BIOL 190L and CHEM 121 Fall 2017

An Experimental Approach to the Practicality of Making One's Own Solutions in Biology and Chemistry

Prepared by

Dr. Steve Carman, Professor of Biophysical Sciences

WNC-Carson Campus

Student Name		Date	
Lab Section		Prof Sign-Off	

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Objectives (Student Learning Outcomes) for This Experiment:

Upon completion of this experiment, the student should be able to determine the following:

1) the molecular weight of a compound
2) the equivalent weight of a compound
3) the number of moles of a compound
4) the number of equivalents of a compound
5) the molarity of a solution
6) the normality of a solution
7) the w/v concentration method of dilutions
8) the normality based on molarity and *vice versa*
9) the proper and safe technique for mixing acids with water
10) the proper and safe dilution of an acid or base from a previously prepared solution
11) the proper and safe preparation of a solution using solid compounds diluted in water
12) the proper use of a graduated cylinder
13) the proper use of a beaker
14) the proper use of an electronic pan balance
15) the correct calculations for and with all of the above,

correctly and properly **100% of the time**.

An Experimental Approach to the Practicality of Making One's Own Solutions in Biology and Chemistry

Solutions and Dilutions

Solutions

A solution is a homogeneous mixture of two or more substances in which the components are present as atoms, molecules or ions. Solutions consist of solutes and solvents. A solvent is the substance present in a solution in the largest amount. Solutes consist of one or more substances present in a solution in an amount lesser than that of the solvent.

Dissolving describes the process of forming a solution when the solvent and solute[s] make a homogeneous mixture, e.g., sugar water.

The Mole

When you go to the bakery to buy 12 rolls, you are also buying a dozen rolls. When you go to the feed store and buy a ton of corn, you are also buying 2000 pounds of corn. When you buy a lot that measures about 44,000 square feet, you are also buying an acre. All of these are just another way of saying the same thing.

Chemists do the same thing: when speaking about the number of particles contained in a sample of element or compound with its atomic or molecular mass expressed in grams, they are also speaking about a mole of that substance. For example, if you look at sulfur on the periodic table, you see that it has a mass of 32.1. That means that one mole of sulfur has a mass of 32.1 grams. Since we've discussed the mole, we can now put units on the atomic mass that are better than atomic mass units: grams per mol (g/mol). If we were to look at chlorine on the periodic table, we now know that it has a mass of 35.5 grams per mole. That means that if we have 35.5 grams of chlorine, we have one mole of chlorine -- just another way of saying something in another way.

Let's look at some numerical examples.

Example 1: Determine the mass in grams of 1.35 mol S.

$$1.35\ mol\ S\left(\frac{32\ g\ S}{1\,mol\ S}\right)=43.2\ g\ S$$

Example 2: Determine the mass in grams of 1.5 mol Cu.

$$1.5\,mol\ Cu\left(\frac{63.55\ g\ Cu}{1\,mol\ Cu}\right)=95.33\ g\ Cu$$

Example 3: Determine the mass in grams of 0.5 mol Ca.

$$0.5\,mol\ Ca\left(\frac{40.08\ g\ Ca}{1\,mol\ Ca}\right)=20.04\ g\ Ca$$

Example 4: Determine the mass in grams of 0.10 mol HCl.

Solution: This one is slightly different: it involves a compound instead of just an element. Go to the periodic table and look up the atomic masses of H and Cl. Add them up (1 + 35.5 = 36.5 g/mol). NOW it's just like the other problems.

$$0.10\ mol\ \ HCl\left(\frac{36.5\,g\ HCl}{1\,mol\ \ HCl}\right)=3.65\ g\ HCl$$

Example 5: Determine the mass in grams of 0.4 mol acetic acid ($HC_2H_3O_2$).

Solution: Do just like the previous example. Go to the periodic table and look up the atomic masses for H, C and O (1, 12 and 16 g/mol). Multiply the mass of H by 4, C by 2 and O by 2 – there are 4-H, 2-C and 2-O. Add the totals up (4 + 24 + 32 = 60 g/mol). Do it just like the previous problem:

$$0.4\,mol\ \ HOAc\left(\frac{60\ g\ HOAc}{1\,mol\ \ HOAc}\right)=24\ g\ HOAc$$

Example 6: 15 g HCl is how many mol HCl?

Solution: This is just a variation on a theme we've already done:

$$15\ g\ HCl\left(\frac{1\,mol\ \ HCl}{36.5\,g\ HCl}\right)=0.411\ mol\ \ HCl$$

Example 7: 30 g H_2SO_4 is how many mol H_2SO_4?

