

MANY REASONS WHY WE ENCOURAGE YOU NOT TO STORE CHEMICALS IN ALPHABETICAL ORDER

PRODUCTS STORED TOGETHER	POSSIBLE REACTIONS
Acetic acid + acetaldehyde	small amounts of acetic acid will cause the acetaldehyde to polymerize thus releasing great amounts of heat.
Acetic anhydride + acetaldenylde	reaction can be violently explosive
Aluminum metal + ammonium nitrate	a potential explosive
Aluminum metal powder + antimony trichloride	aluminum metal burns in the presence of antimony trichloride
Aluminum metal + any bromate, chlorate or iodate	finely divided aluminum metal in contact with a bromate, chlorate or iodate can be easily detonated by heat, shock or friction
Aluminum + bromine vapor	aluminum foil reacts with bromine vapor at room temperature and incandescens
Aluminum chloride, anhydrous	$AlCl_3$, anhydrous is constantly generating hydrochloric acid. After long storage, tightly closed containers have been known to explode when opened.
Ammonia vapor + bromine vapor	unstable nitrogen tribromide is formed and explosion may result
Ammonium nitrate + acetic acid	a mixture may result in ignition especially if the acetic acid is concentrated.
Antimony + bromine vapor or any halogen vapor	antimony is spontaneously flammable in the presence of any halogen vapor
Arsenic + any bromate, chlorate or iodate	a potentially explosive combination if detonated by heat, shock or friction
Barium + carbon tetrachloride	a violent reaction may occur
Calcium hypochlorite + charcoal	a mixture can result in an explosion if heated
Carbon + any bromate, chlorate or iodate	a potentially explosive combination if detonated by heat, shock or friction
Carbon disulfide vapor + powdered aluminum	finely divided aluminum will spontaneously burst into flame in the presence of carbon disulfide
Copper + bromate, chlorate or iodate	a potentially explosive combination if detonated by heat, shock or friction
Cupric sulfide + cadmium chlorate	will explode on contact
Hydrogen peroxide (6% or more) + ferrous sulfide	a vigorous, highly exothermic reaction
Hydrogen peroxide (6% or more) + lead (II) or (IV) oxide	violent, possibly explosive reaction
Lead sulfide + hydrogen peroxide (6% or more)	vigorous, potentially explosive reaction
Magnesium hydroxide + maleic anhydride	potentially explosive reaction
Mercuric nitrate + methyl alcohol	may form mercury fulminate—an explosive
Mercuric oxide + magnesium metal	an explosion may result if heated
Mercuric oxide + zinsphorus	percussion may ignite this mixture
Nitric acid + magnesium metal powder	will react with explosive force
Nitric acid + phosphorus	phosphorus will burn spontaneously in the presence of nitric acid
Potassium cyanide + potassium nitrate	a potentially explosive mixture if heated
Silver metal + tartaric acid	an explosive mixture
Silver oxide + sulfur	a potentially explosive mixture
Sodium + sulfur	under the right conditions the reaction can proceed with explosive violence
Sodium nitrate + sodium thiosulfate	a mixture of dry materials can result in explosion
Stannic chloride + turpentine	a flame-producing, exothermic reaction

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SUGGESTIONS FOR THE TAKING OF A CHEMICAL INVENTORY IN A SCHOOL SCIENCE DEPARTMENT

- Have spill/breakage aids available
- Make sure the room is well lighted
- Plan before you start
- Alert school administrators about the inventory
- Use safe ladders
- Wear appropriate clothing
- Avoid involving students
- Work slowly

We are sure that responsible science teachers and school administrators agree that it is necessary to know exactly what chemical substances are present on school premises and in what quantities. Such an inventory would serve many valuable purposes such as (but not limited to):

- To comply with regulatory requirements
- To make the school safer
- To efficiently use (and perhaps share) the existing inventory
- To rid the premises of excess/unused chemical substances
- To implement the storage of all remaining substances in compatible chemical families
- To isolate and safely store particularly hazardous substances
- To create and maintain a perpetual inventory of all chemical substances
- To identify substances (severe toxins, carcinogens, etc.) that should not be found on school premises and rid the premises of these materials
- To identify substances as a function of their specific hazardous character (flammables, acids, oxidizers, etc.) and provide dedicated and approved storage for them.

