
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.

6.0 Practical Concerns for running an amateur lab

Although it is not a nice issue to bring up, it remains true that in most places around the world, especially industrially advanced, chemistry at home is frowned upon. For example, in a place like the United States chemistry was a widely practiced hobby until the 70's where environmental concerns and safety considerations made chemistry seem forbidden and dangerous. Saying that you are performing a chemistry experiment may shock people in your area and might force them to call the authorities.

The legality of the procedures that you perform usually will fall into questionable territory. Outside of using common over the counter reagents for their intended over the counter purpose you are walking a thin line. The use of sulfuric acid in the form of drain

cleaner to act as a catalyst might not seem like a breach of the law but some chemicals will flatly state on the back of them that it is illegal to use that chemical for anything other than the instructions listed on the opposite side. Therefore it may be prudent to move all obtained chemicals to new containers, and if possible between the move, purify them.

Aside from these legality issues of chemical possession and use, you come to the disposal issue. You will not be able to recover every bit of product from every reaction, you won't be able to continuously run any series of reaction without generating waste along the line somewhere. You will have to dispose of this waste you create, and although the disposal is completely up to you, you should always dispose of chemicals in the most environmentally friendly way possible, disposing of certain chemicals, by dumping on the ground, flushing down a toilet, or throwing in the trash is a major crime that can bring about jail time, and or extraneous fines.

Also the illegal dumping of chemicals can cause immediate destruction to your local ecosystem. Your grass and trees may die, accidental releases are also a problem. The unintended release of large quantities of noxious gasses can also kill grass and make your neighbors life miserable. Increasing their likelihood on calling the authorities. Although you shouldn't have to sneak around in the middle of the night, which would make others more suspicious you shouldn't perform your reactions in the public eye. Doing so just increases that chance that someone will see you and object to what you are doing. And if that happens disastrous consequences can result, people with small children are often the most objective over chemicals, but, it is a reasonable response on their part.

Considering all of these aspects it is usually a good thing to not flash around the fact that you have a chemistry hobby. Your chemicals should be kept under lock and key just in case anyone wants to get to them just for the fun of mixing something up. This whole situation is a sad one in some respects but it is the way that you should follow your hobby, carefully disposing of waste, not willingly divulging more information than you have to, and working out of the public eye.

6.1 Starting up and Stocking your Lab Space (The essentials)

Here is a table of some of the basic items that should be in any laboratory, those highlighted in **green** are indispensable, you can do chemistry without them, but nothing that would be considered quantitative or productive. Those in **orange** are very useful and should be purchased at first convenience, and finally those in **yellow** are quite useful, you will want to own these after awhile.

Item	Description	Source
Test Tubes	Roughly 20 – 30 ml in volume, borosilicate is best.	Chemistry Supply
Beakers	A variety is best, small (100 ml), large (500 ml), medium (250 ml) are most used.	Chemistry Supply

Test Tube Holder	Holding more than one test tube, allows for viewing of reactions and hands free manipulation.	Can be made at home or purchased.
Graduated Cylinder	A 100 ml cylinder is the staple for precise measurements of liquid.	Chemistry Supply
Watch Glass	A concave circle of glass, for covering beakers or evaporating liquids to obtain crystals.	Chemistry Supply (Many objects can suffice as watch glasses)
Thermometer (glass)	The normal range is from -10C to 150C the higher and lower the better.	Grocery store (Candy Thermometer), Chemistry Supply
Pipette / Eye Dropper	For dispensing small quantities of liquid or sucking up different layers of liquid.	Pharmacy, Chemistry Supply Store, Grocery Store
Funnel (glass)	For pouring liquid and for filtration.	High end cooking stores, chemistry supply
Scale	Digital or balance, should be able to measure to the gram.	Office supply stores for weighing mail, internet
Vacuum Source	To create suction for filtration or distillation.	Hand: Auto store (for break lines), Internet Mechanical: Salvaged Compressor or Medical/Chemical Supply
Heating Source	Torch, coil heater, hot plate, alcohol lamp, etc.	Most any place
Stirring Rods	Glass is the best	Chemical Supply, can be improvised easily.
Scoops	To remove reagents from jars for weighing or use.	Long plastic spoons can be readily purchased at grocery stores.
Reagent Bottles	To keep the things you make and acquire	Keep your eye out.

