
Notice!

I've found that this book project has been showing up on more and more search engines lately and is also being directly linked to for the information it contains⁽¹⁾. I therefore find it necessary to warn all persons viewing this document that it is a work in progress, and as such it contains errors of all kinds, be them in experimental procedures that may cause harm, or in faulty reasoning that would get you slapped by nearly any chemistry instructor. Please for now take the information here with a grain of salt.

Most Importantly!

By reading further you agree not to hold the authors of this document responsible for any injuries/fatalities that may occur from attempting to make any of the products or following any of the procedures that are outlined within. Chemistry inherently possesses a degree of danger and you must understand this, wear gloves and more if the situation calls for it, your safety is in your own hands, not mine!

Also note that this project is open for contribution by any party on the internet. Simply submit a section to Rob.Vincent@gmail.com and it will be added into the text pending editing and such within a few weeks. Any person contributing will have their name mentioned in the credits. Thank you for reading this, and enjoy!

¹ Although this document may be directly linked to, it will not work in that manner as I have hotlink protection for documents, however directly linking to the html document is possible, still though I would prefer links be to the main project page.

1.0 Introduction/Statement of Purpose

There are lots of pages scattered across the internet that can serve the amateur chemist in their endeavors, however each one has its own focus. Improvising a distillation apparatus, production of a specific chemical, some go further and tell how to stock a lab at home. There are still other works that are similar in goal to this work and I don't mean to compete with these, just as there are innumerable books available to a 'professional' chemistry student covering the basics this work will just be a further reference in that series, though hopefully very comprehensive. There are other places to look for the information here and a student of chemistry should not be adverse to looking

over the basics of chemistry from many different sources, after all some people learn better in one way over another.

It was originally my concept that this work should have as few web references as possible. The reasoning being that they will pass into non-existence in due time. But really at home chemistry is a constantly devolving and changing hobby, an over the counter source for one chemical may be phased out without notice, during work on this project for example sodium hydroxide which was widely available over the counter started to be phased out. Hence despite my wishing that this work be somewhat timeless, that is impossible, links will be provided and they will pass into non-existence and sources for chemicals will be given that likely won't make it to the end of the decade. Still though, it is the goal of this work to explain many of the basic concepts/materials/apparatuses used in chemistry. It is further the goal of this work to depict this in a useful way directly relating to real life and real observations. In doing so this should most closely represent anything you would run across in real life giving you the best idea as to what to expect.

In reading this text you will notice that some things are in **bold face** these are either key points or are sections to which you can refer to for more information on the relevant topic. Words in *italics* are usually shown in this manner to indicate that the definition of that word can be found in section **12** the index under the subsection "Technical Terms". Additionally as you read through this you will see numbers in superscript with parenthesis around them such as ⁽¹⁾ these indicate that at the end of the section you are in there is additional relevant information about the topic at hand, each piece of information matching up with the topic number, this can also include references to web works and book works.

Additionally since this is meant to be a highly readable work, some of the more in depth material including mathematical calculations and other material that might be considered supplemental is occasionally separated from the section where it would normally be contained, either following it immediately or referenced as being compiled into the index. For example, the calculation of the hydrogen ion concentration in an aqueous solution is a useful calculation to perform for some reactions, however it is on the whole dry boring material in most peoples eyes, as such sections such as this will be removed from the more literary part of the text so they do not disturb the flow of the section.

Back to the content there are two sections of experiments for the amateur and by the second half, experienced chemist to perform. Each experiment is intended to develop skills that will be necessary to complete experiments found elsewhere in the future. But not only does this text help to explain itself, but lays out strategies for projects that you devise yourself, sections on real research, and the gritty sections on out of control experiments and contingency plans. Upon reading though all the material presented here you should be able to go out and perform chemistry with a degree of confidence that the at home chemist is not normally afforded. As I said before, this will not be a timeless work, but hopefully it will be a good read even in the future when performing the

experiments talked about here in a home setting would be dubbed thoroughly insane (though some might find them insane right now). Never the less I wish the readers the best of luck in all their chemical endeavors even if you never make it past being an armchair chemist⁽²⁾.