In our opinion, just plain old-fashioned "good sense" suggests that it is time for action! Action demands that you know what you have and how much of it you have. Once this inventory is accomplished a great many benefits will follow.

It is very important to point out that laboratory chemicals should no longer be purchased like other routine school supplies! The normal routine of most schools is to acquire a year's supply of needed chemicals at one time, along with other routine science supply needs. The result of this process is that dozens of chemical items, many in very large quantities, arrive at the school and are then stored in science storerooms never designed to handle such quantities and rarely equipped to meet even minimum standards of safe storage. We are sure your conventional wisdom says that the smaller the quantities of these materials found in schools at any given time, the smaller the problem.

We cannot emphasize strongly enough the need for science teachers, science department heads and, most particularly, school administrators and business managers to recognize the problems created by lumping hazardous chemicals into the buying routine. To continue to apply the same buying routine to hazards simply aggravates and per-

petuates the problem. Those in the school with science backgrounds must educate the non-science-trained administrators about the severe problems created by continuing to buy hazardous chemicals in the same manner as they buy routine school supplies.

It can also accurately be stated that when a large school with many science teachers has no one in charge of managing the chemical storeroom, the problem is made more severe. When every science teacher or multiple science teachers are in charge of this matter—then, in fact, no one is in charge.



Multiple school building districts should also give very serious consideration to establishing a central "liter committee." This committee could routinely see every chemical requisition. Their review would be aimed at completely eliminating or reducing the quantity of some substances purchased. No, we are not suggesting that science teachers be denied access to needed reagents. We are, however, suggesting that the matter be managed. Who better to manage the problem than the knowledgeable users, i.e., the science teachers meeting as a committee.

It is not uncommon to find, among multiple school buildings, an excess of a chemical in Building A while the science teacher in Building B just placed an order for the very same chemical. Why can't inventories be shared with the goal in mind of better system-wide substance management? If the impediment to better, safer and more efficient substance management is the "established system" or the "established bureaucracy" then the "system" or the "bureaucracy" must be educated and their methods changed. Would you not agree that an efficient method of substance management in a multiple science department building or in multiple buildings is to provide inventory level information to all

Continued on next page

users and allow all users access to excess inventories? No, one school should not be allowed to rob another school's inventory. However, can't excesses be identified and shared? The science teacher who is a good substance or inventory manager should not be penalized to serve the poor

manager in another department or building. Conventional wisdom suggests, however, that excess substances can be better managed by sharing knowledge of their existence.

You have now decided it is time to take an inventory. Plan for the event using the following:

CONSIDERATIONS WHEN PLANNING AN INVENTORY

- Who will be the team members to perform the inventory?
- How much time shall you allow to perform this task?
- As materials are taken from the shelf (if you elect to do this at this time) where and how will they then be housed?
- Do you have the requisite safety items to protect yourselves during the process?
- Will this be simply an inventory of what substances you have or will it be a major reorganization of the chemical stores facility?
- Are flashlights, ladders and other such devices available?
- Will the room be properly ventilated during the process?
- Will a means of communicating with the outside be available in case of a serious problem like spill, breakage or fire.
- How will you record the chemicals on a substance-by-substance basis?
- How will you handle unknowns or "mystery" substances as these are encountered?
- Will spill materials, such as sand, neutralizers, etc., be available and, if yes, which have you chosen?
- Will alternate containers (empty bottles, cans, bags, etc.) be available when a broken container is encountered?
- Is there a plastic broom, plastic dust pan and plastic receptacle available for clean-up?
- Have you made arrangements for the removal of unwanted substances or, if you want to isolate these materials, have you planned for temporary and safe storage methods while you examine your disposal options?
- Will a fume hood be available to very temporarily store a substance which, upon discovery, needs your immediate attention?
- Have you undertaken and completed as much storeroom housekeeping as possible prior to the inventory so you are not faced with obstacles that would lead to an accident?
- Have school authorities and maintenance people been alerted to this inventory undertaking?
- If you elect to do some disposal during the inventory process (we urge against this) are the reacting chemicals available?
- Have you arranged for the process to be free of interruptions that might distract you at a critical moment?
- Will the team members performing the inventory be wearing appropriate clothing?
- Will all sources of ignition be eliminated?
- Is it your plan to add some form of label or other kind of identification to each chemical container and, if so, have you decided how this is to be done and are the means to do it available?
- Will you have a supply of replacement caps available for containers with bad closures? If you expect to transfer some substances to alternate containers—are such available?
- What will be done with the many bottles of solutions that have been prepared and stored for lab use over the past years? Will you include these in your inventory? How?
- If you expect to rearrange your chemical shelves during the process are shelf labels available?
- Do you expect to identify substances by their hazardous character during the process? If yes, will you then house them (like flammables, acids, etc.) in dedicated and approved cabinets? Are the cabinets now available? Is there sufficient space in the existing cabinets?
- Will the method you select to record this inventory allow you, if you elect to do so, to perpetually maintain the inventory?
- Will you have tape or an adhesive of some kind available to affix loose labels? Will you have blank labels available to place on currently unlabeled materials which you can identify with accuracy?

A very effective means of taking and temporarily recording your inventory is by means of portable dictation equipment. Perhaps you can find, at the school or at home, a battery-operated recording device. It would be ideal if the device could be placed in your pocket or attached to your person along with a microphone that would hang around

your neck or be attached to your collar. This would free both hands so you can have maximum flexibility in moving about the storeroom. It is an absolute that you never undertake an inventory alone. You must always have a teammate. The teammate is there to help you, to hold a ladder, to go for help or just to be there but, in any case, you should never

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CHEMICAL INVENTORY *continued*

work alone. We urge against recruiting students. It is also an absolute that the right kind and type of fire extinguishers be in the room with you and immediately available for use.

Another absolute is that you are appropriately dressed and spill materials are present. In general, we assume you have done all the preplanning and all the plans have been implemented.



With your recording equipment operable you now start across your shelves. You recite into the recording equipment the full name of each substance, the approximate size of the container and the amount of the contents. A typical recording might sound like, "One 5 lb. bottle, glass container, of acacia, about one-half full." If you wish, you might want to spell the name of each substance. Some schools turn this tape over to their business training department for typing. If a non-technical person would, at some later time, be called upon to transcribe this data you must be articulate and spell the name of each substance. Such detail only takes a matter of seconds on your dictating tape.

To the extent you can, you should avoid actually touching or moving bottles to take this inventory. If your shelves are loaded you may have to remove some bottles in order to see the bottles at the rear of the shelf or cabinet. Try to avoid as much moving or transfer as possible.

It is unlikely that you will want to reorganize your shelves at this time since your primary goal is to determine what you have and how much of it you have. Once the inventory is complete and has been converted to hard copy then you can begin to think about the reorganization process. At this point focus on just discovering and recording what and how much you have. You really should not consider major reorganization until you know the "what and how much" since these facts may cause you to elect not to set shelf space aside for substances you wish to eliminate from your inventory. It is our experience that in an average school (if there is such a thing as an average school) four out of ten bottles on the shelves have not been used in the last five years and will not be used in the next five years. There is no need to dedicate shelf space to such excess substances.

If your shelves and cabinets are just loaded and a lot of movement of substances is required to inventory all the materials, then the task will require several hours. If how-

ever, most substances can be viewed and recorded with little bottle shifting or relocation then even a very large high school chemical stores facility will not require much more than about 2-2½ hours to record all of these substances on your tape. The use of a portable, battery-operated, necktie microphone recording instrument is a very efficient means of rapidly concluding this part of the process.