Solution: Go to the periodic table and find the atomic masses for H (1), S (32.1) and O (16). The molecular weight of sulfuric acid is 98 g/mol.

$$30\ g\ H_2SO_4\left(\frac{1\,mol\ \ H_2SO_4}{98\ g\ H_2SO_4}\right)=0.306\ mol\ \ H_2SO_4$$

Example 8: You have been given 49 g H_2SO_4. You were told that this was 0.5 mol. What is the molecular weight of sulfuric acid?

Solution: This is easier than it looks. As long as you remember that the units on molecular weight are g/mol (read as grams PER mol), you'll always be able to do this sort of problem:

$$MW=\left(\frac{grams}{mol}\right)=\left(\frac{49\ g\ H_2SO_4}{0.5\,mol\ \ H_2SO_4}\right)=98\ \frac{g\ H_2SO_4}{mol\ \ H_2SO_4}=98\ {}^{g}\!/_{mol}$$

Molarity

By definition, molarity (M) is the number of moles of solute (the substance[s] in lesser amounts) per liter of solution.

Example 1: 36.5 g HCl are dissolved in enough water to make 1 liter of solution. What is the molarity of the solution?

Solution:

$$M = \frac{mol\ solute}{L\ solution} = 36.5\ g\ HCl \left(\frac{1\ mol\ HCl}{36.5\ g\ HCl}\right)\frac{}{1\,L} = 1\, {}^{mol}\!/\!_{L} = 1\,M$$

Example 2: 18.25 g HCl are dissolved in enough water to make 250 mL of solution. What is the molarity of the solution?

Solution:

$$M = \frac{mol\ solute}{L\ solution} = 18.25\ g\ HCl \left(\frac{1\ mol\ HCl}{36.5\ g\ HCl}\right)\frac{}{250\ mL}\left(\frac{1000\ mL}{L}\right) = 2\, {}^{mol}\!/\!_{L} = 2\,M$$

A variation of this has to do with diluting aqueous solutions that are more concentrated to a more dilute concentration.

When dealing **ONLY** with **mono-protic acids and mono-hydroxy bases**, the following equation will be quite useful to you:

$$C_1V_1 = C_2V_2$$

Where C_1 is equal to the concentration of the more concentrated reagent and V_1 is the volume of the more concentrated reagent added to reach the final diluted concentration. C_2 equals the concentration of the more dilute solution you're making and V_2 equals the final volume of the more dilute solution that you're making.

Example (and it really helps to memorize the molar concentrations of the more common concentrated acids to make your calculations much easier!): you need to make 100 mL of a 0.1 M solution of HCl. You have 12 M HCl in the manufacturer's bottle. How much of the concentrated (con) acid do you need to add to water to make the final volume.

Solution:

$$\mathrm{C_1V_1 = C_2V_2}$$
$$\mathrm{(12\ M)\ (x) = (0.1\ M)\ (100\ mL)}$$
$$\mathrm{x = \frac{(0.1\ M)\ (100\ mL)}{12\ M}}$$
$$\mathrm{x = 0.83\ mL\ con\ HCl}$$

Some thoughts:

1) When adding con acids to water, ALWAYS add the acid to the water, and,

2) NEVER pour the acid in the water as the mixing temperatures can become quite hot and the reactions can be quite rapid and can burn you badly, e.g., sulfuric acid makes water boil on rapid addition,

3) You WON'T take 0.83 mL of con HCl and add it to 99.17 mL of water because in chemistry it doesn't work that way to make 100 mL due to the attraction of the water to the glass in the graduated cylinder, so

4) You'll put (via a pipet for very small volumes OR via decanting larger volumes as demonstrated in the pre-lab lecturette) the 0.83 mL of con acid in about 50 mL of water and mix it with a glass stirring rod, THEN pour that into a graduated cylinder and fill with water to the 100 mL mark and

5) You'll then pour the final mixture back-n-forth between the graduated cylinder and beaker 6-10 times to mix it properly BEFORE you can use it in your experiment.

What took 5 steps to write can be written in less than one line: **take 0.83 mL con HCL qs H_2O 100 mL**. This simply means to take your 0.83 mL of con HCl with a quantity sufficient (qs) of water to make a final volume of 100 mL.

You do the same when mixing diluted solutions of bases, as well, again, **only using mono-protic acids and mono-hydroxy bases**.

So … what do you do when you're handling a di- or tri-protic acid or di- or tri-hydroxy base? That's what the next section is for (it'll work for what we just did above, as well).

