Chem 4 -- Fall '08 Exam #2 Review

Things to study: (including, but not limited to)

NOMENTCLATURE!!!

Sig. Figs.
Scientific notation
Metric to metric conversions
Volume conversions
Conversions between metric and standard systems (I'll give you conversions factors, you just need to know how to use them)
Dimensional analysis (basically more conversions)
Problem Solving
Formula Mass

Keep in mind that this is not intended as a comprehensive summary of the exam. What does that mean? It means that the question can be worded differently on the exam and that the examples here are the basics that you need to know. You need to prove to me that you can think, not just vomit memorized pieces onto your exam. The best use of this review is to do the provided problems, and then think about how I can change them. The most important thing here is to THINK! I will not ask you any questions for which you do not have the knowledge to answer.

There are additional sig. fig. and conversion problems already posted on the course website. This is intended as a supplement for them, so GO DO THEM! There are some additional problems here too. You guys need all the practice you can get!

Before going to far, here are some more sig. fig. practice problems. DO THEM, you need the practice.

1) $\frac{-2.379\times10^{-5}}{6.23}$
2) 72.368000 – 432.80
3) $\frac{9.81301\times0.00238}{2300}$
4) 1.2863 + 0.002493 – 0.9248
5) 61.23 – 0.000046
6) 61.23 x 0.000046
7) $51.16g\ \text{NaCl}\times\frac{1mol\ \text{NaCl}}{58.443g\ \text{NaCl}}\times\frac{6.02\times10^{23}molecules\ \text{NaCl}}{1mol\ \text{NaCl}}=$ (don't worry about the units, just do it!)
8) 0.00258 + 0.004
9) 16.22 – 0.943 + 572.9
10) 1.3280 – 15.628
11) 0.235600 + 11.283
12) $\frac{0.5423}{8.2}$
13) 457900 x 6.78

Metric conversions:

In order to perform metric conversions, you need to be able to identify BASE units and PREFIXED units. Base units are the units that everything else in the metric system is built upon; for example, grams, meters, liters, seconds, joules, pascals etc. Prefixed units are base units with a prefix attached, i.e. *kilo***meter** (km), *micro***liter** (μL), *milli***second** (ms), *mega***joule** (MJ) and so forth. The prefix simply tells you want multiple or fraction of the base unit you are talking about. You don't even have to know what the base unit is if you know the prefix! If I told you there was a *kilo***mike** (don't get any ideas), then you would automatically know that you had 1×10^3 mikes (scary) whatever a mike might be! So now that we can identify base units and prefixed units, what good does that do us?

Say I ask you to convert 0.00671 seconds (s) to milliseconds (ms). First thing you need to do is decide which is the base unit and which is the prefixed unit. Hopefully you knew that seconds are the base unit and milliseconds are the prefixed unit.

Next, decide what units go on top and what units go on the bottom. In this case, we are converting FROM s TO ms. We want s on the bottom so that they cancel out which means ms must go on the top.

$$0.00671\ s \times \frac{ms}{s}$$

Next, PUT A 1 IN FORNT OF THE PREFIXED UNIT!!! Again, you don't have to do it this way, but a lot of you ignored this advice on the quiz and it cost you!

$$0.00671\ s \times \frac{1\ ms}{s}$$

Now put the exponent you have memorized in front of the BASE unit (you MUST memorize these prefixes and exponents!!!!!)

$$0.00671\ s \times \frac{1\ ms}{1 \times 10^{-3}\ s}$$

Now comes the answer. Remember, metric conversions have infinite sig. figs.!

$$0.00671\ s \times \frac{1\ ms}{1 \times 10^{-3}\ s} = 6.71\ ms$$

Example: Convert 36.95 megawatts (MW) to watts (W)… (do we care what a watt is? NO!)

$$36.95\ MW \times \frac{1 \times 10^{6}\ W}{1\ MW} = 3.695 \times 10^{7}\ W$$

Example: How many liters in $5.62 \text{x} 10^{5}$ μL?

$$5.62 \times 10^{5}\ \mu L \times \frac{1 \times 10^{-6}\ L}{1\ \mu L} = 0.562\ L$$