Your next step is to transcribe this information into hard copy. That copy may take the form of 3" x 5" cards, sheet of paper, etc. You may even wish to consider acquiring the Flinn manual or computer perpetual chemical inventory systems.

Next assign compatible chemical family designations and hazard data to each listing. Our computer chemical inventory system has established 15 alpha designations to identify hazards. You may wish to use this same system to code your list. The designations are shown below.

FLINN HAZARD CAUTION CODES

- A — Flammable
- B — Volatile
- C — Toxic
- D — Strong oxidizer or reducer
- E — Carcinogenic
- F — Produces Peroxides
- G — Skin and/or eye irritant
- H — Contains harmful impurities
- I — Unpredictable explosive
- J — Harmful dust or vapors
- K — Avoid contact with water
- L — Avoid contact with air
- M — Corrosive
- N — Allergen
- O — Avoid contact with organic material

if you do not know either the hazardous character or compatible chemical family of a substance, you need look no further than the individual listings of any chemical in the *Flinn Chemical Catalog/Reference Manual*.

Your next step would be to decide what stays and what goes in this total inventory. We urge you to be ruthless in ridding your premises of these unused and unneeded chemicals. In fact, when you have made the decision about ridding yourself of many substances, then consider getting those items off your shelf first. No, do not simply acquire some cartons and pile bottle upon bottle into cartons and create a new problem. Rather, use your conventional wisdom and ask yourself if the item is hazardous and then investigate its hazardous character.

• Be able to call for help in the event help is needed

Should it be physically isolated? An example please. Let's assume you find a 500-gram bottle of aluminum chloride, anhydrous, and you wish to rid yourself of this substance. You do not know how to achieve this but you want it off the shelf and yet protected and safe for later disposition. Place the bottle in three thicknesses of Baggies®. You can get Baggies at your local grocery store. Flinn has heavy

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FLINN COMPATIBLE CHEMICAL FAMILY CODES

When you assign compatible chemical family data you may wish to use the system created by Flinn. Those family designations are listed both below and in more detail in the Reference Section of this Chemical Catalog/Reference Manual.

FLINN ORGANIC COMPATIBLE FAMILY CODES

- 01 - Acids, Amino Acids, Anhydrides, Peroxides
- 02 - Alcohols, Glycols, Sugars, Amines, Amides, Imines, Imides
- 03 - Hydrocarbons, Esters, Aldehydes, Oils
- 04 - Ethers, Ketones, Ketenes, Halogenated Hydrocarbons, Ethylene Oxide
- 05 - Epoxy Compounds, Isocyanates
- 06 - Peroxides, Hydroperoxides, Azides
- 07 - Sulfides, Polysulfides, Sulfoxides, Nitriles
- 08 - Phenols, Cresols
- 09 - Dyes, Stains, Indicators
- 0M - Miscellaneous

FLINN INORGANIC COMPATIBLE FAMILY CODES

- 11 - Metals, Hydrides
- 12 - Acetates, Halides, Iodides, Sulfates, Sulfites, Thiosulfates, Phosphates, Halogens
- 13 - Amides, Nitrates (except Ammonium Nitrate), Nitrites, Azides
- 14 - Hydroxides, Oxides, Silicates, Carbonates, Carbon
- 15 - Sulfides, Selenides, Phosphides, Carbides, Nitrides
- 16 - Chlorates, Bromates, Iodates, Chlorites, Hypochlorites, Perchlorates, Perchloric Acid, Peroxides, Hydrogen Peroxide
- 17 - Arsenates, Cyanides, Cyanates
- 18 - Borates, Chromates, Manganates, Permanganates
- 19 - Acids (except Nitric) (Nitric Acid is isolated and stored by itself.)
- 110 - Sulfur, Phosphorus, Arsenic, Phosphorous Pentoxide
- 1M - Miscellaneous

duty plastic bags called Chem-Saf® Bags for this purpose. You will find Chem-Saf® Bags listed in this Chemical Catalog/Reference Manual. Next, acquire some clean, never-used, one-quart and one-gallon paint cans. Flinn has such containers called Saf-Stor® Cans. These are also listed in this Chemical Catalog/Reference Manual. You can acquire similar cans (less heavy duty) at a local paint store or store that might sell and mix paints to order.