These items are all useful as you will find out in your experiments. But the necessary chemicals to do reactions are really non-existent. This is because each chemical usually opens many possibilities for experimentation. To start out though it is good to have one acid, any acid will do, even vinegar, and one base, sodium bicarbonate for cooking works for this. That is already a good start. With acetic acid you can create acetates, which are luckily one of the classes of compounds that are widely soluble. With it you can dissolve aluminum, magnesium, iron, zinc and some other metals and you can also add hydrogen peroxide, even the concentration available for cleansing wounds and it will attack even more metals. From here you can evaporate solutions of metal salts and collect them for later use. Each chemical created opening more possibilities to make still more chemicals.

6.2 Legality

6.3 Storage of chemicals, Separation of reagents

6.4 Disposal of waste materials generated



Treating wastes containing hydrazine with excess sodium hypochlorite converts the hydrazine to harmless nitrogen gas.

When it comes to disposal the home chemist must do what they can to ensure their chemicals are disposed of in the most health conscientious and environmentally friendly manner possible. Though there are usually some compromises to be had that is the overall goal in the disposal of hazardous reagents. To get straight to the point let us start by taking a look at inorganic chemicals. Believe it or not some metal cations are themselves hazardous, for example barium wastes can cause sickness readily upon skin contact if they are appropriately soluble, so the solution is to render them insoluble, treating a soluble barium salt with sulfuric acid or a sulfate leads to the precipitation of highly insoluble barium sulfate, a chemical so insoluble that it is actually intentionally consumed prior to X-rays of the gastrointestinal tract to outline the details. There are also anions that are inherently hazardous, the most famous being the cyanide anion (CN^-), cyanide can be converted to the considerably less toxic cyanate anion by simply treating a soluble cyanide solution with excess bleach. I therefore present these tables, remember to consider both your cation and anion in the method of disposal. These are no where near perfect solutions to the problem of waste management, however they are the best us chemists can often do, attempting to turn the chemicals to the least soluble compounds where they can do no harm or into the naturally occurring form of the compound. [Note: For those of you with septic systems take extra care, you do not want to kill the bacteria involved in destroying your organic wastes, be careful with what you flush.]

Cation disposal options:

Cation	Disposal	Cation	Disposal
Aluminum (Al^{3+})	Although aluminum salts are implicated in the cause of	Antimony (Sb^{3+})	Conversion to the sulfide*.

	Alzheimer's, they are usually safe for disposal.		
Arsenic (As ³⁺)	Conversion to the sulfide*.	Barium (Ba ²⁺)	Conversion to the sulfate, carbonate**, or sulfide*.
Beryllium (Be ²⁺)		Bismuth (Bi ³⁺)	
Boron (B ³⁺)	Boron salts are not inherently toxic, though it doesn't follow as set of a trend as some of the other elements.	Cadmium (Cd ²⁺)	
Calcium (Ca ²⁺)	Calcium salts do not pose any inherent danger due to the cation.	Chromium	
Cobalt (Co ²⁺)		Copper (Cu ²⁺)	Though copper salts are somewhat toxic, it is acceptable to dispose of them in the municipal sewer system, as evidenced by over the counter CuSO ₄ root killer. Conversion to the sulfide is another possibility.
Gold (Au ⁺)		Iron (Fe ²⁺)	
Iron (Fe ³⁺)		Lead (Pb ²⁺)	
Lead (Pb ⁴⁺)		Lithium (Li ⁺)	Soluble lithium salts are neurotoxic, reaction with steric acid gives insoluble soaps.
Magnesium (Mg ²⁺)	Magnesium salts do not pose any inherent danger due to the cation.	Manganese	
Mercury (Hg ⁺)	Conversion to the sulfide.	Mercury (Hg ²⁺)	Conversion to the sulfide, reduction may be necessary.
Molybdenum		Nickel (Ni ²⁺)	Reduction to the base metal, alternately conversion to the carbonate** or phosphate.
Silver (Ag ⁺)	Reaction with a soluble chloride, bromide, or iodide.	Sodium (Na ⁺)	Sodium salts do not pose any inherent danger due to the cation.
Strontium (Sr ²⁺)		Tantalum	
Thallium (Tl ⁺)		Tin (Sn ²⁺)	
Tungsten		Zinc (Zn ²⁺)	Zinc salts do not pose any inherent danger due to the cation.

