45 – 2)$$
$$= 45^2 – 2^2$$
$$= 2025 – 4$$
$$= 2021$$

    - Another method is to use the distributive property “backwards”. Let’s say that you have to solve the problem 12 x 14. To make this problem simpler to solve, think of 14 as 12 + 2, so:

$$12 \times 14 = ?$$
$$12(12 + 2) = ?$$
$$(12 \times 12) + (12 \times 2) = ?$$
$$12^2 + (12 \times 2) = ?$$

Problems

DO NOT use a calculator on these problems. This should all be able to be done without them.

1) Complete the following chart – have the fractions in lowest terms.

	Decimal	Fraction		Decimal	Fraction
a)	0.375		j)	0.67	
b)	0.75		k)	0.125	
c)	0.875		l)	0.33	
d)	0.60		m)	0.5	
e)	0.25		n)	0.20	
f)	0.020		o)		$\frac{3}{4}$
g)	0.075		p)		$\frac{1}{4}$
h)	0.005		q)		$\frac{1}{5}$
i)	0.625		r)		$\frac{1}{16}$

2) Solve the following by <u>rewriting them as fractions (if needed) and **show your work**.</u>

Express answers in this column as a fraction or whole number			Express answers in this column as a decimal (may approximate if needed)	
a)	$\frac{0.5}{0.125}$		g)	$\frac{1}{1.25}$
b)	$\frac{0.25}{0.50}$		h)	$\frac{0.5}{0.2}$

c)	$\frac{0.025}{0.075}$		i)	$\frac{1/8}{1/5}$
d)	$\frac{0.125}{0.075}$		j)	$\frac{1}{2\,1/5}$
e)	$\frac{0.6}{0.02}$		k)	$\frac{3/8}{2.5}$
f)	$\frac{0.6}{0.2}$		l)	$\frac{2.625}{1.75}$

3) Solve the following, **showing all of your work.**

a)	$\dfrac{6 \text{ x } 10^{18}}{4 \text{ x } 10^{-5}} =$
b)	$\dfrac{1}{4 \text{ x } 10^{-5}} =$
c)	$\dfrac{(4 \text{ x } 10^{-5})(1.5 \text{ x } 10^{13})}{1.5 \text{ x } 10^{4}} =$
d)	$(4 \text{ x } 10^{-5})(1.5 \text{ x } 10^{13}) =$
e)	$\dfrac{(2 \text{ x } 10^{7})(1.5 \text{ x } 10^{4})}{4.5 \text{ x } 10^{8}} =$
f)	$(4 \text{ x } 10^{-5})^3 =$

4) Solve the following problems, using cross canceling of numbers. **Show your work.**

a) $9 \times \dfrac{1}{18} \times \dfrac{2}{4} \times \dfrac{44}{1} =$ ________

e) $87 \times \dfrac{1}{174} \times \dfrac{3}{2} \times \dfrac{28}{1} =$ ________

b) $280 \times \dfrac{1}{28} \times \dfrac{3}{1} \times \dfrac{6}{1} =$ ________

f) $12 \times \dfrac{1}{2} \times \dfrac{1}{2} \times \dfrac{42}{1} =$ ________

c) $70 \times \dfrac{1}{28} \times \dfrac{1}{1} \times \dfrac{42}{1} =$ ________

g) $165 \times \dfrac{1}{55} \times \dfrac{2}{4} \times \dfrac{158}{1} =$ ________

d) $48 \times \dfrac{1}{32} \times \dfrac{2}{3} \times \dfrac{158}{1} =$ ________

h) $0.33 \times \dfrac{1}{44} \times \dfrac{1}{1} \times \dfrac{100}{1} =$ ________

5) Solve for "*x*".

a) $\dfrac{(x)(x)}{0.5} = 5.0 \times 10^{-5}$

b) $\dfrac{(x)(x)}{0.25} = 6.4 \times 10^{-7}$

c) $\dfrac{(x)(x)}{0.125} = 3.2\times10^{-9}$

d) $(x)(2x)^2 = 3.2\times10^{-8}$

e) $\dfrac{(x)(x)}{0.5} = 8.0\times10^{-16}$

f) $(3x)^3(2x)^2 = 1.08\times10^{-3}$

Examples of AP Multiple Choice Questions

Do the problems and answer the questions.

1. What is the mole fraction of ethene, C_2H_4, in an aqueous solution that is 28 percent ethene by mass? The molar mass of ethene is 28 g, the molar mass of H_2O is 18 g.

   (a) 0.20
   (b) 0.25
   (c) 0.50
   (d) 0.67
   (e) 0.75

   To solve this problem you will need to solve this:
   Then your final answer is found by

2. If 200. mL of 0.80 *M* $MgCl_2$(aq) is added to 600. mL of distilled water, what is the concentration of Cl^-(aq) in the resulting solution?

   To solve this problem you will need to solve this:

   (a) 0.20 *M*
   (b) 0.30 *M*
   (c) 0.40 *M*
   (d) 0.60 *M*
   (e) 1.2 *M*

3. How many grams of calcium carbonate, $CaCO_3$, contain 48 grams of oxygen atoms?

   (a) 41 grams
   (b) 50. grams
   (c) 62 grams
   (d) 88 grams
   (e) 100 grams

   To solve this problem you will need to solve this:

4. When a 1.25-gram sample of limestone, that co … ms of CO_2 was generated. What was the percent of $CaCO_3$ by mass in the limestone?