Now, line the bottom of the can with just enough vermiculite or cat litter (cat litter is bentonite) to cushion the plastic bag-enclosed bottle. Place the plastic bag-enclosed bottle in the center of the can. Fill the remaining empty void of the can with vermiculite or cat litter. Place the friction lid on the can and label the outside of the can with the chemical formula of the substance contained therein. By using the chemical formula rather than the full name you can thwart the potential vandal intent upon securing or using a hazardous chemical. The vandal simply will not be able to read the formula.

You have now provided a secure container for this unwanted substance. You may now assign an area in the storeroom where such hazards will be safe until you inves-

tigate and ultimately exercise your disposal or removal options. You will find that plastic bags and cans can be among your best friends for isolating and containing hazards during your investigation.

The cans will serve to protect against breakage and even act as a miniature fire cabinet to prevent these hazards from being directly involved in a conflagration.

Those substances which remain on your shelves can now be reorganized into their compatible chemical families. We urge that you review all the details of appropriate and safe storage in the section of this Chemical Catalog/Reference Manual dedicated to that subject.

• Avoid distractions

For the first time you know exactly the substances and their quantities in your chemical stores area. It is from this base of knowledge that you can begin to manage this matter of chemicals on school premises. You needed to take this first, important step. You may need further help and advice. If you do, call Flinn.

Improved Chemical Storage Codes

Flinn technical staff recommends changes to make chemical storage safer and code

In 1996, Flinn's staff chemists undertook a complete review of the Flinn Compatible Chemical Family Code and Suggested Storage Codes.

To make storage safer, we have added a new family code, Organic (OP) for dyes, stains and indicators. These materials can be safely stored together and are easier to find. Refer to this group.

We have also included more detail on the classification of acids and bases. This will help you determine storage needs for acids and bases that are classified as weak acids and bases.

This review is part of a series of updates designed to help you manage chemicals with the most complete and accurate reference manual available.

1996

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Chemical Inventory & Storage



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SUGGESTED SEQUENCE OF STEPS TO MORE SAFELY ORGANIZE YOUR SCHOOL'S CHEMICAL STORES AREA

1 Take an inventory of the chemicals on your premises. You will never know the extent of your problem until you know exactly what you have. Record the inventory. You may want to consider the purchase of the FLINN CHEMICAL INVENTORY SYSTEM to facilitate this task.

2 Decide what products you will need for the next year (at best, two years). Ruthlessly rid yourselves of the remainder of the accumulated materials.

3 Reorganize the remaining products into their compatible chemical families (see our Suggested Chemical Storage Patterns). Hundreds of teachers who have reorganized their shelves, using these patterns, tell us products are easier to find versus the alphabetical system previously used. When you reorganize, you may need some estimate of the percentage of shelf space each family might occupy. If yours is a "typical" high school, the following profile may be a helpful guide:

INORGANIC FAMILIES

FAMILIES	PERCENTAGE OF SHELF SPACE OCCUPIED
Acids (Inorganic 9)	Store away from all other items. Store in a dedicated acid cabinet. Store nitric acid away from all other materials.
Metals, etc. (Inorganic 1)	Less than 5%
Halides, Sulfates, Phosphates, Acetates, etc. (Inorganic 2)	Could be 35-40% of available space. This is usually the largest family.
Nitrates, etc. (Inorganic 3)	Approximately 5-10%
Hydroxides, Oxides, etc. (Inorganic 4)	Approximately 10%

FAMILIES	PERCENTAGE OF SHELF SPACE OCCUPIED
Sulfides, etc. (Inorganic 5)	Less than 1%
Chlorates, Perchlorates, etc. (Inorganic 6)	5+%
Arsenates, etc. (Inorganic 7)	Less than 1%
Borates, Chromates, etc. (Inorganic 8)	Less than 1%
Sulfur, Phosphorus, etc. (Inorganic 10)	Approximately 3%

4 ORGANIC AND ORGANIC FAMILIES

Organic acids (Organic 1) will probably occupy about 5+% of your organic shelf space except for acetic acid which should be stored with the inorganic acids (hydrochloric, etc.) in a dedicated acid cabinet. Keep acetic acid away from nitric acid, if your school is "typical," the remainder of your organic materials may occupy about 15-20% of your total shelf space. You should store all flammable organics in a dedicated flammables cabinet.