That's all fine and well, but what if you are asked to convert from one prefixed unit to another? It turns out it is essentially the same, but you need to make 2 steps instead of 1. WHEN CONVERTING BETWEEN TWO PREFIXED UNITS, ALWAYS CONVERT THE FIRST PREFIED UNIT TO THE BASE UNIT AND THEN FROM THE BASE UNIT TO THE SECOND PREFIXED UNIT! Huh? Observe:

How many decigrams are in 739.22 centigrams?
First, write the conversion for centigrams to grams:

$$739.22\ cg \times \frac{1 \times 10^{-2}\ g}{1\ cg}$$

(notice that the 1 is still in front of the prefixed unit)

now write the conversion for the base unit to the second prefixed unit (dg) and answer:

$$739.22\ cg \times \frac{1 \times 10^{-2}\ g}{1\ cg} \times \frac{1\ dg}{1 \times 10^{-1}\ g} = 73.922\ dg$$

See? It is the same process, but with two steps instead of one.

Example: How many milliwatts (mW) are in 1.21 gigawatts (GW)? (again, don't worry about watts, I just to say 1.21 gigawatts, and they are just units)

$$1.21\ GW \times \frac{1 \times 10^{9}\ W}{1\ GW} \times \frac{1\ mW}{1 \times 10^{-3}\ W} = 1.21 \times 10^{12}\ mW$$

Example: The Borh radius is 53 nanometers. What is that distance in cm?

$$53\ nm \times \frac{1 \times 10^{-9}\ m}{1\ nm} \times \frac{1\ cm}{1 \times 10^{-2}\ m} = 5.3 \times 10^{-6}\ cm$$

Okay, here are some for you to try:

1) 23.6 kilojoules (kJ) to joules (J)
2) 58216 microliters to dekaliters
3) 46.875 terabytes to kilobytes
4) How many femtoseconds in 22.16 milliseconds
5) If something has a mass of $3.78 \text{x} 10^{-2}$ megagrams, what is its mass in centigrams?

Before I get much further in this "review", I want to remind you about conversions factors. A conversion fact is simply a way of changing from one unit to another. 1 in = 2.54 cm is a conversion factor because it allows you to convert from inches to centimeters or centimeters to inches. Densities can be thought of as conversion factors: 11.35 g per cm^3 is a conversion factor because it lets you convert from a volume (cm^3) to a mass (g) or vise versa. Anything with two or more units is just a conversion factor. You don't have to know what those units are or what they mean as long as the convert from one thing to another. Finally, I want to remind you that these conversion factors can be written in one of several ways:

2.54 cm = 1 in 2.54 cm per inch $\frac{2.54\ cm}{1\ in}$ $2.54\ {}^{cm}\!/_{in}$

Each one of these is equivalent to the others and they are all the exact same conversion factor.

<u>Conversion between systems of measure</u>:
The main difference between this and the metric conversions is that you will not have to memorize these conversions; they will be given to you. That should make it easier… maybe). So, how do you do this? Let's start off fairly easy and work our way up.

Example: How many liters in 43.7 gallons?

First thing you want to do on ANY conversion problem is write what you are given and what you are asked for. On a problem like this it may seem to be a waste of time, but as the problems get more complicated, it will be vital in order to keep track of what you are doing.

What is given? 43.7 gallons
What is asked for? Liters

Great, I know where to start, but where do I go from there? I need a conversion factor that will allow me to get from gallons to liters, so I look in my book and see that 1 gal = 3.785 L. Looks good to me… I'll give it a try. Remember, that units only cancel if they are on opposite sides of the division bar.

$$43.7\ \boldsymbol{gal} \times \frac{3.785\ \boldsymbol{L}}{1\ \boldsymbol{gal}} = 165\ \boldsymbol{L}$$

Cool, my answer ended up in L, which is exactly what I needed.

If only all of the problems were quite that straight forward. So how do you deal with more complicated problems? In the last problem you were able to find a direct conversion between gallons and liters. There will not always be a direct conversion, which is when you are really going to have to think.

Example: How many inches are in 0.018 m?

