

DATE: 6/10/2011

RE: AP Chemistry, Summer 2011 Preparation

Dear AP Chem Students and Parents,

It is not uncommon for students in AP classes to have a bit of extra work to do over the summer. For example, students in AP English may have to read several novels. For AP Chemistry, I am asking students to strengthen their understanding of high school level Chemistry, and learn a little bit more. AP Chemistry is a college level General Chemistry class. Unlike most college level classes, the sole criterion of your efforts that colleges will look at is a single test that will be taken at the end of the year in May. If you are unfamiliar with the grading process of AP exams, I recommend a visit to the College Board online; this URL will direct you to an explanation of the scoring system:

[http://www.collegeboard.com/student/testing/ap/exgrd\\_set.html](http://www.collegeboard.com/student/testing/ap/exgrd_set.html)

The College Board is responsible for auditing all AP courses. Because the sole criterion of your efforts is a single score, it is important you prepare well, hence this summer packet. If you find that a concept or mathematical problem eludes you, I encourage you to call a classmate over the summer and work with him or her.

In addition, I am asking students in Intro, Honors, and AP Chemistry classes to read the first three chapters of *Six Easy Pieces* by Richard Feynman. The book is short and cheap. I feel that the prose, because it is familiar, will help give you some extra intuition about molecules.

Finally, I realize you would like to spend your summer doing other things as well; most of this summer packet can be completed in a week if you spend 6–8 hours a day studying and practicing. Effectively, I am asking for less than three days of your summer. However, I recommend spreading the work out over the summer.

I hope you find the packet practical, and I also hope you have a great summer. I look forward to working with you come August.

Sincerely,  
Andrew Ritchie

## Introduction

This packet hopes to give you some guidance over the summer in preparing for AP Chemistry; unfortunately, I do not know when you will receive your textbook. My words will be accompanied by links (URLs) to content that will provide you with information or test your knowledge. If you have questions about anything, please discuss them with your peers over summer. If this isn't possible, please ask questions in the first week of class. The information I want you to review or learn is found in Chapters 1, 2 and 3 of your textbook, along with sections 5.1, 7.1, 7.2, 7.3, and 7.4.

You don't need to watch the videos if there are any, but you should read the tutorials and try out some problems. This is the main site from which you can find the other links I will provide throughout this packet:

<http://www.chemteam.info/ChemTeamIndex.html>

Significant Figures  
(sig figs)

A value may only have a few numbers that we care about. For example, 89.0002340 may have anywhere between 1 and 9 significant figures. It depends on the information we started with. If we multiplied two numbers, one with 9 sig figs and one with 23 sig figs, then our answer should have 9 sig figs; 89.0002340 has 9 so we're good. However, if we only multiplied two numbers, and one of them had only 1 sig fig, then 89.0002340 has 8 sig figs too many; 90 would be a better answer.

If the number 1000 is reported, we infer it has only 1 sig fig. If the number 1000. is reported, we understand it to have 4 sig figs.

Please review sig figs. You should pay special attention to zeroes, and what could make a zero insignificant. Also important is to note the differences between adding and multiplying numbers; the rules for reporting sig figs after each operation are different.

Also, when you add, it is best to make sure that *all your terms are expressed using the same exponent for the ten base*. I cannot find a link that discusses this properly, so I will show you. Example:

$$1.003 + (1.003 \times 10^3) + (1.003 \times 10^6)$$

You might be tempted to write:

$$\begin{array}{r} 1.003 \times 10^6 \\ +1.003 \times 10^3 \\ +1.003 \underline{\hspace{2cm}} \end{array}$$

In which case, your answer might come out any number of ways. Using the same exponent for all ten bases eliminates confusion; below I use  $10^0$ , or 1, which does not need to be written, but I write it anyways:

$$\begin{array}{r} 1,003,000 \quad x10^0 \\ + \quad 1,003 \quad x10^0 \\ + \quad \quad 1.003x10^0 \\ \hline 1,004,000 \quad x10^0 \end{array}$$