Bromic

- 1 Example of a reference in the text, this is where relevant information to that passage would be found.
- 2 An armchair chemist is occasionally used as a derogatory term meaning that the person has no experience with how to work in the real world and draw all of their 'experience' from books where the information may conflict with observations or be entirely wrong, in other words a procedure they come up with may only work in theory not practice. It may be difficult to carry out in real world conditions, many people start out as armchair chemists.

1.1 Disclaimer

Each person is responsible for his or her own fortunes. It is not reasonable to hold the person writing a hunk of text responsible for your mistake should you choose to pursue their strategies, as stated in the disclaimer at the start of this document, **by reading further you agree not to hold the authors of this document responsible for any injuries/fatalities that may occur from attempting to make any of the products that are outlined within.**

Further, although many of these procedures have been attempted solely for the completion of this project, not every procedure was done or thoroughly researched. Chemistry inherently possesses some danger to it and there is always some chance somehow that things may go wrong. Please use common sense, if you are following a procedure to the letter and something occurs involving excessive heat generation or violent gas evolution and it is not mentioned in a procedure, do not just assume that it is normal, if it scares you take steps to rectify the situation, always have a contingency plan for any procedure you are doing for the first time.

People who are pregnant should not attempt many of the experiments described herein. Additionally chemistry should not be practiced around small children who may interfere with the proceedings, consume chemicals, or become more readily injured though any mishaps. You should not perform a procedure mentioned here until you are familiar with the procedure, the chemicals involved, and the possible extraneous reactions that could take place. Please, for your own safety, consider all safety precautions, gas masks, gloves, aprons, gas scrubbing. Damage done with many chemicals can be forgiving, but over time it can be disastrous, and some never give you a second chance. You only get one life, take precautions now so you do not ruin it in the future.

1.2 Safety Precautions/Gear

Before beginning on any chemical adventure there are certain steps that should be taken. The first thing you should do before starting a new experiment is to find out the properties of any reagents that are being used, along with your intended products. This

can be accomplished in many ways, looking up in a chemistry dictionary for example. However the most thorough way to determine the properties of a compound is to look up its Material Safety Data Sheet (MSDS). At the bare minimum one should tie back loose hair when in the laboratory, not eat while doing an experiments and wear closed toe footwear, no sandals. Long pants are always a good thing; as are long sleeve shirts, not loose ones though.

Regardless of the specific dangers of a chemical one should always wear gloves and goggles or a face shield. Some experiments may even require you to wear a respirator when standing up wind is not enough. There are very few chemicals that will go though a good pair of gloves⁽¹⁾. Some solvents will eat them and cause them to become gummy on the outside but a good pair of gloves will last you.

When it comes to the clothing you should wear during chemistry that is somewhat of a matter of debate. The safest thing you could wear would be a full environmental suit, lacking that disposable painting suits made of Tyvek® that cover the full body, even have their own hood attached are widely available. Another choice for a full body suit would be a Nomex® flight suit, widely available on eBay. This is the choice for persons working at high heat or interested in pyrotechnics due to the high heat resistance of this fabric. Common cloth jump suits like the one pictured also work to a lesser degree though possess inherent flammability. However there are other things to consider then fabric.



A chemistry outfit does not necessarily have to be something altogether different from something you would normally wear. The only thing that it has to be is something that you will not care if it gets ruined. What it should also be is something not absurdly flammable like many synthetic fabrics. It should also not be excessively loose or skin tight. If the clothing is too loose it can knock over beakers or drag in reagents, if it is too tight and you get something on it, it might immediately soak though to the skin. You should always be able to remove any effected clothing quickly. In case of spill or fire.



In the case of gloves there are several types. Those that totally cover the digits, the palm, and a majority of the back of the hand are good for most situations. Gloves that only cover the bottom part of the hand and cover the back with webbing are decent for handling solids but not liquids. Disposable latex/nitrile gloves are good for most anything with nitrile being superior to latex, however there is a

sweating problem, these kind of gloves can be bought in relative bulk fairly cheaply and are great to have around, the bulk kind are disposable. Finally elbow length gloves are good in situations where you are handling large quantities of reagent or there is a reaction that is causing extraneous conditions, e.g. splashing though boiling so you can easily handle the reaction if need be without splatter hitting you to any extent.