Equivalents

For most reactions, there is no certain method in which to attain the stoichiometric relationships between reactants and products except to write out a balanced reaction. On the other hand, acid-base reactions are such that they allow chemists with a little careful thought to bypass the balanced equation in most cases. In acid-base neutralization reactions, acids provide protons (H^+) and bases provide hydroxide ions (OH^-). Regardless of the acid-base combination, however, the NET ionic equation for the neutralization reaction is ALWAYS exactly the same:

$$H^+ + OH^- \rightarrow H_2O$$

Let's suppose that 36 grams of an acid, e.g., HCl, was able to furnish specifically one mole of protons, and a base, e.g., NaOH, one mole of hydroxide ions. Since one mole of acid reacts with one mole of base, as presented in the neutralization reaction, above, we now know that 36 grams of acid is exactly enough to react with 40 grams of the base (how do we know 40 grams?). It is possible to do this without knowing what the particular acid or base is. All we absolutely have to know is how much of the acid donates 1 mole of protons and how much base it requires to give one mole of hydroxide ions. The type of reasoning we have just developed constitutes the basis of defining a chemical quantity called the equivalent, which is abbreviated Eq.

The specific definition depends on whether the reaction is an acid-base reaction or a reduction-oxidation reaction. For the purposes of this laboratory experiment, we won't limit ourselves just to the acid-base type of reactions. The definition of an equivalent in either reaction, however, is such that equivalents always react in/on a one-to-one ratio. This key concept is summarized, below:

1 Eq of reactant A reacts with exactly 1 Eq of reactant B

The next question is how shall we define equivalents for acids and bases? The definitions are below:

By definition, an equivalent (Eq) of base is that amount of base that contributes or provides 1 mol of hydroxide ion (OH^-):

$NaOH \rightarrow$ 1 mol OH^- which is 1 Eq OH^-

$Ba(OH)_2 \rightarrow$ 2 mol OH^- which is 2 Eq OH^-

$Al(OH)_3 \rightarrow$ 3 mol OH^- which is 3 Eq OH^-

By definition, an equivalent (Eq) of acid is that amount of acid that contributes or provides 1 mol of hydronium (H_3O^+) or hydrogen (H^+) ion:

$HCl \rightarrow$ 1 mol H^+ which is 1 Eq H^+

$H_2SO_4 \rightarrow$ 2 mol H^+ which is 2 Eq H^+

$H_3PO_4 \rightarrow$ 3 mol H^+ which is 3 Eq H^+

By definition, an equivalent (Eq) of salt is that amount of salt that will contribute or provide 1 mol of positive (OR negative) charges when dissolved or dissociated:

$KCl \rightarrow K^+ + Cl^-$ which gives 1 Eq (1^+ or 1^- total charges)

$CaCl_2 \rightarrow Ca^{2+} + 2Cl^-$ which gives 2 Eq (2^+ or 2^- total charges)

$AlCl_3 \rightarrow Al^{3+} + 3Cl^-$ which gives 3 Eq (3^+ or 3^- total charges)

There is, therefore, a relationship between moles and equivalents for acids: **the number of equivalents in one mole of any acid is equivalent to the number of protons that are neutralized when one molecule of the acid reacts.**

The number of equivalents in any base may be determined in a likewise manner, although the focus is now on the hydroxide groups. Thus, we may now define what an equivalent for bases is: **the number of equivalents in one mole of the base is equal to the number of hydroxides in one formula unit of the base.**

The number of equivalents in any salt (and even in an acid or a base) are determined in a similar manner, although the focus is on the total number of positive OR negative charges: **the number of equivalents in one mole of any salt (or acid or base) is equal to the total number of positive OR negative charges when dissolved or dissociated.**

Remember that we can calculate Molecular Weight by dividing the mass of X mol of substance (in grams) by the number of mols ("X") to get molecular weight in g/mol. Using equivalents, we can calculate EQUIVALENT WEIGHT, as well.

In using equivalents, it is most helpful to know the mass of an equivalent of each of the reactants. Earlier we discussed a scenario where we used 36 grams of an acid to provide 1 mol (abbreviation for mole) of H^+ and 40 grams of a base provided 1 mol of OH^-. The given quantities each corresponded to one equivalent of acid and base. Knowing this likeness establishes a mass relationship between the two reactants, which may be utilized in stoichiometric relationships. The weight in grams of one equivalent is called the equivalent weight. Determining the value for a specific chemical is done most simply using the molecular weight and having prior knowledge of the number of equivalents per mol.

Example: PROBLEM: calculate the equivalent weight of aluminum hydroxide ($Al(OH)_3$), assuming it will be completely neutralized when it reacts.

SOLUTION: The formula weight (molecular weight) of aluminum hydroxide is 88 g/mol. Therefore, 1 mol of $Al(OH)_3$ has a mass of 88 grams.