* = In the case of a soluble salt, the solution containing the cations may be treated with a soluble sulfide (such as sodium sulfide) or with hydrogen sulfide gas (**Dangerous**, see section 4.13 Gasses for the entry on hydrogen sulfide), usually in the case of the sulfide it is preferred as the disposable form of the cation as it is both highly insoluble (except in highly basic or oxidizing environments) and that it is the naturally occurring mineral in

which the element is found. In all instances where the sulfide is the preferred final form it will precipitate from the solution whereupon filtration is possible to remove it.

**=Conversion to the carbonate is accomplished by first making the solution neutral or slightly basic and then adding a solution of a soluble carbonate such as sodium carbonate. Also the solution can be made fairly basic with hydroxide (assuming the hydroxide is soluble) and then carbon dioxide can be bubbled into the solution to precipitate the carbonate.

Anion Disposal Options:

Acetate (C ₂ H ₃ O ₂ ⁻)	Acetate poses no unusual hazard for humans.	Azide (N ₃ ⁻)	Azides can be unpredictably explosive, in solution they can be treated with sodium hypochlorite to convert them to nitrogen.
Bisulfate (HSO ₄ ⁻)	Although acid in nature it poses no unusual hazard.	Sulfate (SO ₄ ²⁻)	Sulfates are fairly benign.
Sulfite (SO ₃ ²⁻)	A weak reducing agent, sulfites can usually be disposed of with no further treatment.	Thiosulfite (S ₂ O ₃ ²⁻)	
Sulfide (S ²⁻)	Sulfides should not be treated with acid as hydrogen sulfide may be evolved, many sulfides are insoluble enough to be safely disposed of, sulfides of the alkali metals should be treated with a solution of cation that will form an insoluble sulfide, such as copper.	Borate (BO ₃ ³⁻)	Borates can be mildly basic but nothing of major concern.
Bromide (Br ⁻)	The bromide anion can have a sedative effect on the human body but that is only in large concentration, overall bromide is safe for disposal.	Hydrogen Carbonate (HCO ₃)	Only the alkali metals and a few others can form the hydrogen carbonate salt, this salt is safe enough to be disposed of in nearly any manner.
Carbonate (CO ₃ ²⁻)	Aside from the alkali metals and some of the alkali earths the carbonates are fairly insoluble, the carbonate anion is non-hazardous.	Chloride (Cl ⁻)	The chloride anion is non-hazardous and can be disposed of in nearly any manner.
Hypochlorite (ClO ⁻)	Hypochlorite is a good oxidizing agent but can safely be dumped down drains in normal amounts.	Chlorite (ClO ₂ ⁻)	
Chlorate (ClO ₃ ⁻)		Perchlorate (ClO ₄ ⁻)	The perchlorate anion is suspect as having a long term environmental impact, excess perchlorate can be disposed of by heating to decomposition with charcoal (Note , some perchlorates are violently