Face protection should be present to prevent splashing into the eyes, goggles like those in the above picture are ideal, they are covered from all sides and have enough air circulation to prevent them from being uncomfortable. Face shields will work and afford some additional protection, however they do not prevent splatter from certain directions, therefore a good pair of goggles are preferred. Just having any form of eye protection does help though, even safety glasses are better then nothing. However if you wear contacts you should take them out before pursuing a chemical reaction, the vapors can cause them to fuse to your eye resulting in a painful removal surgery.

Optional to some, mandatory to others, it really depends on what kind of experiments you plan to do weather or not you need a gas mask. They are available as a full mask, which covers the eyes as well as the mouth and nose, this eliminates the need for additional protective eyewear. The picture above shows a half-mask which only covers the lower part of the face. Masks are also available that utilize one cartridge or two, two providing easier breathing and longer cartridge life. The protection afforded to you by your mask is directly related to the cartridge you use. Some masks which are for military use may be picked up surplus and offer a wide variety of chemical agents to which they can offer some degree of protection, however they vary in their protection from mask to mask and therefore can only be compared on an individual basis. For a more detailed look at gas masks look at section **4.13** on gasses.

As of far all the considerations have been for working at what is known as standard temperature, room temperature, or just normal temperature, defined as 25°C or about 75°F. Now though we delve into the special gear that is necessary for working in conditions other then regular room temperature. For working at high temperature a welding shop is a goodies store, offering welding aprons and gloves that can help up to 1000°C. On the other hand working at cryogenic temperatures might be a seasonal thing, attempting to buy thick winter gloves in the middle of summer might prove to be difficult. Still though even if it is something like a pair of gloves for welding, they are insulated to keep you from the heat, they can be used just as effectively to protect you from colder temperatures, but the reverse is not true, most of the fabrics used in winter gloves and such might combust if brought into contact with hot iron. Working at high temperatures is another aspect of chemistry that depends entirely on you, some people might never need a thermometer that goes over 150°C and some people might work at high temperatures all the time, or cryogenic temperatures for that matter and never get into the realm where a thermometer would be realistic.

Aside from the personal gear that is worn it is also a good idea to have some extinguishing media around in case of fire. A fire extinguisher will work for most situations except some metal fires. In those cases sand (another good thing to have on

hand) is used to smother the fire⁽²⁾. In that case it is best to move away any hazardous chemicals you can get to and let the fire burn itself out. Putting water on a magnesium fire or other highly reactive metal can easily lead to explosion.

Another good thing to have handy are neutralization chemicals. In case of an acid spill you should have a nice wide mouthed container of sodium bicarbonate (baking soda) laying around, tossing this on an acid spill will neutralize its corrosive properties and render it somewhat safer at least so you can clean it up. Base spills are usually less of a problem but sodium bisulfate (used to adjust the pH of pools) can be conveniently located around your lab. Flushing most acids or bases with large quantities of water also helps the situation, however in the case of large spills of concentrated phosphoric or sulfuric acid extra care should be taken as these heat up greatly on combination with water, if you are applying water to these do so very quickly and in large quantity to help remove the heat and prevent *flash boiling*.

Always remember that safety should come first. It is not worth getting a severe burn because you are too cheap to buy some long sleeve welding gloves or respiratory damage because you won't invest in a gas mask. Always consider the possibility of long-term damage and if you think there is something reasonably extra that you can do to prepare for an upcoming reaction spare no expense. It has been learned by many chemists over the years, take the time to do it right the first time, get the right chemicals, set up the apparatus with all the extra safety precautions you think might be necessary but don't want to take the time to do, keep your patience and don't rush and things will always turn out a lot better.