For complete neutralization, 1 mol $Al(OH)_3$ = 3 Eq OH^-; therefore, 1 Eq $Al(OH)_3$ = 0.33 mol $Al(OH)_3$. Since 0.33 mol $Al(OH)_3$ has a mass of 29.33 grams, 1 Eq $Al(OH)_3$ = 29.33 grams $Al(OH)_3$.

We could also work this problem with the factor label method and start thusly: 1 Eq $Al(OH)_3$ = ? grams

To solve this, we multiply conversion factors to manipulate the equation to grams:

$$\left(\frac{(88\ g\ Al(OH)_3)}{1\,mol\ \ Al(OH)_3}\right)\left(\frac{1\,mol\ \ Al(OH)_3}{3\,Eq\ OH^-}\right) = 29.33\,\frac{g}{Eq}$$

Let's calculate the equivalent weight of $AlCl_3$ -- this has a molecular weight of 133.5 g/mol:

$$\left(\frac{(133.5\,g\ AlCl_3)}{1\,mol\ \ AlCl_3}\right)\left(\frac{1\,mol\ \ AlCl_3}{3\,Eq\ OH^-}\right) = 44.50\,\frac{g}{Eq}$$

Notice that we used the total number of positive charges (OR negative charges: 3 * 1 = 3) for our equivalents. Let's calculate the equivalent weight of sulfuric acid, LiCl and magnesium hydroxide:

$$\text{Eq Wt } H_2SO_4 = \left(\frac{98\text{ g } H_2SO_4}{\text{mol } H_2SO_4}\right)\left(\frac{1\,\text{mol } H_2SO_4}{2\text{ Eq}}\right) = 49\ {}^{g}\!/_{Eq}$$

$$\text{Eq Wt LiCl} = \left(\frac{42.5\text{ g}}{\text{mol LiCl}}\right)\left(\frac{1\,\text{mol LiCl}}{1\,\text{Eq}}\right) = 42.5\ {}^{g}\!/_{Eq}$$

$$\text{Eq Wt Mg(OH)}_2 = \left(\frac{58\text{ g Mg(OH)}_2}{1\,\text{mol Mg(OH)}_2}\right)\left(\frac{1\,\text{mol Mg(OH)}_2}{2\text{ Eq}}\right) = 29\ {}^{g}\!/_{Eq}$$

Clinically, the unit milli-equivalent is used (mEq) when measuring serum concentrations of electrolytes, e.g., sodium and potassium ions.

Normality

In previous experiments and problem sets, the term MOLARITY has been used to express the concentration of a solution. If you recall, since MOLARITY is equal to the number of moles of the solute per liter of solution, the number of moles of the solute may be determined by simply multiplying MOLARITY by VOLUME in liters. This concept allows us to provide the number of moles in some container or reaction to a given volume.

We have now learned of another unit which allows us to express MASS AMOUNTS in a new unit which is similar to moles: EQUIVALENTS. If moles are similar to equivalents, then MOLARITY must have a likewise similar unit. This unit is called NORMALITY (N), and is expressed as the number of equivalents per liter of solution.

Put another way: When we first learned about the mole, we extended our knowledge by studying a concentration term called molarity (M = Molar = mol/L). This is a unit that expresses how many mols of a substance (solute) are dissolved in one liter of solution. We can use equivalents to do a similar concentration term: normality (N = Normal = Eq/L).

If there is a solution which is expressed as 1 N (1 NORMAL or 1 Normal), this would mean that there is 1 equivalent of the solute per liter of solution. One would suspect that since normality and molarity are similar that there is a relationship between the two concentration units **when the concentrations are known**. This is the case, indeed, table, below:

N = M x

N = Normality

M = Molarity

x = the number of either H^+ OR OH^-

The relationship between the two units relies upon the number of protons or hydroxide ions present in the acid or the base – or the total number of positive OR negative charges in a salt (or acid or base, too, remember).

Let's take, for example, HCl and H_2SO_4. Using the above equation, if each acid is 0.5 M, the respective normalities are 0.5 and 1 N. This is because there is only one H^+ in HCl and 2 H^+ in H_2SO_4. Likewise, if we were to look at 1 M solutions of NaOH and $Ca(OH)_2$, their normalities would be 1 and 2 N, respectively. This is due to the numbers of OH^- groups.