   (a) 20%
   (b) 40%
   (c) 67%

   To solve this problem you will need to solve this:

(d) 80%
(e) 100%

5. A gaseous mixture containing 7.0 moles of hydrogen, 2.5 moles of oxygen, and 0.50 mole of helium at a total pressure of 0.60 atmospheres. What is the partial pressure of the hydrogen?

(a) 0.13 atm
(b) 0.42 atm
(c) 0.63 atm
(d) 0.90 atm
(e) 6.3 atm

To solve this problem you will need to solve this:

6. The density of an unknown gas is 2.00 grams per liter at 3.00 atmospheres pressure and 127 °C. What is the molecular weight of this gas? (R = 0.0821 liter-atm / mole-K)

(a) 254/3 R
(b) 188 R
(c) 800/3 R
(d) 600 R
(e) 800 R

To solve this problem you will need to solve this:

7. $CH_4(g) + 2\ O_2(g) \rightarrow CO_2(g) + 2\ H_2O(l)$; $\Delta H = -890$ kJ

$\Delta H_f^\circ\ H_2O(l) = -\ 290$ kJ / mole

$\Delta H_f^\circ\ CO_2(g) = -\ 390$ kJ / mole

What is the standard heat of formation of methane, $\Delta H_f^\circ\ CH_4(g)$, as calculated from the data above?

(a) -210. kJ/mole
(b) -110. kJ/mole
(c) -80. kJ/mole
(d) 80. kJ/mole
(e) 210. kJ/mole

To solve this problem you will need to solve this:

8. If 70. grams of K_3PO_4 (molar mass 210 grams) is dissolved in enough water to make 250 milliliters of solution, what are the concentrations of the potassium and the sulfate ions?

	$[K^+]$	$[PO_4^{3-}]$
(A)	0.75 M	0.75 M
(B)	1.0 M	2.0 M
(C)	1.3 M	1.3 M
(D)	2.0 M	2.0 M
(E)	4.0 M	1.3 M

To solve this problem you will need to solve this:

9. What mass of Cu is produced when 0.0500 mol of Cu_2S is reduced completely with excess H_2?

To solve this problem you will need to solve this:

(a) 6.35 g
(b) 15.9 g
(c) 24.5 g
(d) 39.4 g
(e) 48.9 g

10. $CS_2(l) + 3\ O_2(g) \rightarrow CO_2(g) + 2\ SO_2(g)$

What volume of $O_2(g)$ is required to react with excess CS_2 (l) to produce 2.0 liters of $CO_2(g)$? (Assume all gases are measured at 0ºC and 1 atm.)

(a) 6 L
(b) 22.4 L
(c) 1/3 x 22.4 L
(d) 2 x 22.4 L
(e) 3 x 22.4 L

To solve this problem you will need to solve this:

11. A 2 L container will hold about 6 g of which of the following gases at 0ºC and 1 atm?

To solve this problem you will need to solve this:

(a) SO_2

(b) N_2

(c) CO_2

(d) C_4H_8

(e) NH_3

12.

$$2\ N_2H_4(g) + N_2O_4(g) \rightarrow 3\ N_2(g) + 4\ H_2O(g)$$

When 8 g of N_2H_4 (32 g mol^{-1}) and 46 g of N_2O_4 (92 g mol^{-1}) are mixed together and react according to the equation above, what is the maximum mass of H_2O that can be produced?

(a) 9.0 g
(b) 18 g
(c) 36 g
(d) 72 g
(e) 144 g

To solve this problem you will need to solve these two problems:

13. What number of moles of O_2 is needed to produce 71 grams of P_4O_{10} from P? (Molecular weight P_4O_{10} = 284)

(a) 0.500 mole
(b) 0.625 mole
(c) 1.25 mole
(d) 2.50 mole
(e) 5.00 mole

To solve this problem you will need to solve this:

$$\text{Rate} = k[A]^2\,[B]$$

14. The rate of a certain chemical reaction between substances A and B obeys the rate law above. The reaction is first studied with [A] and [B] each 1×10^{-3} molar. If a new experiment is conducted with [A] and [B] each 2×10^{-3} molar, the reaction rate will increase by a factor of

(a) 2
(b) 4
(c) 6
(d) 8
(e) 16

To solve this problem you will need to solve this:

$[2]^2[2] =$

15. A 0.5-molar solution of a weak monoprotic acid, HA, has a K_a of 3.2×10^{-5}. The $[H_3O^+]$ is?

(a) 5.0×10^{-7}
(b) 2.0×10^{-7}
(c) 1.6×10^{-5}
(d) 1.6×10^{-4}
(e) 4.0×10^{-3}

To solve this problem you will need to solve for x.