I realize you might object and say that the answer should be 1,004,004 or 1,004,004.003; perhaps you will see it better if I use  $10^6$ :

$$\begin{array}{r} 1.003 \quad x10^6 \\ +0.001003 \quad x10^6 \\ +0.000001003 \quad x10^6 \\ \hline 1.004 \quad x10^6 \end{array}$$

Basically, for addition, you look at the term that ends with the largest fraction of a whole number; in the above example, the largest fraction is *a thousandth of a million*. The smallest fraction is the bottom term, which ends with *a billionth of a million*. Notice our language: *of a million*. That is because our first term is 1 million and 3 thousand; that 3 thousand is a thousandth of a million. In the last term, the 1 is a millionth of a million. A thousandth is larger than a millionth. This makes sense, right?

<http://www.chemteam.info/SigFigs/SigFigs.html>

### Scientific Notation

Scientific notation, as you may know, is necessary because it allows us to report the minimal amount of sig figs of a value in a compact form. You have actually been practicing something similar to scientific notation since fourth grade. For example: multiplying 10 by 12, we get 120. But if we wrote it out, we'd write 20, and then under that 20 we'd write 10; the 10, however, is bumped over to the left. In our addition, the 10 is really 100; whereas we write the base 10 and its exponent in scientific notation, the base 10 and its exponent is implied by bumping numbers further to the left when multiplying by hand.

It would be quite easy for me 'show' you the above mathematical operation by displaying it in the way I would write it; that is, with 12 on top of 10 and so forth. I don't show it because a big part of chemistry is *imagining* what the text is telling you. When you read something, don't forget to imagine it; perhaps the best way to do this is by having a pen and

paper and drawing what you imagine is going on. There are certain things you must memorize, like names. Reading chemistry is not like reading a novel; whereas novels tend to be based on experiences familiar to us all, chemistry is at first *unfamiliar*; you must take the time to imagine it. That is why I provide you with 2.5 inches of margin on the left to write your thoughts as you read this. Memorizing lines of text generally isn't as good as interacting with the text. However, you should probably not write in books that your parents buy for you.

## Fractions

You need to be comfortable adding, multiplying, and dividing fractions; please know how to divide two fractions. Briefly: to divide two fractions, you take the bottom fraction, flip it, and then multiply it by what was the top fraction. Example:  $1/5$  divided by  $2$  is the same as  $1/5$  multiplied by  $1/2$ , equalling  $1/10$ . To add two fractions, they must share the same denominator (it must be 'common', as they say).

As I'm sure you know, we treat *units*, such as meters and seconds, as if they were algebraic quantities; variables, like  $x$  and  $y$ , cancel out; if you multiply  $x$  by  $x$ , you will get  $x^2$ , just like you will get square meters ( $m^2$ ) if you multiply  $m$  by  $m$ . If you divide  $m$  by  $m$ , then the two units cancel each other out. It is always nice when you get the unit you expect to get; it makes your answer correct. The best way to do this is to make a habit of checking (or 'analyzing') your dimensions; hence 'dimensional analysis'.

*The multiple choice content of the AP exam will have mathematical questions, but you are not allowed to use a calculator for multiple choice; therefore, I recommend becoming comfortable with numbers, that is to say: being able to make good estimations and calculations very quickly, using pencil and paper or just your mind. This is why I am advocating you become comfortable with fractions. I imagine that the best way to do this is to make it a daily habit ... perhaps a fun habit; see the next two paragraphs for examples.*

My fondness of fractions is perhaps best explained by comparing  $1/16$  with  $.0625$ . They are equal, but is it easier to imagine  $1/16$  of something, or  $.0625$  of something? If your mother asks you to cut her a slice of pie, would it be easier for you to know that she wants  $.0625$  of it, or  $1/16$  of it?