Sometimes calculating the normality isn't as straight-forward as the above relationship might suggest. In that case, we have to remember that Normality is defined as the number of equivalents of a substance that is dissolved in one liter of solution (Eq/L). Let's calculate the normality of a solution that has 40 g NaOH dissolved in 1 L of water, and, then, let's calculate the normality of a solution of 29.15 g $Mg(OH)_2$ that is dissolved in 500 mL of water – note that for neither do we have any molar information.

$$\text{N NaOH} = 40\text{ g NaOH}\left(\frac{\text{mol NaOH}}{40.00\text{ g NaOH}}\right)\left(\frac{1\text{ Eq}}{1\text{ mol NaOH}}\right)\left(\frac{}{1\text{ L H}_2\text{O}}\right) = 1\frac{\text{Eq}}{\text{L}} = 1\text{ N NaOH}$$

$$\text{N Mg(OH)}_2 = 29.15\text{ g Mg(OH)}_2\left(\frac{\text{mol Mg(OH)}_2}{58.3\text{ g Mg(OH)}_2}\right)\left(\frac{2\text{ Eq}}{1\text{ mol Mg(OH)}_2}\right)\left(\frac{}{500\text{ mL H}_2\text{O}}\right)\left(\frac{1000\text{ mL}}{1\text{ L}}\right) = 2\frac{\text{Eq}}{\text{L}} = 2\text{ N Mg(OH)}_2$$

Dilutions

Preparation of Solutions

There are five (5) processes necessary to making a solution (and diluting it) properly:

1) Determine the volume needed for the experiment.

2) Determine the appropriate units, e.g., M, N, m, %, ppm, ad nauseum.

3) Mass out the solute.

4) Place the solute in the appropriate container.

5) Add solvent and mix.

The **volume needed** generally reflects the amount of solution that you will need to complete your experiment plus a little bit more to cover mistakes. The **concentration units** you'll need to use are those units that will work the best with your experiment. **Massing out** the solute requires either weighing paper or weighing boats, along with spatulas -- remember: **if you take it out of the bottle and it's too much, toss it (your professor will tell you where to toss it)!** Do NOT replace it in the bottle. Placing the solute in the **appropriate container** can be tricky, e.g., you may need a funnel or the like.

Common Dilution Methods, Concentrations and Calculations

While these methods have likely reached maturation, they are still used on a regular basis in inorganic chemistry with qualitative analysis:

w/w = weight % = (mass of solute/mass of solution) · 100

v/v = volume % = (volume of solute (mL)/volume of solution (mL)) · 100

w/v = weight-volume % = (mass of solute (g)/volume of solution(mL)) · 100

Examples

85% w/w $HClO_4$ = 85 g $HClO_4$ per 100 g solution

10% w/v $NaNO_3$ = 10 g $NaNO_3$ per 100 mL of solution

30% v/v NaOH = 30 mL NaOH (aq) in a final volume of 100 mL of solution

Solution Diluent Volume Ratios: 2 Methods

In spite of the topic heading for this section, solution-diluent volume ratios are defined as the volume of the more concentrated reagent in ratio to the volume of solvent to dilute it, e.g., 1:3 = 1 part concentrated reagent and 3 parts of water. There are two approaches to this.

Method 1 Analytical Chemistry Approach: preparing a 1:3 solution of nitric acid = 1 part of concentrated Nitric Acid and 3 parts of Water.

Method 2 Biochemistry Approach: preparing a 1:3 solution of Nitric Acid = 1 part of Concentrated Nitric Acid and 2 parts Water

ppm

In general, a 1 ppm (part per million) solution has 1 mg of solute per liter of solution, e.g., 100 ppm NaCl = 100 mg NaCl dissolved in a final volume of 1 liter of solution.

Containers/Vessels Used in The Biology and Chemistry Laboratory

Beakers and Erlenmeyer flasks are for PRE-MIXING ONLY -- they are the "mixing bowls" of chemistry and biology. Even though they have volumes printed on their sides, at best, they are within MAYBE 25% of being correct.

Graduated cylinders are good choices for measuring volumes of liquids.

Volumetric flasks (with either rubber, cork or ground glass stoppers) are the most accurate and precise vessel to use for solutions that HAFTA have known concentrations within a very tight range, i.e., with minimal error. In both graduated cylinders and volumetric flasks, one must use the meniscus of the solvent to determine the appropriate volume. In the graduated cylinder, stay at eye level and consistently use the same part of the meniscus for volume determinations. Once poured into the graduated cylinder, pour the solvent into a beaker with the solute (depending on the solute) and stir to dissolve. In the volumetric flask, put the solute in the flask and fill the flask to the line in the neck. Stopper and mix by inversion. If it is liquids, invert a minimum of 20 times. If you are dissolving a solid solute, pre-mix the solute with a minimal amount of solvent in a beaker and pour into the flask. Rinse the beaker with minimal amounts of solvent 6-8 times, pouring the rinse washings into the volumetric flask. Fill the volumetric flask to the line with solvent using either a pipet, medicine dropper or squirt bottle. Stopper and invert to mix 20 times.