What is given? 0.018 m
What is asked for? inches

Since the 0.018 m is the only value given, we know that we must start there. So we go to our handy dandy conversion table and look for a conversion from meters to inches… and come up empty handed. What now? Now we need to use a little bit of intuition. We look at the conversion table a see that about the only conversion involving inches also involves cm. Can we work with that? Maybe, but in order to use that conversion, we must be in units of either inches or centimeters. We are starting in meters… what can be done? Hmmm, meter and centimeters… That is a metric conversion!! We can do that!

$$0.018\ \boldsymbol{m} \times \frac{1\ \boldsymbol{cm}}{1\times10^{-2}\ \boldsymbol{m}}$$

Now I am in centimeters and can use the cm to inch conversion!

$$0.018\ \boldsymbol{m} \times \frac{1\ \boldsymbol{cm}}{1\times10^{-2}\ \boldsymbol{m}} \times \frac{1\ \boldsymbol{in}}{2.54\ \boldsymbol{cm}} = 0.71\ \boldsymbol{in}$$

I am in inches and that is what the question asked for!

Example: What is the volume in fluid ounce of a vat containing 0.02391 megaliters?

What is given? 0.02391 ML
What is asked for? fl. oz.

Again, the only place to start is with 0.02391 ML, but again, my conversion table has failed me; there is not a ML to fl. oz. conversion anywhere to be found. In fact, ML doesn't appear anywhere in my table, but I see fluid ounces in 2 places: 1 qt = 32 fl.oz. and 1 fl.oz. = 29.6 mL. Hmmm, ML and mL, I think I can do something about that! All I need to do is convert ML to mL, which is a prefix unit to prefix unit metric conversion!

$$0.02391\ \boldsymbol{ML} \times \frac{1\times10^{6}\ \boldsymbol{m}}{1\ \boldsymbol{ML}} \times \frac{1\ \boldsymbol{mL}}{1\times10^{-3}\ \boldsymbol{m}}$$

Now I am in mL and can use the 1 fl.oz. = 29.6 mL conversion

$$0.02391\ \boldsymbol{ML} \times \frac{1\times10^{6}\ \boldsymbol{m}}{1\ \boldsymbol{ML}} \times \frac{1\ \boldsymbol{mL}}{1\times10^{-2}\ \boldsymbol{m}} \times \frac{1\ \boldsymbol{fl.oz.}}{29.6\ \boldsymbol{mL}} = 8.08\times10^{4}\ \boldsymbol{fl.oz.}$$

NOTE: the 1 fl.oz. = 29.6 mL conversion is NOT exact, so it limits sig. figs.

These conversions are all about doing whatever it takes to get from one unit to another. Above, there was no meter to inch conversion, so we had to see what was available and sort of… build a bridge. This is what you need to practice. Some advice; the process is the same for every one of these so don't get wrapped up in each individual problem, but pay attention to overall thought process.

Practice: (use the "SI Units and Conversion Factors" table in your book to do these)

1) Convert 103 kg to ounces
2) What is the equivalent of 653 nm in angstroms?
3) How many liters are there in 6.375 pints
4) 0.75 tons is equal to how many kg?
5) How many atomic mass units (amu) are in $3.89266\text{x}10^{-17}$ pounds?
6) What is the distance in μm of 8.00 ft?
7) How many millimeters in a marathon (26.22 miles)
8) What is the volume in nL of 2.336 gallons?

Multidimensional units:

HUH? What is that word? It is referring to square units (square feet, in^2) and cubic units (cm^3, cubic meters). These conversions are done the same way as all of the conversions we have done so far (we want to cancel units) and in fact employ the same conversions we have used so far as well. If we want to convert mm^2 to m^2, we still use the conversion 1 mm = 10^{-3} m and we still want mm on the bottom so that we have a chance to cancel them out. The problem arises when we try to cancel mm^2 and mm; they aren't the same. Remember, in order to cancel out, the units must be IDENTICAL! In order to cancel out the mm^2, we are going to have to square the entire conversion factor! You only do this if the units don't already cancel because again, it is all about canceling the units.