16. Uranium-235 undergoes neutron capture as shown in the equation below. Identify nuclide ***X***.

$$^{235}_{92}\text{U} \;+\; ^{1}_{0}\text{n}^{0} \longrightarrow\, ^{145}_{56}\text{Ba} \;+\; 3\,^{1}_{0}\text{n}^{0} \;+\; X$$

(a) $^{93}_{34}\text{Se}$
(b) $^{90}_{34}\text{Se}$
(c) $^{88}_{36}\text{Kr}$
(d) $^{90}_{36}\text{Kr}$
(e) $^{93}_{36}\text{Kr}$

To solve this problem: the numbers on the top for the reactants must equal the numbers on the top for the products. Same is true for the bottom numbers.

17. $H_2(g) + Br_2(g) \leftrightarrow 2\ HBr(g)$

At a certain temperature, the value of the equilibrium constant, K, for the reaction represented above is 4.0×10^{5}. What is the value of K for the <u>reverse</u> reaction at the same temperature?

(a) 4.0×10^{-5}
(b) 2.5×10^{-6}
(c) 2.5×10^{-5}
(d) 5.0×10^{-5}
(e) -4.0×10^{5}

To solve this problem you will need to solve

18. If the acid dissociation constant, K_a, for an acid HA is 8×10^{-4} at 25 °C, what percent of the acid is dissociated in a 0.50-molar solution of HA at 25 °C?

(a) 0.08%
(b) 0.2%
(c) 1%
(d) 2%
(e) 4%

To solve this problem you will need to solve for x in the first equation and then plug it into the second expression and solve.

AP CHEMISTRY SUMMER ASSIGNMENT

To: Students presently registered to take AP Chemistry in 2018-2019

From: Mr. Byrnes (rbyrnes@rutherfordschools.org)

Date: May, 2018

Important Note:
This is a **required assignment**. It is a review of the early concepts covered in Honors Chemistry. Portions of this assignment (as noted) will be collected and graded, and the material will be covered on the first unit test. We will spend the first few days of school focusing on Chapters 1-3.

Welcome to AP chemistry! AP chemistry is a difficult course - this is why I give a summer assignment. I need you ready for the start of the school year by reviewing the things you should have learned in Honors Chem or Chem 1. I will not have the time to re-teach what was covered in those earlier courses. We will be dealing with the same topics but at a deeper and more technical level. With this in mind, if you find the summer assignment too difficult or just too much work, you may want to reconsider taking this course.

The AP Chemistry curriculum is content-intensive, so we will move quickly in order to be ready for the AP exam in May. As such, the class will be challenging and you should expect some challenging assignments. Don't forget that this course is designed to match a first-year college chemistry class. Keep in mind that the biggest factor in determining your success will be the amount of effort you put in.

Over the summer, you are responsible for completing all of the assignments in this packet. The ten worksheets (clearly labeled) will be collected and graded. They are due on the first day of school.

Included in this packet is a copy of your new periodic table and the formulas page used on the actual exam - so you should start getting used to it. You might notice that there is no list of polyatomic ions on the back of the table; that's because you are expected to know them!

The Summer Assignment: (All materials referenced here can be found in the google classroom site - entry code: sva4s8)

Part I:

Mathematics Review for AP Chemistry Packet:
- format of AP Chemistry exam, strategies for doing the math on the exam, conversions and dimensional analysis, scientific notation and general math review
- practice problems (***not scored***) including math required for some sample AP exam problems

Part II:

Read chapters 1 – 3 in this textbook:
Chemistry, Zumdahl and Zumdahl, 8th Edition
Note: This is not the text we use during the year – however, this is an excellent resource and I encourage you to use it heavily for this summer assignment.

The chapters are provided on-line in the AP google classroom.

Part III:

Answer the following ***suggested*** questions from the assigned chapters (these will not be collected). Be sure to report all answers for problems involving calculations to the correct number of significant figures.

Chapter 1 problems, pages 31-38, #s 4, 8, 15, 24, 60, 64, 66, 73, 77, 79, 82, 105

Chapter 2 problems, pages 69-75, #s 2, 5, 6, 7, 10, 11, 12, 14, 15, 23, 32, 33, 34, 56, 60, 62, 80, 95, 103, 106, 108, 110

Chapter 3 problems, pages 117-128, #s 13, 15, 16, 27, 30, 64, 69, 75, 76, 99, 100, 101, 106, and any from the "Additional Exercises, #s 132-148

Part IV:

AP Chemistry is not all about memorization; however, having the following items memorized is essential for success in learning the concepts covered in the course. Make flashcards, have your friends and family quiz you, take the lists with you on vacation, or do whatever it takes to get this information firmly planted in your head.

Five things to memorize: (they are attached for your convenience)

1) Rules for determining oxidation numbers
2) Solubility rules
3) Rules for naming ionic compounds
4) Rules for naming acids
5) Common ions and Polyatomic ions

Part V:

Do the worksheets: **All will be turned on the first full day of school and graded.**

These worksheets are also provided as separated pdf files in the AP Chem Google Classroom.

Worksheet #1: Significant Figures and Dimensional Analysis

Worksheet #2: Structure of the Atom and the Periodic Table

Worksheet #3: Naming Inorganic Compounds

Worksheet #4: Writing Equations for Chemical Reactions

Worksheet #5: The Mole

Worksheet #6: Empirical and Molecular Formulas

Worksheet #7: Stoichiometry Problems

Worksheet #8: Limiting Reactants and Theoretical Yield

Worksheet #9: Solubility Rules

Worksheet #10: Personal Statement

Rules for Determining Oxidation Numbers (aka Oxidation States)

Oxidation Number: A number assigned to an atom in a molecular compound or molecular ion that indicates the general distribution of electrons among the bonded atoms.