5 AND OTHER MATERIALS

There may be some very large space consumers in 2 kilogram (5 lb.) containers; i.e., calcium chloride, calcium hydroxide, etc. Certainly you may wish to extend family storage in a separate location for such large volumes of large packages.

6 Congratulations! You have now reorganized your chemical stores facility to:

- store compatible products together
- separate acids into dedicated storage
- separate flammables into dedicated storage
- lock up all poisons
- record all inventory
- rid yourselves of excess materials

YOURS IS NOW A SAFER FACILITY

SUGGESTED CHEMICAL STORAGE PATTERN

Storage of laboratory chemicals presents an ongoing safety hazard for school science departments. There are many chemicals that are incompatible with each other. The common method of storing these products in alphabetical order sometimes results in incompatible neighbors. For example, storing strong oxidizing materials next to organic chemicals can present a hazard.

A possible solution is to separate chemicals into their organic and inorganic families and then to further divide the materials into related and compatible families. Below is a list of compatible families. On the next page you will find this family arrangement pictured as shelf areas in your chemical stores area. The pictured shelf arrangement will easily enable you to rearrange your inventory into a safer and more compatible environment.

INORGANIC

1. METALS, HYDRIDES
2. ACETATES, HALIDES, IODIDES, SULFATES, SULFITES, THIOSULFATES, PHOSPHATES, HALOGENS
3. AMIDES, NITRATES, (EXCEPT AMMONIUM NITRATE), NITRITES, AZIDES
4. HYDROXIDES, OXIDES, SILICATES, CARBONATES, CARBON
5. SULFIDES, SELENIDES, PHOSPHIDES, CARBIDES, NITRIDES
6. CHLORATES, BROMATES, IODATES, CHLORITES, HYPOCHLORITES, PERCHLORATES, PERCHLORIC ACID, PEROXIDES, HYDROGEN PEROXIDE
7. ARSENATES, CYANIDES, CYANATES
8. BORATES, CHROMATES, MANGANATES, PERMANGANATES
9. ACIDS (EXCEPT NITRIC)
(Nitric Acid is isolated and stored by itself.)
10. SULFUR, PHOSPHORUS, ARSENIC, PHOSPHORUS PENTOXIDE

ORGANIC

1. ACIDS, AMINO ACIDS, ANHYDRIDES, PERACIDS
2. ALCOHOLS, GLYCOLS, SUGARS, AMINES, AMIDES, IMINES, IMIDES
3. HYDROCARBONS, ESTERS, ALDEHYDES, OILS
4. ETHERS, KETONES, KETENES, HALOGENATED HYDROCARBONS, ETHYLENE OXIDE
5. EPOXY COMPOUNDS, ISOCYANATES
6. PEROXIDES, HYDROPEROXIDES, AZIDES
7. SULFIDES, POLYSULFIDES, SULFOXIDES, NITRILES
8. PHENOLS, CRESOLS
9. DYES, STAINS, INDICATORS