Here is what I mean…

Example: Say you are asked to convert from 56.3 m^3 to km^3. Start off by writing the regular conversion for meters to kilometers:

$$56.3\ \boldsymbol{m}^{3} \times \frac{1\ \boldsymbol{km}}{1\times10^{3}\ \boldsymbol{m}}$$

Look at this, do the units cancel? No, you have m^3 on top and m on the bottom. The only way to cancel out the units if they are identical so you have to cube the conversion factor.

$$56.3\ \boldsymbol{m}^{3} \times \left(\frac{1\ \boldsymbol{km}}{1\times10^{3}\ \boldsymbol{m}}\right)^{3}$$

Now, remember back to algebra; EVERYTHING in the parentheses must be cubes, not just the units, so don't forget to cube the 1x10^3 when you put this in your calculator.

$$56.3\ \boldsymbol{m}^3 \times \left(\frac{1\ \boldsymbol{km}}{1\times10^3\ \boldsymbol{m}}\right)^3 = 5.63\times10^{-8}\,\boldsymbol{km^3}$$

Example: How many square meters are in 1502 in^2?

What is given? 1502 in^2
What is asked for? m^2.

Again, no direct conversion from inches to meters is available, so we'll have to find a way. While doing that, we are going to have to keep track of whether we are going square the conversion factors too. I know that a good conversion from English to metric lengths is inches to cm and then I know how to go from cm to meters, so here I go:

$$1502\ \boldsymbol{in}^2 \times \frac{2.54\ \boldsymbol{cm}}{1\ \boldsymbol{in}} \times \frac{1\times10^{-2}\ \boldsymbol{m}}{1\ \boldsymbol{cm}}$$

Now, which conversions do I need to square? Well, the first needs to be squared because I need to cancel in^2 and I only have inches. Because I have to square everything in the parenthesis I am left with cm^2 now, so I have to square the second conversion also so that I can cancel cm^2 and be left with m^2.

$$1502\ \boldsymbol{in}^2 \times \left(\frac{2.54\ \boldsymbol{cm}}{1\ \boldsymbol{in}}\right)^2 \times \left(\frac{1\times10^{-2}\ \boldsymbol{m}}{1\ \boldsymbol{cm}}\right)^2 = 0.9690\,\boldsymbol{m^2}$$

(remember that you have to actually square 2.54 and 1x10^{-2})

So what would be an example of when the conversion factor should NOT be cubed? Good question. The answer is that if the units already match, you don't need to cube (or squre).

Example: How many minutes would it take to fill a 1500. m^3 hot air balloon if it is being filled at a rate of 1.25x10^5 cm^3 per minute?

What is given? 1500. m^3 and 1.25x10^7 cm^3 per minute
What is asked for? min.
Where do you start? 1500. m^3 (Keep in mind the hint I gave you. When you can, start with the number that has a single unit. 1500. m^3 has one unit [m^3] and 1.25x10^7 cm^3 per min has two [cm^3 and min])

We are starting in m^3, but have to be in cm^3 to use the 1.25x10^7 cm^3/min conversion, so the first step should be to convert m^3 to cm^3. This is a cubic unit to cubic unit conversion, so you MUST cube the conversion factor:

$$1500.\ \boldsymbol{m}^3 \times \left(\frac{1\ \boldsymbol{cm}}{1\times10^{-2}\ \boldsymbol{m}}\right)^3$$

The next step is to use the conversion between volume (cm^3) and time (min). This conversion already has cm^3, so we do not have to change anything. Just use as is.

$$1500.\ \boldsymbol{m}^3 \times \left(\frac{1\ \boldsymbol{cm}}{1\times10^{-2}\ \boldsymbol{m}}\right)^3 \times \frac{1\ \boldsymbol{min}}{1.25\times10^7\,\boldsymbol{cm^3}}$$

The m^3 cancel, the cm^3 cancel, and I am left with minutes, which is what I am asked for. The answer is 120. minutes.

Example: Convert 33.33 ft^3 to cm^3

What is given? 33.33 ft^3
What is asked for? cm^3

$$33.33\ ft^3 \times \left(\frac{12\ in}{1\ ft}\right)^3 \times \left(\frac{2.54\ cm}{1\ in}\right)^3 = 9.438 \times 10^5\ cm^3$$

Each step was a $unit^3$ to $unit^3$ conversion, so each step had to be cubed.