- (1) One exceptional substance that can easily penetrate gloves is methyl mercury, which can go through many common available glove materials, but considering the toxicity of it, it is better to just not use this compound.
- (2) Note that fires of very reactive metals like magnesium will not appreciate being smothered in sand and will continue to react even with the sand, sometimes even more vigorously than with the air, there are special mixtures available commercially to smother these fires which contain among other things magnesium oxide.

1.2(a) Definitions of common medical terms

Lets assume that you are being responsible and looking out for your own health and the health of those around you and you are looking up MSDS sheets of the chemicals you will be working with. Some of the information on the sheets may be easy to understand, but when it comes to side effects of chemicals you might often come upon words such as 'pulmonary edema' and 'renal failure' and you wonder to yourself, "What do these words mean?" This can be a stumbling block when deciding on choosing one compound over another, not knowing the potential side effects puts you at a large disadvantage, although you are still encouraged to look up specific definitions for each of these terms, here is a general overview of the major terminology used:

Renal Failure: Often used to designate that a chemical upon entering the body may cause massive damage to the kidneys causing them to shut down usually permanently.

Pulmonary Edema: Corrosive gasses and other chemicals can cause this condition where fluids build up in the lungs, in serious cases this can be so bad that you can drown in your own fluids.

Necrosis: A term used to describe the process of tissue dying and/or rotting while still on the body.

1.3 How to read/write a chemical reaction

If you're just beginning to start a chemistry hobby there are a few skills that you should have. The most useful of these is reading and writing chemical reactions. There are many places on the web and in books and classrooms what will be able to more thoroughly explain this procedure than I will be able to, these skills are easy to explain but take practice to understand, therefore this section is mostly to just show the standard way in which a chemical reaction will be written in this text.

PERIODIC CHART OF THE ELEMENTS

IA	IIA	IIIB	IVB	VB	VIB	VII B	VIII	IB	IIB	IIIA	IVA	VA	VIA	VIIA		
1 H 1.00797														1 H 1.00797		
3 Li 6.939	4 Be 9.0122										5 B 10.811	6 C 12.0112	7 N 14.0067	8 O 15.9994	9 F 18.9984	
11 Na 22.9898	12 Mg 24.312										13 Al 26.9815	14 Si 28.086	15 P 30.9738	16 S 32.064	17 Cl 35.453	
19 K 39.102	20 Ca 40.08	21 Sc 44.956	22 Ti 47.90	23 V 50.942	24 Cr 51.996	25 Mn 54.9380	26 Fe 55.847	27 Co 58.9332	28 Ni 58.71	29 Cu 63.54	30 Zn 65.37	31 Ga 69.72	32 Ge 72.59	33 As 74.9216	34 Se 78.96	35 Br 79.904
37 Rb 85.47	38 Sr 87.62	39 Y 88.905	40 Zr 91.22	41 Nb 92.906	42 Mo 95.94	43 Tc [99]	44 Ru 101.07	45 Rh 102.905	46 Pd 106.4	47 Ag 107.870	48 Cd 112.40	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.904
55 Cs 132.905	56 Ba 137.34	*57 La 138.91	72 Hf 178.49	73 Ta 180.948	74 W 183.85	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.09	79 Au 196.967	80 Hg 200.59	81 Tl 204.37	82 Pb 207.19	83 Bi 208.980	84 Po [210]	85 At [210]
87 Fr [223]	88 Ra [226]	†89 Ac [227]	104 Rf [261]	105 Db [262]	106 Sg [266]	107 Bh [262]	108 Hs [265]	109 Mt [266]	110 ? [271]	111 ? [272]	112 ? [277]					

Numbers in parenthesis are mass numbers of most stable or most common isotope.

Atomic weights corrected to conform to the 1963 values of the Commission on Atomic Weights.

The group designations used here are the former Chemical Abstract Service numbers.