1. The oxidation number of any uncombined element is zero.
2. The oxidation number of a monatomic ion equal the charge on the ion.
3. The more electronegative element in a binary compound is assigned the number equal to the charge it would have if it were an ion.
4. The oxidation number of fluorine in a compound is always –1
5. Oxygen has an oxidation number of –2 unless it is combined with F, when it is +2, or it is in a peroxide, when it is –1.
6. The oxidation state of hydrogen in most of its compounds is+1 unless it combined with a metal, in which case it is –1.
7. In compounds, the elements of groups 1 and 2 as well as aluminum have oxidation number of +1, +2, and +3, respectively
8. The sum of the oxidation numbers of all atoms in a neutral compound is zero.
9. The sum of the oxidation number of all atoms in a polyatomic ion equals the charge of the ion.

Solubility Rules

1. Salts containing Group I elements are soluble (Li^+, Na^+, K^+, Cs^+, Rb^+). Exceptions to this rule are rare. Salts containing the ammonium ion (NH_4^+) are also soluble.

2. Salts containing nitrate ion (NO_3^-) are generally soluble.

3. Salts containing Cl^-, Br^-, I^- are generally soluble. Important exceptions to this rule are halide salts of Ag^+, Pb^{2+}, and $(Hg_2)^{2+}$. Thus, $AgCl$, $PbBr_2$, and Hg_2Cl_2 are all insoluble.

4. Most silver salts are insoluble. $AgNO_3$ and $Ag(C_2H_3O_2)$ are common soluble salts of silver; virtually anything else is insoluble.

5. Most sulfate salts are soluble. Important exceptions to this rule include $BaSO_4$, $PbSO_4$, Ag_2SO_4 and $SrSO_4$.

6. Most hydroxide salts are only slightly soluble. Hydroxide salts of Group I elements are soluble. Hydroxide salts of Group II elements (Ca, Sr, and Ba) are slightly soluble. Hydroxide salts of transition metals and Al^{3+} are insoluble. Thus, $Fe(OH)_3$, $Al(OH)_3$, $Co(OH)_2$ are not soluble.

7. Most sulfides of transition metals are highly insoluble. Thus, CdS, FeS, ZnS, Ag_2S are all insoluble. Arsenic, antimony, bismuth, and lead sulfides are also insoluble.

8. Carbonates are frequently insoluble. Group II carbonates (Ca, Sr, and Ba) are insoluble. Some other insoluble carbonates include $FeCO_3$ and $PbCO_3$.

9. Chromates are frequently insoluble. Examples: $PbCrO_4$, $BaCrO_4$

10. Phosphates are frequently insoluble. Examples: $Ca_3(PO_4)_2$, Ag_3PO_4

11. Fluorides are frequently insoluble. Examples: BaF_2, MgF_2 PbF_2.

Naming Covalent Compounds Rules

RULES FOR NAMING COVALENT COMPOUNDS

Diatomic Molecule (*1 element only*)

- Br_2, I_2, N_2, Cl_2, H_2, O_2, F_2
- Name the element!

Examples:

- **H_2** ______________________________
- **I_2** ______________________________

WHAT IS A PREFIX?

- A word added to the beginning of an element name that indicates how many of that element is present

PREFIXES

Look at the subscripts to tell you how many of each element you have

One	***mono-***
Two	***di-***
Three	***tri-***
Four	***tetra-***
Five	***penta-***
Six	***hexa-***
Seven	***hepta-***
Eight	***octa-***
Nine	***nona-***
Ten	***deca-***

Covalent Binary (*Nonmetal / Nonmetal*)

- Name the first element
    - Add appropriate **prefixes** *EXCEPT* **"mono-"**
- Name the second element
    - Add appropriate **prefixes** *INCLUDING* "**mono-**"
- Change ending of second element to "**-ide**"

Examples:

- **P_2O_5** ______________________________
- **CO** ______________________________

Rules for Naming Binary Ionic Compounds

Examples:

NaCl – sodium chloride BaF2 – barium fluoride CuO – copper (II) oxide

1. The full name of the cation is listed first. (A cation is a positive ion).
2. The root of the anion name is listed second and is followed by the suffix "ide."(An anion is a negative ion).
3. If the compound contains a transition metal, a Roman numeral is included after the cation name to indicate the oxidation number of the metal.
4. Remember that the cation(s) and anion(s) combine in the simplest ratio that balances the charge. That is, the sum of the charge must be equal to zero in the compound formed.

Rules for Naming Ionic Compounds Containing Polyatomic Ions

Examples:

$CaCO_3$- calcium carbonate $Fe(OH)_3$-iron (III) hydroxide $(NH_4)_2SO_4$ – ammonium sulfate

1. The full name of the cation is listed first.
2. The full name of the anion is listed second.
3. Use the table below for common polyatomic ions
4. Remember that the cation(s) and anion(s) combine in the simplest ratio that balances the charge. That is, the sum of the charge must be equal to zero in the compound formed.
5. Finally, use parentheses when the simplest ratio requires more than one polyatomic ion in the compound formula.