Example: What is the mass of 52.10 cm^3 of ethanol? (for ethanol, 1 cm^3 = 0.789 g)

$$52.10\ cm^3 \times \frac{0.789\ g}{1\ cm^3} = 41.1\ g$$

You are converting from a $unit^3$ to a non-cubed unit, so the conversion is not cubed.

<u>Density:</u>

The book defines density as $d = \frac{mass}{volume} = \frac{m}{v}$ which is obviously accurate. So I could tell you that the density of sea water at 20.0 ^oC is 0.9997021 g per cm^3, which would follow the above equation because it has mass units over volume units. Great, but look at the density again and you might notice that this is a conversion factor just like any of the ones above. This one happens to convert grams to cm^3 instead of inches to centimeters. That means that you can USE it like any other conversion factor.

Example: What is the volume of 1.224x10^5 g of seawater?

$$1.2249 \times 10^5\ g \times \frac{1\ cm^3}{0.9997021\ g} = 1.2253 \times 10^5 cm^3$$

Example: What is the mass in kg of a 98.0 cm^3 block of aluminum? (d = 2.70 g/cm^3)

$$98.0\ cm^3 \times \frac{2.70\ g}{1\ cm^3} \times \frac{1\ kg}{1 \times 10^3\ g} = 0.265\ kg$$

<u>Again, there are several practice problems posted on the dimensional analysis review</u>

<u>Problem solving:</u>
Problem solving is essentially a combination of everything in this review, put into a blender. I am going to do a step-by-step work-through of one of the problems that we didn't get to in class. I want you to try the problem first and see if you can get through it. If you have already done the problem, I want you to do 2 things before you do it again: 1) put away the answers and your previous work. 2) forget what you did before. For everyone, I want you to think about each step. After each conversion you do, ask yourself "what units am I in now, what units am I trying to get to, and what should my next step be?"

Example: The standard London Gold Delivery Bar has a volume of 7.20x10^5 mm^3. As of March 20, 2007, gold was selling for $658.00 per troy ounce. If gold weighs 19.3 grams per cm^3, how much is one London Gold Delivery Bar worth? (1 troy ounce = 31.10347 g)

DO IT!!

My solution: *What is given?* 7.20x10^5 mm^3 and $\frac{\$658.00}{1\ troy\ oz.}$ and $\frac{19.3\ g}{1\ cm^3}$ and $\frac{31.10347 g}{1\ troy\ oz.}$

What is asked for? **$**
Where do I start? 7.20x10^5 mm^3 (it is the only number with a single unit)

I look at where I start and see where I could possibly go. Well, the density has a cm^3 in it, so maybe I can use that, but I have to convert mm^3 to cm^3 first. This is a prefix to prefix conversion, so go to the base unit first AND I am converting from $unit^3$ to $unit^3$, so I have to cube the conversion factor:

$$7.20\times10^{5}\ \boldsymbol{mm^{3}}\times\left(\frac{1\times10^{-3}\ \boldsymbol{m}}{1\ \boldsymbol{mm}}\right)^{3}\times\left(\frac{1\,\boldsymbol{cm}}{1\times10^{-2}\ \boldsymbol{m}}\right)^{3}$$

Okay, I am in cm^3, so I can use the volume to mass conversion. This is a cm^3 (cubed unit) to g (non-cubed unit) conversion, so you do NOT cube the conversion!

$$7.20\times10^{5}\ \boldsymbol{mm^{3}}\times\left(\frac{1\times10^{-3}\ \boldsymbol{m}}{1\ \boldsymbol{mm}}\right)^{3}\times\left(\frac{1\,\boldsymbol{cm}}{1\times10^{-2}\ \boldsymbol{m}}\right)^{3}\times\frac{19.3\ \boldsymbol{g}}{1\ \boldsymbol{cm^{3}}}$$

Now I am in grams… what the heck can I do with that? Well, I have another conversion that has grams, so I'll give that a shot.