You'll find it very helpful for the remainder of the semester to have a periodic table (and this experiment) at your disposal when determining mols and equivalents. Here's a helpful periodic table for you to use:

Periodic Table of the Elements

1 IA 1A	2 IIA 2A	3 IIIB 3B	4 IVB 4B	5 VB 5B	6 VIB 6B	7 VIIB 7B	8	9 VIII 8	10	11 IB 1B	12 IIB 2B	13 IIIA 3A	14 IVA 4A	15 VA 5A	16 VIA 6A	17 VIIA 7A	18 VIIIA 8A
1 **H** Hydrogen 1.008																	2 **He** Helium 4.003
3 **Li** Lithium 6.941	4 **Be** Beryllium 9.012											5 **B** Boron 10.811	6 **C** Carbon 12.011	7 **N** Nitrogen 14.007	8 **O** Oxygen 15.999	9 **F** Fluorine 18.998	10 **Ne** Neon 20.180
11 **Na** Sodium 22.990	12 **Mg** Magnesium 24.305											13 **Al** Aluminum 26.982	14 **Si** Silicon 28.086	15 **P** Phosphorus 30.974	16 **S** Sulfur 32.066	17 **Cl** Chlorine 35.453	18 **Ar** Argon 39.948
19 **K** Potassium 39.098	20 **Ca** Calcium 40.078	21 **Sc** Scandium 44.956	22 **Ti** Titanium 47.867	23 **V** Vanadium 50.942	24 **Cr** Chromium 51.996	25 **Mn** Manganese 54.938	26 **Fe** Iron 55.845	27 **Co** Cobalt 58.933	28 **Ni** Nickel 58.693	29 **Cu** Copper 63.546	30 **Zn** Zinc 65.38	31 **Ga** Gallium 69.723	32 **Ge** Germanium 72.631	33 **As** Arsenic 74.922	34 **Se** Selenium 78.971	35 **Br** Bromine 79.904	36 **Kr** Krypton 83.798
37 **Rb** Rubidium 85.468	38 **Sr** Strontium 87.62	39 **Y** Yttrium 88.906	40 **Zr** Zirconium 91.224	41 **Nb** Niobium 92.906	42 **Mo** Molybdenum 95.95	43 **Tc** Technetium 98.907	44 **Ru** Ruthenium 101.07	45 **Rh** Rhodium 102.906	46 **Pd** Palladium 106.42	47 **Ag** Silver 107.868	48 **Cd** Cadmium 112.414	49 **In** Indium 114.818	50 **Sn** Tin 118.711	51 **Sb** Antimony 121.760	52 **Te** Tellurium 127.6	53 **I** Iodine 126.904	54 **Xe** Xenon 131.294
55 **Cs** Cesium 132.905	56 **Ba** Barium 137.328	57-71	72 **Hf** Hafnium 178.49	73 **Ta** Tantalum 180.948	74 **W** Tungsten 183.84	75 **Re** Rhenium 186.207	76 **Os** Osmium 190.23	77 **Ir** Iridium 192.217	78 **Pt** Platinum 195.085	79 **Au** Gold 196.967	80 **Hg** Mercury 200.592	81 **Tl** Thallium 204.383	82 **Pb** Lead 207.2	83 **Bi** Bismuth 208.980	84 **Po** Polonium [208.982]	85 **At** Astatine 209.987	86 **Rn** Radon 222.018
87 **Fr** Francium 223.020	88 **Ra** Radium 226.025	89-103	104 **Rf** Rutherfordium [261]	105 **Db** Dubnium [262]	106 **Sg** Seaborgium [266]	107 **Bh** Bohrium [264]	108 **Hs** Hassium [269]	109 **Mt** Meitnerium [278]	110 **Ds** Darmstadtium [281]	111 **Rg** Roentgenium [280]	112 **Cn** Copernicium [285]	113 **Nh** Nihonium [286]	114 **Fl** Flerovium [289]	115 **Mc** Moscovium [289]	116 **Lv** Livermorium [293]	117 **Ts** Tennessine [294]	118 **Og** Oganesson [294]

Lanthanide Series	57 **La** Lanthanum 138.905	58 **Ce** Cerium 140.116	59 **Pr** Praseodymium 140.908	60 **Nd** Neodymium 144.243	61 **Pm** Promethium 144.913	62 **Sm** Samarium 150.36	63 **Eu** Europium 151.964	64 **Gd** Gadolinium 157.25	65 **Tb** Terbium 158.925	66 **Dy** Dysprosium 162.500	67 **Ho** Holmium 164.930	68 **Er** Erbium 167.259	69 **Tm** Thulium 168.934	70 **Yb** Ytterbium 173.055	71 **Lu** Lutetium 174.967
Actinide Series	89 **Ac** Actinium 227.028	90 **Th** Thorium 232.038	91 **Pa** Protactinium 231.036	92 **U** Uranium 238.029	93 **Np** Neptunium 237.048	94 **Pu** Plutonium 244.064	95 **Am** Americium 243.061	96 **Cm** Curium 247.070	97 **Bk** Berkelium 247.070	98 **Cf** Californium 251.080	99 **Es** Einsteinium [254]	100 **Fm** Fermium 257.095	101 **Md** Mendelevium 258.1	102 **No** Nobelium 259.101	103 **Lr** Lawrencium [262]