Let's imagine we are at a store. You want a jacket and it costs \$50 dollars. Using fractions,  $6/10$  is multiplied by 50. You know that 50 divided by 10 is 5, and 5 times 6 is 30. So \$30 is the new total. In Oregon, there is no such thing as the pre-tax amount, because there is no sales tax.

It should also be easy for you to go between fractions and percentages and decimals, and so you should be able to compute the tips for restaurant bills. If your parent tells you that the tip is going to be 16%, how can you compute it? By moving the decimal over once to the left; this will give you 10%. The 5% is obtained by dividing that 10% in half. 1% is achieved by moving the decimal from the total over by two spaces. Briefly: The total is \$27.61. So, 10% = 2.76; 5% = 1.38; and 1% = .28. At a glance, it looks to be about 2.8 + 1.4 + .3 so tip should be about \$4.50.

You also know this is *about* right, because \$27 is about \$25, and 16% is about 20%; 20% (or 1/5) of 25 is \$5. Be warned: in Washington, I became friends with a man who adjusted for 'pre-tax' amounts; he once scolded me for not subtracting the tax before computing the tip. Therefore, know your audience.

#### Dimensional Analysis

Checking your dimensions is not only necessary, it may also be helpful if you're in a bind on a problem. As a teaching assistant, I was able to solve most problems not by consulting or memorizing an equation, but by merely lining up the values given to me in a problem in such a way that the units canceled out to give me the correct unit. Dimensional analysis is easily visualized and kept tidy by using fractions. I *always* solve my problems by taking up two lines for a single value. Even if it is just 5 meters per second, multiplied by 10 seconds, I will write:

$$\frac{5 \text{ m}}{1 \cancel{\text{ s}}} \times \frac{10 \cancel{\text{ s}}}{1} = 50 \text{ m}$$

You are able to create your own problems with dimensional analysis, and this may be the best way to get into the habit. If you wanted to, you could calculate how many compact disc cases you'd need to cover the surface of the moon, or how many pencils it would take to reach the sun (I imagine there are enough pencils manufactured in one year to reach the sun). Please remember that 1 liter is equal to 1 cubic decimeter; from units of distance, we can express volumes.

#### Atoms

Atoms are not the smallest units of matter; electrons and protons and neutrons are smaller than an atom; they are subatomic. Most of the space an atom takes up is due to the electron moving in and out about the nucleus. When we talk about the electron, probability is often discussed. This is because the electron doesn't spend its time at a fixed point away

from the nucleus, like a planet ... if planets moved in circles, that is. This is why we have wave functions; we will learn more about the wave function later on, *don't worry about it* now.

Anyway, we have this thing called a wave function. If we square it we get what is called a *probability distribution*; it tells us where we can probably find the electron. Where we can *probably* find it in a Hydrogen atom with an electron in the 1s orbital is the *Bohr radius*, which was calculated by Niels Bohr, who *did* think the electron moved at a fixed radius from the nucleus. That is to say, an electron in the hydrogen 1s orbital spends *most* of its time about 53 picometers (this is the Bohr radius) away from the nucleus; Bohr unknowingly calculated the *average* distance.

How does the electron move in a hydrogen 1s orbital? This is best saved for a discussion.

Notice I haven't strayed yet from the hydrogen 1s orbital; things get more complicated, but we won't need to worry about it.

Electrons are moving so fast that they form a layer that is hard to penetrate; think of the blades of a fan; an electron moves much faster. Electrons in atoms are moving so fast and are so repulsed by each other (like charges repel) and are yet so closely packed to each other; the combination of these factors are the reason why you can sit in a chair without falling through; they are why you can't walk through walls. Again, think of your fan. When it's off you can put your finger between the blades easily. However, the faster it goes, the harder it gets.

You need to know how orbitals fill up, and their order: 1s, 2s, 2p, 3s ....

If you change the number of protons, you change the element and the mass of the atom is significantly changed.