$$7.20\times10^{5}\ \boldsymbol{mm^{3}}\times\left(\frac{1\times10^{-3}\ \boldsymbol{m}}{1\ \boldsymbol{mm}}\right)^{3}\times\left(\frac{1\,\boldsymbol{cm}}{1\times10^{-2}\ \boldsymbol{m}}\right)^{3}\times\frac{19.3\ \boldsymbol{g}}{1\ \boldsymbol{cm^{3}}}\times\frac{1\,\boldsymbol{troy\ oz.}}{31.10347\ \boldsymbol{g}}$$

Okay, now what? Well, I am in the units of troy oz. and I am trying to get to dollars. Wow, how convenient, I have a mass to dollar conversion!

$$7.20\times10^{5}\ \boldsymbol{mm^{3}}\times\left(\frac{1\times10^{-3}\ \boldsymbol{m}}{1\ \boldsymbol{mm}}\right)^{3}\times\left(\frac{1\,\boldsymbol{cm}}{1\times10^{-2}\ \boldsymbol{m}}\right)^{3}\times\frac{19.3\ \boldsymbol{g}}{1\ \boldsymbol{cm^{3}}}\times\frac{1\,\boldsymbol{troy\ oz.}}{31.10347\ \boldsymbol{g}}\times\frac{\boldsymbol{\$}658.00}{1\,\boldsymbol{troy\ oz.}}$$

I am in units of dollars and those are the units I want. DONE! The answer is **$**$2.94\times10^5$

Here are some practice word problems. You should do these using the 4 steps that we have covered in class!

1) A cyclist is traveling downhill at 55 km/hr. How fast is she moving in feet per second?
2) Carl Lewis, a sprinter in the 1899 Olympic Games, ran the 100.-m dash in 9.92 s. What was is speed in miles per hour?
3) When the space probe *Galileo* reached Jupiter in 1995, it was traveling at an average speed of 27,000 mi/hr. What was its speed in kilometers per second?
4) The Sun is approximately 93 million miles from the Earth. How many seconds will it take for light from the Sun to travel to the Earth if the velocity of light is 3.00x108 m/s?
5) A very strong camel can carry 990. lb. If one straw weighs 1.5 grams, how many straws can the camel carry without breaking it's back?
6) The largest nugget of gold on record was found in 1872 in New South Wales, Australia, and had a mass of 93.3 kg. Assuming the nugget is pure gold, what is its volume in cubic centimeters? What is it worth by today's standards if gold is $345/(troy oz)? (14.85 troy oz = 1 lb., density of gold is 19.3g/cm3)
7) Some Honda Preludes used to come with a 2.0L engine. What was the volume of the engine in cubic feet?
8) Sulfuric acid is the most produced industrial chemical in the United States, with 9.536×10^{10} pounds being made in 1995. If the density of $H_2SO_{4(aq)}$ is 1.84 g per cm^3, what volume (in m^3) of sulfuric acid was produced?
9) A standard garden hose has a flow rate of about 54.5 in^3 per second. An Olympic swimming pool has a volume of 2.500×10^6 L. How many days would it take to fill an Olympic pool with a garden hose?

At this point, I think you have several problems you can try to work through. I know you may have done several of them, but try them again and practice the thought process and the concepts above and on the previous review. If you can do the problems I have given as homework and you can do the problems I gave in class, you will be able to handle anything I can throw at you on the exam.

- All of this is systematic. I tried to give you plenty of practice problems so that you would see the patterns. If you didn't catch the patterns, GO BACK AND LOOK AGAIN!
- Think things through. If you made it through this, you know how to do the work, it is just a matter of applying what you learned to the problem in front of you.
- Don't get confused by the wording of the question. Break down the question into three parts: where are you starting, where are you going, and what outside knowledge might be useful. If you know where you are starting, then there are only a few places the next immediate step can go. Same thing with the next step after that. Pretty soon you are at the end!
- USE UNITS!!! Units are the roadmaps of chemistry. Carry through your units as you go, make SURE things cancel, don't just cross out the top unit of one step and the bottom of the next step. If you get to the end and you have the wrong units, you made a mistake somewhere.