* Lanthanide Series

58 Ce 140.12	59 Pr 140.907	60 Nd 144.24	61 Pm [147]	62 Sm 150.35	63 Eu 151.96	64 Gd 157.25	65 Tb 158.924	66 Dy 162.50	67 Ho 164.930	68 Er 167.26	69 Tm 168.934	70 Yb 173.04	71 Lu 174.967
--------------------	---------------------	--------------------	-------------------	--------------------	--------------------	--------------------	---------------------	--------------------	---------------------	--------------------	---------------------	--------------------	---------------------

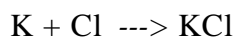
† Actinide Series

90 Th 232.038	91 Pa [231]	92 U 238.03	93 Np [237]	94 Pu [242]	95 Am [243]	96 Cm [247]	97 Bk [247]	98 Cf [249]	99 Es [254]	100 Fm [253]	101 Md [256]	102 No [256]	103 Lr [260]
---------------------	-------------------	-------------------	-------------------	-------------------	-------------------	-------------------	-------------------	-------------------	-------------------	--------------------	--------------------	--------------------	--------------------

Pictured above is your basic periodic table (See section 12.1 for a complete legible listing off all the elements in alphabetical order). The periodic table lists elements by increasing atomic number (which usually means increasing atomic weight). Also it has trends in it which can allow you to predict the properties of an element in its uncombined

state. The most common grouping that people fall back on is family. That is the vertical groups of elements. For example, on the far right, second to last column, beginning with the letter F, that family is the halogens. In descending order they are Fluorine, chlorine, bromine, iodine and radioactive astatine. Fluorine is the most reactive of the group and the reactivity decreases as you go down.

The 'atomic weight' previously mentioned is defined by the quantity called the mole (also referred to simply as mol or a mol). This is a chemistry quantity and what it basically means is 'one unit'. So, if you look at potassium on the list (K is the symbol for potassium) you will see 39.102 underneath it, what that means is that 39.102 grams of potassium metal is one unit of potassium. All the elements have units with respect to one another. For example one unit of chlorine (Cl on the list) weighs 35.453 grams and it will react with one mol of potassium (39.102 grams) completely to give 1 mol of potassium chloride, KCl which will have weight equal to the sum of the two since mass is not lost to give a total weight of potassium chloride of 74.555 grams, this reaction would be expressed by the following system:



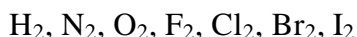
Reactions in this work will be in the same form of $A + B \rightarrow AB$

Another specific example would be $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$ Translating this from chemical speak to common tongue is simple. Looking at a periodic table you find that the letter H represents hydrogen, a colorless odorless gas, and that O represents oxygen, and I would hope you are all familiar with the product H_2O . The prefix, that is the number before the letter signifies the number of whatever it is in front of that take part in the reaction. The numbers behind the letters stand for the number of that element in a compound. Hydrogen and oxygen are gasses that exist not as individual atoms but as two atoms bound together, hence the two behind each of them. So what it is saying is, four atoms of hydrogen, combine with two atoms of oxygen, to produce two molecules of water. Note the distinction between atoms and molecules, O_2 is a molecule containing 2 atoms of oxygen, H_2O is a molecule containing 2 atoms of hydrogen and one atom of oxygen. Chemical reactions of this type are balanced, with each molecule appearing in the same quantity on both sides, if that is not the case the equation is dubbed 'unbalanced' and steps can be taken to rectify it (Note that although a molecule of oxygen contains two oxygen atoms you can still treat it like it is just O in equations, just double the molecular weight to get the weight of the O_2 molecule).

Diatomic Molecules and More

When it comes to a chemical reaction the periodic table gives the symbols only for individual atoms of an element, which is not how many of them are found. For example, many gasses are diatomic molecules (di meaning two in this case, so the molecules are formed from two atoms). What this means is that two atoms of the substance have a bond between them and therefore come in a pair. Here is a quick list of elemental gasses

that are diatomic:



Although bromine and iodine are liquids and solids respectively, in the gas phase they consist of two atoms bonded together. These bonds between the atoms account for a degree of their reactivity, for example, the bond between fluorine atoms is very weak, it breaks readily from light and as a consequence you end up with highly reactive free fluorine. Chlorine will also break its bond to itself from daylight, when the bond breaks it can attack hydrocarbons and chlorinate them. On the other side of the situation the nitrogen-nitrogen bond is actually a triple bond, there are three bonds connecting one nitrogen atom to another. This is actually one of the strongest bonds in chemistry and accounts to some extent for the lack of reactivity of nitrogen (note that it accounts for a large portion of the air we breathe). The fact that these are diatomic is not of great importance in chemical reactions because the molecular weight of one atom is still the same, however it is important in calculating the amount of a gas. One mole of gas usually takes up approximately 22.4L of space at standard temperature and pressure. But it's not one mole of O that takes up that space, it is one mole of O₂ so actually there would be two moles of atomic oxygen for 22.4L of space.

Going further there are other elements that associate so their formulas are usually or can be expressed as different combinations of atoms, explanations are not given here but notable examples include B₁₂, S₈, and P₄.

Exceptions to this rule are nonstoichiometric reactions, reactions that do not have a specific reaction that takes place and a number of products can be formed under different conditions though a main product is usually known or is the desired product of the reaction. This includes a wide variety of organic reactions, a specific example being:



Notice how the by product, water is not included in the reaction, and that the amount of HNO₃ (nitric acid) and H₂SO₄ (sulfuric acid) reacting with the C₆H₆ (benzene) to produce C₆H₅NO₂ (nitrobenzene) is not a part of the equation, this can be read '*in the presence of*' therefore allowing the reaction to be read, "Benzene, in the presence of nitric acid and sulfuric acid reacts to produce nitrobenzene". Another time that information can appear in between the arrows could be a *catalyst* which only speeds up the reaction, additionally temperature information can appear there as can pressure. Specific reaction conditions are not usually included in the condensed equation and it is not safe to assume that every reaction you see will run at STP (standard temperature and pressure) as a matter of fact there are many reactions not run at STP and because of this you really hardly know anything of reaction conditions when you see a reaction written out, this can be a real pain in the butt.

Now let's say you want to write a chemical reaction. First you should know the chemicals/elements involved along with what you believe to be the products. You write

them out in the format previously described, reactants (things reacting to give your desired product) on the left and products on the right, then you attempt to balance the equation by adding to the products or reactants side. If an element only shows up on one side something is automatically off. Just remember that there is not always one correct chemical reaction and just because a reaction looks good on paper does not magically make it the real reaction, a reaction that is nearly impossible may look just as plausible on paper as a simple reaction time tested for the past hundred years anyone can make up a reaction, be wary of reactions you see with no information backing them up.

In addition to the common elements there are also components that the average chemist will come across that almost behave as though they are elements. They are more evident in aqueous solutions in the form of ionic compounds. Collectively they are known as ions but more specifically positively charged species are known as *cations* and negatively charged species are known as *anions*. Most aqueous chemistry (chemistry occurring in water) revolves extensively around cations and anions and it is quite useful to have a ready reference list of cations, anions, and their respective charges, and it just so happens that there are many lists available besides the one here:

Anions:

Acetate	$C_2H_3O_2^-$		Hydrogen Carbonate	HCO_3^-		Hydride	H^-
Arsenate	AsO_4^{3-}		Carbonate	CO_3^{2-}		Hydroxide	OH^-
Arsenite	AsO_3^{3-}		Chloride	Cl^-		Nitrate	NO_3^-
Azide	N_3^-		Hypochlorite	ClO^-		Nitrite	NO_2^-
Bismuthate	BiO_3^-		Chlorite	ClO_2^-		Nitride	N^{3-}
Bisulfate	HSO_4^-		Chlorate	ClO_3^-		Oxide	O^{2-}
Sulfate	SO_4^{2-}		Perchlorate	ClO_4^-		Peroxide	O_2^{2-}
Hydrogen Sulfite	HSO_3^-		Chromite	CrO_3^{2-}		Phosphate	PO_4^{3-}
Sulfite	SO_3^{2-}		Chromate	CrO_4^{2-}		Phosphite	PO_3^{3-}
Thiosulfate	$S_2O_3^{2-}$		Dichromate	$Cr_2O_7^{2-}$		Metaphosphate	PO_3^-
Hydrosulfite	$S_2O_4^{2-}$		Cyanide	CN^-		Phosphide	P^{3-}
Peroxy-disulfate	$S_2O_8^{2-}$		Thiocyanate	SCN^-		Permanganate	MnO_4^-
Bisulfide	HS^-		Cyanate	OCN^-		Iodide	I^-
Sulfide	S^{2-}		Fluoride	F^-			
Borate	BO_3^{3-}		Formate	$HCOO^-$			
Bromide	Br^-		Oxalate	$C_2O_4^{2-}$			