			explosive on their own, take caution!)
Chromate (CrO ₄ ²⁻)		Dichromate (Cr ₂ O ₇ ²⁻)	
Cyanide (CN ⁻)	Soluble cyanide solutions can be treated with excess hypochlorite solutions to oxidize them to the considerably less toxic cyanate.	Cyanate (OCN ⁻)	Can be disposed of as long as it is not in any area where it may be consumed by animals and humans.
Fluoride (F ⁻)	Soluble fluoride compounds are toxic, treatment of fluoride solutions with calcium cations is recommended to precipitate the fairly safe CaF ₂ .	Formate (HCOO ⁻)	Formate is toxic however provided the amounts are not excessive it may be flushed down the drain as products that contain it are disposed of in this way.
Oxalate (C ₂ O ₄ ²⁻)	Conversion of soluble oxalates to calcium oxalate (insoluble) is one method, all oxalates are subject to thermal decomposition so just heating to ~250 °C should do the trick, be warned CO may be produced.	Hydroxide (OH ⁻)	Aside from basicity the hydroxide anion has no terrible toxicity and can safely be flushed, even concentrated solutions can be dumped providing there are no hazardous cations associated with it.
Nitrate (NO ₃ ⁻)	Nitrates are good for the grass, you can dump them outside in some situations though concentrated solutions will kill the grass. Do not dump where it can go into rivers or streams, destroy by heating to dryness and mixing with carbon and igniting.	Nitrite (NO ₂ ⁻)	Addition of acid will destroy nitrite in solution but converts it to toxic NO ₂ , heating to dryness and mixing with carbon and igniting is another option. Nitrite should not be dumped.
Peroxide (O ₂ ²⁻)	Strong peroxide solutions can get out of hand during destruction procedures. Strongly basifying a peroxide solution will destroy it in a few hours, adding MnO ₂ , iron salts and some other catalysts (such as iodine) will also destroy inorganic peroxide as can reducing agents.	Phosphate (PO ₄ ³⁻)	Do not dispose of in massive amounts in waters that may lead to rivers, phosphate can lead to bacterial blooms in waterways. Other than that phosphate is fairly environmentally benign, it helps flowers bloom brighter, assuming the pH is properly adjusted it can be dumped.
Permanganate (MnO ₄ ⁻)	Initial reduction of permanganate can be accomplished by just allowing a solution of it to stand for several days or with reducing agents. After reduction you are left with soluble manganese salts and manganese dioxide which can easily be disposed of.	Iodide (I ⁻)	Toxic in large amounts but safe to dump.

When in doubt, organic materials can be readily destroyed by the addition of Fenton's Reagent, which is a mixture of strong (>20%) hydrogen peroxide with a soluble iron +2 compound. It is believed that the power of this solution to oxidize nearly anything organic (benzene rings and chlorinated hydrocarbons readily succumb to this treatment) is the result of the formation of the hydroxyl radical HO* in solution which is highly reactive.

6.5 Considering your neighbors/neighborhood in every reaction

Usually when considering a reaction you will consider your own safety, a gas mask, gloves, and you might weigh the possibility of catastrophic error against your life and decide that the reaction is feasible. But before doing any reaction think about how these things relate to your neighbors. You can't have a faulty distillation apparatus spewing out ammonia gas just because you are wearing a gas mask. Your neighbors do not have that luxury. Maybe your reaction could run away and explode, you might be willing to risk that, but you cannot assume your neighbors would. However there is a linear relationship with what kind of risks you can take and how far away from you your nearest neighbor is, it stands to reason that if you live in a remote area you can get away with doing nearly any chemical adventure you can fathom for yourself, likewise if your neighbor is only a dozen meters away then what you do becomes more dependent on how it will affect them.

Not really something to be covered in detail here, it is more of a general awareness that you are not alone in your endeavors, your waste disposal, privacy, and your major risks should all be contemplated with your neighbors in mind. Not only for your sake, for fear of an errant call to the police, but for theirs as well. If you are comfortable with your neighbors you might tell them that chemistry is your hobby, it will make them feel safer then looking in their backyard and seeing you stroll around in a hazmat suit with a self-contained breathing apparatus strapped to your back and assuming the government has sent an agent to probe around the neighborhood.

6.6 Privacy & Security