Naming Acids Rules

RULES FOR NAMING ACIDS

H + Element

- **Hydro** + ***root*** *of element name* + **-ic acid**

Examples:

- **H_3N** ________________________________
- **HI** ________________________________

H + Polyatomic Ion

Root of polyatomic ion name + appropriate ending:

- Polyatomic ion ends in "**-ate**" change ending to "-**ic** acid"
- Polyatomic ion ends in "***-ite***" change ending to "**-ous** acid"

Examples:

- **H_2SO_4** ________________________________
- **$HClO_2$** ________________________________

WHAT IS A ROOT?

- *the **first part** of an element or polyatomic ion name:*

Example:

Nitrogen = ***Nitr-***

Chlorine = ***Chlor-***

REMEMBER!!!!!

-ate -ic

-ite -ous

Polyatomic Ions:

Polyatomic Ions are ions that contain a number of atoms. There is a list of polyatomic ions below. There is no formula for learning how to write their names, you must commit them to memory. (When you commit them to memory, remember the charges, names, and formulas.) Naming Polyatomic compounds is much like naming Binary I or II compounds. Remember transition metals usually form two or more ions and parentheses and Roman numeral should be used.

Memorize the following items. Know name, formula (or symbol) and charges:

Positive Ions (Cations)

1+	2+	3+	4+
ammonium NH_4^+	barium Ba^{2+}	aluminum Al^{3+}	carbon C^{4+}
cesium Cs^+	beryllium Be^{2+}	antimony(III) Sb^{3+}	lead(IV) Pb^{4+}
copper(I) Cu^+	cadmium(II) Cd^{2+}	bismuth(III) Bi^{3+}	silicon Si^{4+}
gold(I) Au^+	calcium Ca^{2+}	chromium(III) Cr^{3+}	tin(IV) Sn^{4+}
hydrogen H^+	chromium(II) Cr^{2+}	cobalt(III) Co^{3+}	
lithium Li^+	cobalt(II) Co^{2+}	gallium Ga^{3+}	
potassium K^+	copper(II) Cu^{2+}	gold(III) Au^{3+}	
rubidium Rb^+	iron(II) Fe^{2+}	manganese(III) Mn^{3+}	**5+**
silver Ag^+	lead(II) Pb^{2+}	nickel(III) Ni^{3+}	antimony(V) Sb^{5+}
sodium Na^+	magnesium Mg^{2+}	iron(III) Fe^{3+}	bismuth(V) Bi^{5+}
	manganese(II)Mn^{2+}		
	mercury(I) Hg_2^{2+}		
	mercury(II) Hg^{2+}		
	nickel(II) Ni^{2+}		
	strontium Sr^{2+}		
	tin(II) Sn^{2+}		
	zinc Zn^{2+}		

Memorize the following items. Know name, formula (or symbol) and charges:

Negative Ions (Anions)

-1	-2	-3	-4
acetate CH_3COO^-	carbonate CO_3^{2-}	arsenide As^{3-}	carbide C^{4-}
bromide Br^-	chromate CrO_4^{2-}	nitride N^{3-}	
chlorate ClO_3^-	dichromate $Cr_2O_7^{2-}$	phosphate PO_4^{3-}	
chloride Cl^-	oxalate $C_2O_4^{2-}$	phosphide P^{3-}	
chlorite ClO_2^-	oxide O^{2-}	phosphite PO_3^{3-}	
cyanide CN^-	peroxide O_2^{2-}		
fluoride F-	silicate SiO_3^{2-}		
hydride H-	sulfate SO_4^{2-}		
hydrogen carbonate HCO_3- (bicarbonate)	sulfide S^{2-}		
hydroxide OH-	sulfite SO_3^{2-}		
hypochlorite OCl-	thiosulfate $S_2O_3^{2-}$		
iodate IO_3-			
iodide I-			
nitrate NO_3-			
nitrite NO_2-			
perchlorate ClO_4-			
permanganate MnO_4-			
thiocyanate SCN-			

Name ___________________________

Worksheet #1
Significant Figures and Dimensional Analysis

For each problem below, write the equation and show your work. Always use units and box your final answer.

1. Round each of the following numbers to four significant figures, and express the result in scientific notation on the line provided:
   a. 300.235800 ________________
   b. 456,500 ________________
   c. 0.006543210 ________________
   d. 0.000957830 ________________
   e. – 0.035000 ________________

2. Carry out the following operations, and express the answers with the appropriate number of significant figures on the line provided:
   a. 1.24056 + 75.80 ________________
   b. 23/67 - 75 ________________
   c. 890,000 x 112.3 ________________
   d. 78,132 / 2.50 ________________
   e. 1.23 + 75 ________________
   f. 1.89 - .20 ________________
   g. 45.6 x 8.2 ________________
   h. 234 / 0.298 ________________
   i. 0.887 + 0.3 ________________
   j. 2340 - 100 ________________
   k. (8 + 9)/(34.0 – 20.) ________________

l. 0.8897 x 2.15 + 0.002/.1 ________________

m. 45.0 x 9.0 + 89.22/ 75 ________________

n. (2.88 + .5) x (23,000 - 0.11) ________________

For each problem below, show your work. Always use units and box in your final answer.