Red = Usually insoluble in water **Blue** = Normally soluble in water **Black** = Follows no trend

Cations:

Hydronium	H_3O^+		Ammonium	NH_4^+		Lithium	Li^+
-----------	----------	--	----------	----------	--	---------	--------

Ion							
Sodium	Na ⁺		Potassium	K ⁺		Magnesium	Mg ²⁺
Calcium	Ca ²⁺		Barium	Ba ²⁺		Chromous	Cr ²⁺
Chromic	Cr ³⁺		Manganous	Mn ²⁺		Manganic	Mn ³⁺
Ferrous	Fe ²⁺		Ferric	Fe ³⁺		Cobaltous	Co ²⁺
Cobaltic	Co ³⁺		Nickelous	Ni ²⁺		Nickelic	Ni ³⁺
Cuprous	Cu ⁺		Cupric	Cu ²⁺		Zinc	Zn ²⁺
Silver	Ag ⁺		Aluminum	Al ³⁺		Stannous	Sn ²⁺
Stannic	Sn ⁴⁺		Plumbous	Pb ²⁺		Plumbic	Pb ⁴⁺

Mind you there are more cations and anions than just the ones listed here, these are just common examples. The charge of an unknown cation is usually more easily determined than that of an anion, especially if you are given a name. Charges of anions usually stay constant whereas metals can have differing charges, knowing the anion a metal is coupled with can give you an indication of what the oxidation state of the metal is. In addition some names are currently written out using the stock system. This greatly simplifies things, instead of a name like manganese dioxide you get manganese (IV) oxide, the Roman numeral four indicating that manganese is in the +4 state and therefore knowing that oxygen has a negative two charge you can determine the formula of this compound to be MnO₂. The use of -ous and -ic at the end of some names to differentiate between the higher and lower oxidation states is an older phenomenon and is somewhat being phased out, however tin (stannous +2 and stannic +4) and lead (plumbous +2 and plumbic +4) are somewhat stuck in this system of naming. Regardless, there are many anions, many cations, existing in different situations, some not stable in water, some only found in water, and others only existing in the solid state. Just remember the overall charge of a molecule must remain neutral.

1.4 Units used throughout the text

The system used in this text will be the most accepted system in chemistry academia. The all mighty metric system. Units of weight will often be expressed in grams (g), of volume, in liters (l) and milliliters (ml) and time in seconds (s), hours (h), and days. In addition temperatures will be measured in degrees Celsius (°C).

When it comes to liquids though there are different units that come into play aside from milliliters. The most useful unit is molarity. This is defined as the number of mols of a substance (solute) dissolved in 1 liter of substance (solvent). From here you can convert one molarity solution to another using the formula:

$$\text{Molarity Initial (Mi)} \times \text{Volume Initial (Vi)} = \text{Molarity Final (Mf)} \times \text{Volume Final (Vf)}$$

For Example:

Chemoleo wants to make a 1 M NaOH Solution in water. So he weighs out one mole of NaOH. looking at the periodic table he finds the atomic mass of sodium to be 22.9. that of

oxygen to be 15.9 and that of hydrogen to be 1.0, adding these together he gets the weight of one mole of NaOH to be roughly 40 g. So after weighing out 40 g of sodium hydroxide pills he adds to them enough water to make the total volume 1 L thus making a 1 M solution. This sits on his shelf for quite some time until one day he finds that he needs 100ml of a .5 M NaOH solution. Having three components of the above equation he can solve for the initial volume of 1 M NaOH he needs to end up with a 100 ml amount of a .5 M solution.

$$1M \times (V_i) = .5 \times 100 \text{ ml}$$

$$V_i = 50 \text{ ml}$$

So Chemoleo must take 50 ml of his 1 M NaOH solution and add to it 50 ml H₂O to bring the total volume to 100 ml of .5 M NaOH solution. Remember to label any reagents you keep laying around Chemoleo.