If you change the number of neutrons, you get a different isotope and the mass of the atom is significantly changed.

If you change the number of electrons, you change the charge, but the mass of the atom is *insignificantly* changed.

Know periodic trends and placements: metals, nonmetals, semimetals or metalloids, noble gases (they are 'noble' because they generally shun the other 'riff-raff' on the periodic table; why? Low chemical reactivity is the answer, but why do they have low chemical reactivity?); also know trends in atomic radii, electronegativity, ionization energy, electron affinity.

Bonus: approximate the mass of a single proton without any resources other than pencil and paper. Hint: what is the most common isotope of hydrogen?

<http://www.chemteam.info/AtomicStructure/AtomicStructure.html>

<http://www.fordhamprep.org/gcurran/sho/sho/lessons/lesson36.htm>

[http://en.wikipedia.org/wiki/Periodic\\_trends](http://en.wikipedia.org/wiki/Periodic_trends)

## Bonds

Some terms: ionic bond, covalent bond, hydrogen bond, van der Waals or London dispersion forces, molecular orbital, intramolecular bond, intermolecular bond.

There are basically two kinds of bonds: ionic and covalent. The ionic bond is an electrostatic attraction. That is to say, an attraction due to charges. A salt like NaCl is held together by electrostatic forces. We would not call NaCl a 'molecule' of NaCl ... this is discussed in *Six Easy Pieces*. This is because one sodium cation is surrounded by six chlorine anions ... and each chlorine anion is surrounded by six sodium cations ... it is a lattice, or a crystal of ions ... we would be hard-pressed to produce a 'molecule' of NaCl, where you have only *one* atom of sodium and only *one* atom of chlorine connected to each other.

Bonus: if we pour ethanol into water, the intramolecular bonds of ethanol do not get broken up. However, if we pour salt into water, the ionic bonds are easily broken. Why does salt dissolve? The answer to this question is also in *Six Easy Pieces* (Hint: Draw dipole bonds on the water molecules surrounding the salt ions). Also, can we pour an unlimited amount of salt into water and expect it all to dissolve?

<http://www.chemteam.info/Bonding/Bonding.html>

<http://www.elmhurst.edu/~chm/vchembook/161Ahydrogenbond.html>

## Stoichiometry

If you know a thing or two about algebra and fractions, you should have a good enough handle on balancing equations. Balancing reactions is all about making sure one side is equal to the other. If you have 10 hydrogens on one side, you better have 10 on the other. Don't forget to worry about compounds in parentheses.

You should be able to define combination, decomposition, and combustion reactions. Some more terms: molecular weight, molecular formula, combustion, molar mass, mole, chemical formula, limiting reactant, theoretical yield.

A word on limiting reactants. Suppose you are about to eat something that requires a sharp and serrated knife. You only need one knife, because your other hand holds the fork. Imagine your knife (Knife type A) weighs a pound. There may be a different kind of knife (Knife type B) that is so light, that *ten* of them weigh only an ounce. You cannot automatically say that more weight means a bigger number of something. If you opted for the ounce, you'd have 9 knives *in excess*.

In the same way, you cannot tell which reactant is limiting and which is in excess by looking at the mass. You must look at the numbers of molecules of reactant, and relate this to the reaction.

For example,  $2A + B = C$ . Let's assume we already converted mass to moles. If we have 2 moles of A and 1.3 moles of B, then A is limiting and B is in excess, *even though we have a greater number of A than B*; we have .3 moles of B left over, and all of A is used up; because all of A is used up before all of B is used up, A is limiting. This is what I mean by 'relate to the reaction'.

<http://www.chemteam.info/Stoichiometry/Stoichiometry.html>

#### Structure

How does geometry affect a molecule's dipole moment? Does a salt like NaCl have a dipole moment? Can you draw the dipole moment for water? What is responsible for a molecule's geometry?

<http://www.chemteam.info/VSEPR/VSEPR.html>