3. The density of pure silver is 10.5 g/cm^3 at 20ºC. If 5.25 g of pure silver pellets are added to a graduated cylinder containing 11.2 mL of water, to what volume level will the water in the cylinder rise?

4. The density of air at ordinary atmospheric pressure and 25ºC is 1.19 g/L. What is the mass, in kilograms, of the air in a room that measures 12.5 x 15.5 x 8.0 ft?

5. An aluminum block has a density of 2.70 g/mL. If the mass of the block is 24.60 g, find the volume of the substance.

6. A student can eat 4.0 M&Ms every 1.00 seconds. If an M&M has a mass of 63 mg, determine how many kilograms of M&Ms can be eaten by a class of 20 students in 3 hours and 45 minutes.

7. Convert the following measurements to the desired unit:

a. 0.050 cm = ______ mm

b. 1872 mg = _______ kg

c. 1.9 dL = ________ cL

d. 3.4x10-3 ks = ________ cs

Name ___________________________

Worksheet #2

Structure of the Atom and the Periodic Table

1. What were the main points of Dalton's Atomic Theory? Which of these points are still accepted today? Which ones do we no longer accept, and why?

2. Summarize the evidence used by J.J. Thomson to argue that cathode rays consist of negatively charged particles.

3. Let's pretend you are holding two atoms of carbon that are isotopes. Describe what the two atoms have in common and how they are different.

4. Fill in the gaps in the table, assuming each column represents a neutral atom:

Symbol	$^{39}_{19}K$				
# Protons		25			82
# Neutrons		30	64		

# Electrons			48	56	
Mass #				137	207

5. Write the correct symbol, with both superscripts and subscripts, for each of the following:

   a) the isotope of sodium with mass 23 ________________

   b) the atom of vanadium that contains 28 neutrons ________________

   c) the isotope of chlorine with mass 37 ________________

   d) an atom of magnesium that has an equal number of protons and neutrons ________________

6. Give the name and the common charge for elements found in each of these groups of the Periodic Table:

a) Group 1 ___________________________ b) Group 2 ___________________________

c) Group 17 ___________________________ d) Group 18 ___________________________

6. Describe where each type of element is found on the Periodic Table:

a) metals ________________________________ b) nonmetals ___________________________

c) transition metals ________________________ d) lanthanides ___________________________

d) actinides _______________________________

Name ___________________________

Worksheet #3
Naming Inorganic Compounds

1. Give the name for each of the following ionic compounds:
   a. AlF_3 ____________________
   b. $Fe(OH)_2$ ____________________
   c. $Cu(NO_3)_2$ ____________________
   d. $Ba(ClO_4)_2$ ____________________
   e. Li_3PO_4 ____________________
   f. Hg_2S ____________________
   g. $Ca(C_2H_3O_2)_2$ ____________________
   h. $Cr_2(CO_3)_3$ ____________________
   i. K_2CrO_4 ____________________
   j. $(NH_4)_2SO_4$ ____________________

2. Write the chemical formula for each of the following compounds:
   a. copper (I) oxide ____________
   b. potassium peroxide ____________
   c. aluminum hydroxide ____________
   d. zinc nitrate ____________
   e. mercury (I) bromide ____________
   f. iron (III) carbonate ____________
   g. sodium hypobromite ____________

3. Give the name or chemical formula, as appropriate, for each of the following acids:
   a. $HBrO_3$ ____________________
   b. HBr ____________________
   c. H_3PO_4 ____________________
   d. hypochlorous acid ____________________
   e. iodic acid ____________________
   f. sulfurous acid ____________________

4. Give the name or chemical formula, as appropriate, for each of the following molecular substances:
    a. SF_6 ________________________________
    b. IF_5 ________________________________
    c. XeO_3 ________________________________
    d. dinitrogen tetroxide ________________________________
    e. hydrogen cyanide ________________________________
    f. tetraphosphorous hexasulfide ________________________________

Name ___________________________

Worksheet #4
Writing Chemical Equations

For each equation below, identify the type (synthesis, decomposition, single replacement, double replacement, or combustion), predict the products, and then write the balanced equation for the reaction. Remember to use the solubility rules for double replacement reactions and the activity series for single replacement reactions. Hint: when writing these reactions, ignore all of the information about heat, or bubbling, or mixing. These are just excess words used to make complete sentences. Simply pull out the chemical formulas.

For example:
Solutions of silver nitrate and magnesium iodide are combined. This is a double replacement reaction.

$2AgNO_3(aq) + MgI_2(aq) \rightarrow 2AgI(s) + Mg(NO_3)_2(aq)$

1. Ammonium sulfate reacts with barium nitrate.

2. Zinc metal is added to a solution of copper (II) chloride.

3. Propane gas (C_3H_8) is burned in excess oxygen.

4. Perchloric acid reacts with cadmium to form cadmium perchlorate and a gas.

5. Magnesium and nitrogen gas are heated together.

6. Chlorine gas is bubbled through a solution of sodium bromide.

7. Solutions of lead nitrate and calcium iodide are combined.
8. Sulfuric acid is combined with sodium hydroxide.

9. Isopropyl alcohol (C_3H_7OH) is burned in oxygen.

10. Iron metal shavings are added to hydrochloric acid.

11. Solid sodium carbonate is heated in a crucible.

12. Sodium metal is added to distilled water.

13. Zinc carbonate can be heated to form zinc oxide and carbon dioxide

14. On treatment with hydrofluoric acid, silicon dioxide forms silicon tetrafluoride and water.

15. Sulfur dioxide reacts with water to form sulfurous acid.

16. Liquid butane fuel (C_4H_{10}) burns in the presence of oxygen gas.

17. A solution of sodium bromide reacts with a solution of vanadium (III) nitrate to form a brightly colored precipitate.