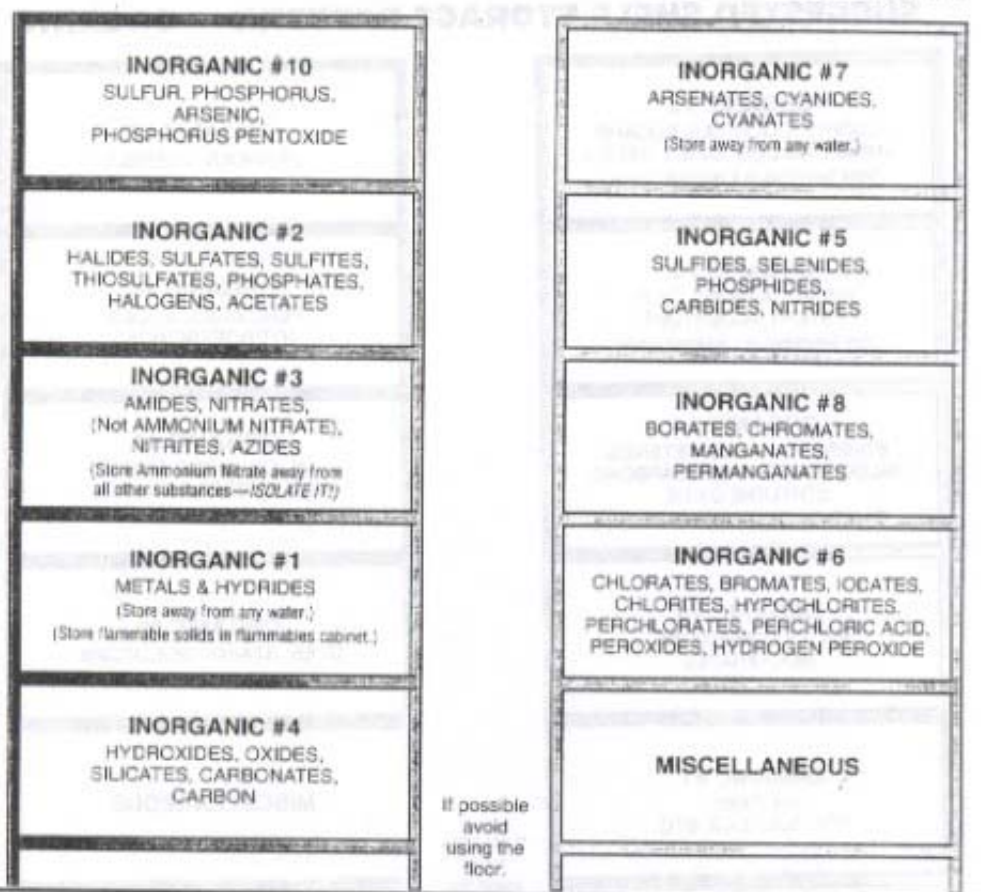
See next page for detailed inventory and storage steps you might follow to vastly improve the safety profile of your chemical storage.

NOTE: If you store volatile materials (ether, hydrocarbons, etc.) in a refrigerator, the refrigerator must be explosion-proof. The thermostat switch or light switch in a standard refrigerator may spark and set off the volatile fumes inside and thus cause an explosion.

Surely this list is not complete and is intended only to cover the materials possibly found in an average school situation. This is not the only method of arranging these materials and is purely offered as a suggestion.



SUGGESTED SHELF STORAGE PATTERN — INORGANIC



STORAGE SUGGESTIONS

1. Avoid floor chemical storage (even temporary)
2. No top shelf chemical storage
3. No chemicals stored above eye level
4. Shelf assemblies are firmly secured to walls. Avoid island shelf assemblies.
5. Provide anti-roll-off lips on all shelves.
6. Ideally, shelving assemblies would be of wood construction.
7. Avoid metal, adjustable shelf supports and clips. Better to use fixed, wooden supports.
8. Store acids in dedicated acid cabinet. Store nitric acid in that same cabinet **only** if isolated from other acids. Store both inorganic and some organic acids in the acid cabinet.
9. Store flammables in a dedicated flammables cabinet.
10. Store severe poisons in a dedicated poisons cabinet.

OTHER STORAGE SUGGESTIONS ARE CONTAINED THROUGHOUT THIS CHEMICAL CATALOG/REFERENCE MANUAL.

INORGANIC #9

ACIDS, except NITRIC

(Acids are best stored in dedicated cabinets.)

Store nitric acid away from other acids unless your acid cabinet provides a separate compartment for nitric acid.

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