Likewise, on top of the following page is a table of concentrated acids' concentrations and a few dilutions that you may find to be of assistance during the course. One thing to remember is that when we calculate based on the con acids' or bases' concentrations, we usually round the concentration to the nearest non-decimal number for ease of calculation, e.g., for HCl, the bottle will say 11.65 M and we'll round it to 12 M. For these courses, it's close enough. If you take Analytical Chemistry, then you'll use 11.65 M.

Concentrated Reagents	Density	Molarity (M)	Normality (N)	Volume (mL) required to make 1000 mL solution:	
				1M	1N
Acetic acid 99.5%	1.05	17.4	17.4	57.5	57.5
Ammonia 35%	0.880	18.1	18.1	55.3	55.3
Ammonia 25%	0.910	13.4	13.4	74.6	74.6
Hydrochloric acid 36%	1.18	11.65	11.65	85.8	85.8
Hydrochloric acid 32%	1.16	10.2	10.2	98.0	98.0
Hydrofluoric acid 40%	1.13	22.6	22.6	44.2	44.2
Nitric acid 70%	1.42	15.8	15.8	63.3	63.3
Perchloric acid 60%	1.54	9.2	9.2	108.7	108.7
Perchloric acid 70%	1.67	11.6	11.6	86.2	86.2
Orthophosphoric acid 85%	1.7	15.2	45.6	65.8	21.9
Sodium hydroxide 47%	1.5	17.6	17.6	56.7	56.7
Sulfuric acid 98%	1.84	18.4	36.8	54.3	27.2

Source: Accessed 27 July 2017, 1228 hours, PDT: https://erowid.org/archive/rhodium/chemistry/equipment/molarity.html

Pre-Lab Exercises

These exercises are to be completed and entered into Canvas prior to coming to lab. **Failure to complete these questions, which includes entering your results into Canvas, shall result in a grade of 0 for this entire experiment.** In addition, failure to complete this experiment will impact your future experiments, as well, since you'll be making your own reagents for those experiments **without** any additional help from your classmates or your professor. Word.

1. 20 g NaOH are dissolved in 1 L H_2O. What is the N of the NaOH solution?

2. 25 g HCl are dissolved in 500 mL of water. What is the N of the HCl solution?

3. 30 g $Sr(OH)_2$ are dissolved in 750 mL water. What is the N of the $Sr(OH)_2$ solution?

4. 150 g H_2SO_4 are dissolved in 750 mL water. What is the N of the H_2SO_4 solution?

5. 75 g $BaSO_4$ are dissolved in 3 L H_2O. What is the N of the $BaSO_4$ solution?

6. A solution is prepared with 565 mg $K_4Fe(CN)_6$ in water and diluted to 1375 mL. Calculate the following:

A) The molarity of the potassium ferrocyanide solution

B) The w/v% of the potassium ferrocyanide solution

C) The ppm of the potassium ferrocyanide solution

7. How many mol of H_2SO_4 do you have if you have 24.5 g H_2SO_4?

8. How many mol of NaOH do you have if you have 10 g NaOH?

9. How many mol of $C_6H_{12}O_6$ do you have if you have 45 g $C_6H_{12}O_6$?

10. How many grams of $CuSO_4$ are present in 0.25 mol of $CuSO_4$?

11. How many grams of $Al(OH)_3$ are present in 3.4 mol $Al(OH)_3$?

12. How many grams of $BaSO_4$ are present in 0.78 mol $BaSO_4$?

13. Determine the equivalent weight for the following compounds; name the compounds:

A) HCl

B) $Ba(OH)_2$

C) $MgSO_4$

D) AlF_3

E) $SrCl_2$

F) LiOAc

G) H_2SO_4

H) H_3PO_4

14. You have 10 grams of each of the following: hydrochloric acid, sulfuric acid, potassium dichromate, potassium oxalate, sodium sulfate and lithium nitrate. You need to dissolve each in 250 mL of water. What is the final M and N of each solution?