Name ____________________________

Worksheet #5
The Mole

For each problem below, show your work. Always use units and box in your final answer.

1. Determine the molar mass of each of the following compounds:

   a) N_2O_5

   b) $FeCO_3$

   c) $Ca(C_2H_3O_2)_2$

   d) $(NH_4)_3PO_4$

   e) sodium nitrate

   f) copper (II) sulfate

   g) disilicon hexabromide

2. The molecular formula of aspartame, the artificial sweetener marketed as NutraSweet, is $C_{14}H_{18}N_2O_5$.

   a) What is the molar mass of aspartame?

   b) How many moles of aspartame are present in 1.00 mg of aspartame? (1000 mg = 1g)

   c) How many molecules of aspartame are present in 1.00 mg of aspartame?

d) How many hydrogen atoms are present in 1.00 mg of aspartame?

3. A sample of glucose, $C_6H_{12}O_6$, contains 2.03×10^{21} atoms of carbon.
   a) How many atoms of hydrogen does it contain?

   b) How many molecules of glucose does it contain?

   c) How many moles of glucose does it contain?

   d) What is the mass of the sample in grams?

4. Calculate the following amounts:
   a) How many moles of chloride ions are in 0.0750 g of magnesium chloride?

   b) What is the mass, in grams, of 3.50×10^{-3} mol of aluminum sulfate?

   c) What is the mass, in grams, of 1.75×10^{20} molecules of caffeine, $C_8H_{10}N_4O_2$?

d) What is the molar mass of cholesterol if 0.00105 mol weigh 0.406 g?

5. Calculate the number of molecules in:
   a) 0.0666 mol propane, C_3H_8, a hydrocarbon fuel

   b) A 50.0 mg tablet of acetaminophen, $C_8H_9O_2N$, an analgesic solid under the name of Tylenol

   c) A tablespoon of table sugar, $C_{12}H_{22}O_{11}$, weighing 10.5 g

6. The allowable concentration level of vinyl chloride, C_2H_3Cl, in the atmosphere in a chemical plant is 2.0×10^{-6} g/L.
   a) How many moles of vinyl chloride in each liter does this represent?

   b) How many molecules per liter is this?

Name __________________________

Worksheet #6
Empirical and Molecular Formulas

For each problem below, show your work. Always use units and box in your final answer.

1. Determine the empirical formula of each of the following compounds if a sample contains
   a. 0.104 mol K, 0.052 mol C, and 0.156 mol O

   b. 5.28g Sn and 3.37g F

   c. 87.5 percent N and 12.5 percent H by mass

2. Determine the empirical formulas of the compounds with the following compositions by mass
   a. 10.4% C, 27.8% S, and 61.7% Cl

b. 21.7% C, 9.6% O, and 68.7% F

3. What is the molecular formula of each of the following compounds?
   a. empirical formula CH_2, molar mass = 84 g/mol

   b. empirical formula NH_2Cl, molar mass = 51.5 g/mol

4. Determine the empirical and molecular formulas of each of the following substances:
   a. Ibuprofen, a headache remedy, contains 75.69% C, 8.80% H, and 15.51% O by mass; the molar mass is about 206 g.

   b. Benzene contains only carbon and hydrogen and is 7.74% hydrogen by mass. The molar mass of benzene is 78.1 g/mol.

5. Many homes in rural America are heated by propane gas, a compound that contains only carbon and hydrogen. Complete combustion of a sample of propane produced 2.641 g of carbon dioxide and 1.442 g of water as the only products. Find the empirical formula of propane. (Hint: Figure out how many moles of C and H were produced. They all came from the fuel.)

6. (This is probably the hardest problem in the whole packet!) Menthol, the substance we can smell in mentholated cough drops, is composed of C, H, and O. A 0.1005 g sample of menthol is combusted, producing 0.2829 g of CO_2 and 0.1159 g of H_2O.
   a. What is the empirical formula for menthol?

b. If the compound has a molar mass of 156 g/mol, what is its molecular formula?

Name ____________________________

Worksheet #7
Stoichiometry Problems

For each problem below, show your work. Always use units and box in your final answer.

1) Why is it essential to use balanced chemical equations in solving stoichiometry problems?

2) Aluminum sulfide reacts with water to form aluminum hydroxide and hydrogen sulfide.
   a. Write the balanced chemical equation for this reaction.

   b. How many grams of aluminum hydroxide are obtained from 10.5 g of aluminum sulfide?

3) Aluminum sulfide reacts with water to form aluminum hydroxide and hydrogen sulfide.
   a. Write the balanced chemical equation for this reaction.

   b. How many grams of aluminum hydroxide are obtained from 10.5 g of aluminum sulfide?