The molarity unit is exceptionally good for one specific reason, it greatly simplifies calculation involving precise reactions and the amount of reagents you are dispensing. Molarity is heavily used in *stoichiometry* and is the staple method of labeling many lab reagents. In physics academia a more popular unit is molality, this is a measurement of mols per kilogram solvent, in this way the molality of a solution will not change with temperature whereas molarity will due to the change in volume of the liquid as the temperature fluxuates.

Another method of measurement one will come across is the percent (%) solution. There are different variations on this, the weight/volume method, the volume/volume method, and the weight/weight method. One common example of a % solution would be 6% NaOCl available OTC as bleach.

The chemist known as BromicAcid just bought 3.8 L of a 6% NaOCl solution. In order to keep his lab space organized he must retain the labeling method he has already begun for his other reagents, therefore he must determine the molarity of the 6% NaOCl solution. So the solution is 6% NaOCl by weight, so 6.0 g / 100 g solution. Now, density would come in handy here, however Bromic was unable to find the information on the web and is too lazy to do physical measurements, therefore he is assuming that the density of the solution is close to water so 1.0 g/ml therefore 1000 ml or 1000 g would have approximately 60 g NaOCl. NaOCl has an atomic weight of around 74 g/mol therefore Bromic has $60/74 = .80$ mols of NaOCl per liter so the molarity equals 0.80M for the solution of NaOCl to store on his shelf.

Often times, as seen above the density of the solution is necessary to determine a more precise molarity calculation from the percent solution. Tables are available online and in the CRC (Handbook of Chemistry and Physics) and elsewhere that give molarity to percent to density conversions that will aid in this task.

Common Percent Solutions to Molarity		
Substance Name	Percent Solution (in H ₂ O)	Molarity
Sulfuric Acid H ₂ SO ₄	100%	18.7 M
	91%	17.1 M
	40%	5.4 M
Nitric Acid HNO ₃	70%	15.8 M
	90%	21 M
Hydrochloric Acid HCl	20%	6.0 M
	28%	8.7 M
	38%	12.4 M
Ammonia NH ₄ OH	4%	2.3 M
Acetic Acid CH ₃ COOH	5%	.8M
Sodium Hypochlorite NaOCl	6%	.85M
	10%	1.45 M
	12.5%	2 M
Hydrogen Peroxide H ₂ O ₂	3%	1.25 M

1.5 Discussion of Legality/Words of Encouragement

Practicing chemistry as a hobby has fallen out of fashion in recent years and as such trying to delve into it may cause you to be greeted with skepticism at best and at worst a strange kind of desperation to wipe you off the earth. Trying to keep out of the public eye is usually a necessity for the continued practicing of chemistry. Despite the fact that many reactions are totally legal there always seems to be a way for you to get into trouble if someone decides to make trouble for you. Example, phosphorus in all of its *allotropes* are illegal to own anywhere in the United States. If you attempt and succeed to make phosphorus you are really breaking the law. This is because there are illicit (illegal) uses for this chemical and because of this, it has been outlawed. As such the chemistry of elemental phosphorus, the useful phosphorus halides and other chemicals are taboo unless you break the law.

But the actual list of chemicals that are illegal is very short compared to the chemicals that can be made by a motivated individual. And as such there are plenty of legal target chemicals that one can take aim at. Try not to break the law, many energetic compounds are illegal, as of course drug precursors are but do not let that discourage you from what you can legally do. Chemistry is fun and if you keep up a beginning spirit you will have fun with it for a long time to come. Not only that but it's useful, giving chemistry a try might be the best thing you do for yourself.