A) HCl

B) H_2SO_4

C) $K_2Cr_2O_7$

D) $K_2C_2O_4$

E) Na_2SO_4

F) $LiNO_3$

15. Name the following acids and bases:

A. HCl

F. HBr

B. H_2SO_4

G. $NaOH$

C. H_3PO_4

H. KOH

D. HNO_3

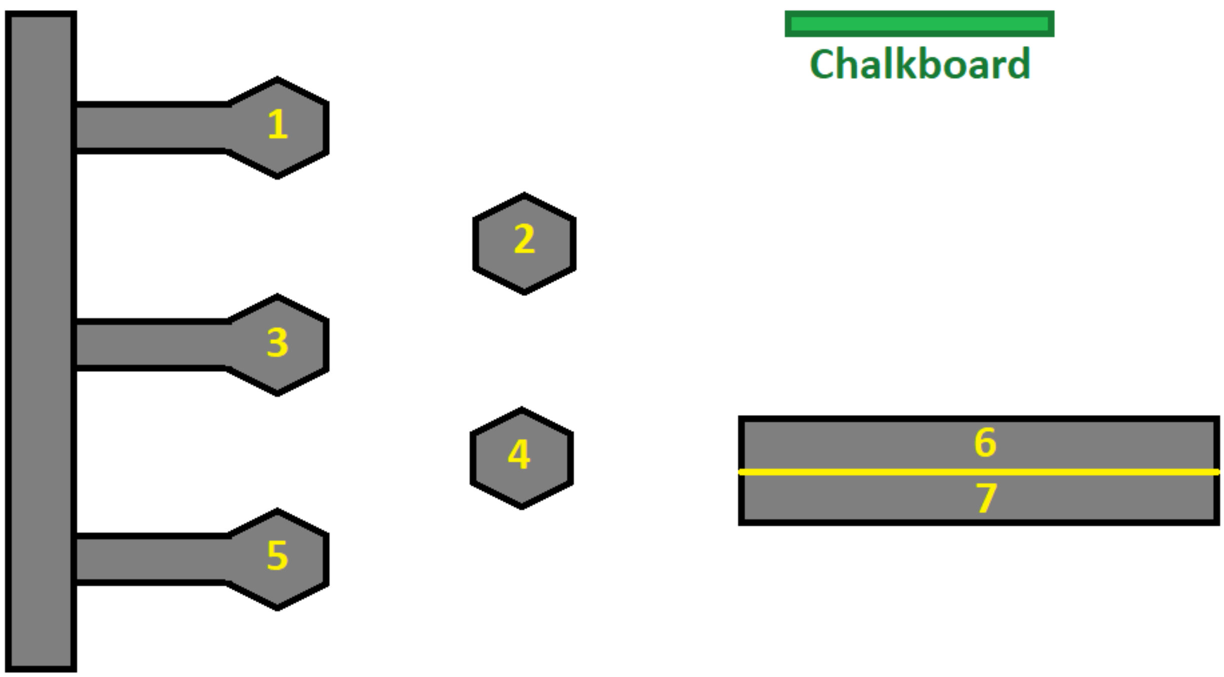
I. HNO_2

E. H_3PO_3

J. NH_4OH

Experimental

Below is a rough diagram of the benches/pods in 329 BRIS:



At Pod 1 (3 students), each student will prepare 100 mL 0.1 N HCl from con HCl.

At Pod 2 (4 students), each student will prepare 100 mL 0.1 N NaOH using solid NaOH pellets (NOTE: NaOH pellets are hygroscopic – close the lid after you've got your sample) .

At Pod 3 (3 students), each student will prepare 100 mL of a 2% (w/v) solution of copper sulfate, using copper sulfate pentahydrate.

At Pod 4 (4 students), each student will prepare 100 mL 1 M potassium nitrate from solid potassium nitrate.

At Pod 5 (3 students), each student will prepare 100 mL 10 ppm ferric nitrate.

At Bench 6 (4 students), each student will prepare 100 mL 2 M HCl from con HCl.

At Bench 7 (4 students), each student will prepare 100 mL 1 N HOAc from glacial acetic acid.

Students using the ADA benches will double check students' calculations prior to students preparing these solutions. (If there aren't enough students to fit this plan, your professor will assign as fits the class.) Once the students have double-checked the calculations of their peers, your professor will triple-check the calculations prior to solution prep. Once your professor has checked you off, you may prepare your solutions.

Once you have your solutions prepared, call your professor over to your bench, who will verify that you did exactly as you had calculated. Once that is done, the solutions are to be disposed of as directed by your professor.

Clean all glassware, dry it off and return it to its proper place. Make sure to get your experiment signed off and you may leave for the day.

FINAL NOTE:

Remember to hang onto this experiment in case you forget how to make your solutions: you'll be making your own solutions in the lab for the remainder of the semester and it's important that you make them correctly or your experiments won't turn out properly, which will impact your results and your experimental score.