4) Calcium carbonate decomposes upon heating, producing calcium oxide and carbon dioxide gas.

   a. Write a balanced chemical equation for this reaction.

   b. How many grams of calcium oxide will be produced after 12.25 g of calcium carbonate is completely decomposed?

   c. What volume of carbon dioxide gas is produced from this amount of calcium carbonate, at STP?

5) Hydrogen gas and bromine gas react to form hydrogen bromide gas.

   a. Write a balanced chemical equation for this reaction.

   b. 3.2 g of hydrogen gas and 9.5 g of bromine gas react. Which is the limiting reagent?

   c. How many grams of hydrogen bromide gas can be produced using the amounts in (b)?

   d. How many grams of the excess reactant is left unreacted?

e. What volume of HBr, measured at STP, is produced in (b)?

6) When ammonia gas, oxygen gas and methane gas (CH_4) are combined, the products are hydrogen cyanide gas and water.

a. Write a balanced chemical equation for this reaction.

b. Calculate the mass of each product produced when 225 g of oxygen gas is reacted with an excess of the other two reactants.

c. If the actual yield of the experiment in (b) is 105 g of HCN, calculate the percent yield.

6) When solutions of potassium iodide and lead (II) nitrate are combined, the products are potassium nitrate and lead (II) iodide.

a. Write a balanced equation for this reaction, including (aq) and (s).

b. Calculate the mass of precipitate produced when 50.0mL of 0.45M potassium iodide solution and 75mL of 0.55M lead (II) nitrate solution are mixed.

c. Calculate the volume of 0.50M potassium iodide required to react completely with 50.0mL of 0.50M lead (II) nitrate.

Name ___________________________

Worksheet #8
Limiting Reactants and Theoretical Yield

For each problem below, show your work. Always use units and box in your final answer.

1. A manufacturer of bicycles has 50 wheels, 30 frames, and 24 seats.
   a. How many bicycles can be manufactured using these parts?

   b. How many parts of each kind are left over?

   c. Which part is like a limiting reactant in that it limits the production of bicycles?

2. The fizz produced when an Alka-Seltzer tablet is dissolved in water is due to the reaction between sodium bicarbonate, $NaHCO_3$, and citric acid, $H_3C_6H_5O_7$:

$$3\ NaHCO_3\ (aq)\ +\ H_3C_6H_5O_7\ (aq)\ \text{-->}\ 3\ CO_2\ (g)\ +\ 3\ H_2O(l)\ +\ Na_3C_6H_5O_7\ (aq)$$

   In a certain experiment 1.00 g of sodium bicarbonate and 1.00 g of citric acid are allowed to react.

   a. Which reactant is the limiting reactant? You must show work to support your answer.

b. How many grams of carbon dioxide form?

c. How much of the limiting reactant is left when the reaction is complete?

d. How much of the excess reactant remains after the reaction is complete?

3. When hydrogen sulfide gas is bubbled into a solution of sodium hydroxide, the reaction forms sodium sulfide and water. How many grams of sodium sulfide are formed if 2.50 g of hydrogen sulfide is bubbled into a solution containing 1.85 g of sodium hydroxide, assuming that the limiting reagent is completely consumed?

4. Solutions of sulfuric acid and lead (II) acetate react to form solid lead (II) sulfate and a solution of acetic acid. If 10.0 g of sulfuric acid and 10.0 g of lead (II) acetate are mixed, calculate the number of grams of sulfuric acid, lead (II) acetate, lead (II) sulfate, and acetic acid present in the mixture after the reaction is complete.

5. A student reacts benzene, C_6H_6, with bromine, Br_2, to prepare bromobenzene, C_6H_5Br, and HBr.

    a. What is the theoretical yield of bromobenzene in this reaction when 30.0 g of benzene reacts with 65.0 g of bromine?

    b. If the actual yield of bromobenzene was 56.7 g, what was the percent yield?

Name ___________________________

Worksheet #9
Solubility Rules

Review Solubility Rules provided at the beginning of the packet and identify each of the following compounds as soluble or insoluble in water. You must memorize the solubility rules!

Na_2CO_3 ____________	$CoCO_3$ __________________	$Pb(NO_3)_2$ ______________
K_2S ________________	$BaSO_4$ __________________	$(NH_4)_2S$ _______________
AgI ________________	$Ni(NO_3)_2$ _______________	KI _____________________
FeS ________________	$PbCl_2$ ___________________	$CuSO_4$ ________________
Li2O _______________	$Mn(C_2H_3O_2)_2$ ___________	$Cr(OH)_3$________________
AgClO3 ____________	$Sn(SO_3)_4$ ________________	FeF_2 ____________________

1) Circle the compounds from the list below which are insoluble in water

HCl, NH_3, $NaClO_3$, $BaSO_4$, $AgNO_3$, $PbCl_2$, Cu_2O, $CuSO_4$, $Pb(C_2H_3O_2)$, AgBr

Name ___________________________

Worksheet #10
Personal Statement

1. Write a paragraph to tell me about your Chemistry experience last year. What did you like and dislike? What were you good at and not so good at? What teaching and learning techniques work well for you?

2. Write another paragraph to tell me about your hopes for AP Chemistry. What made you decide to take this class? How much effort are you willing to give to the class? What do you hope to take away from it?