

# Conducting School Chemical Cleanouts

A Training for the Nebraska SC3 Program

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# Goal 1. Keep you out of trouble



## Goal 2. Keep You Awake





# Goal 3. Keep it light





# Legacy Chemicals

## What's the Issue?

- October 1957 Sputnik launched
- The U.S. panics
- By 1960: \$4,000,000,000 in grants to schools for science
- Schools buy hazardous science lab chemicals by the case
- **They're still there!**



# High Risk Chemicals in Schools

## Peroxide Forming Chemicals & Explosives

- ☼ Potassium, Ether, Dioxane, Tetrahydrofuran, Picric Acid, Sodium Azide, Perchloric Acid, Di- and Tri-nitro Organics

## Water and Air Reactives

- ☼ Potassium, Sodium, Lithium, Calcium Carbide, White Phosphorus, Lithium Aluminum Hydride, Sodium Dithionite

## Corrosives

- ☼ Hydrofluoric Acid, Perchloric Acid, Bromine, Nitric Acid

## Carcinogens and Severe Toxins

- ☼ Arsenic, Cadmium, Chloroform, Formaldehyde, Potassium Dichromate, Mercury & Cyanide compounds, Phenol

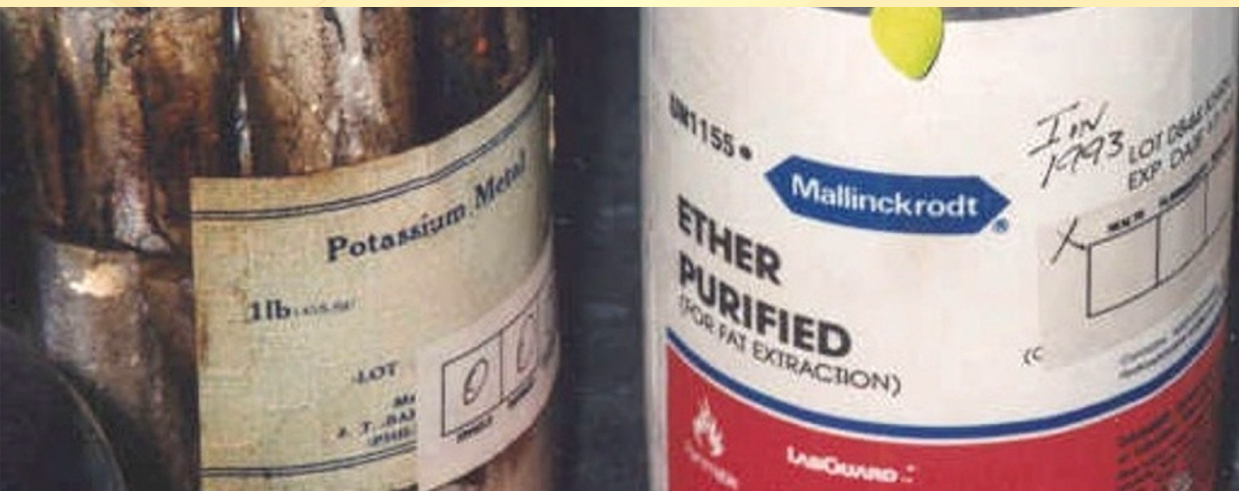
# High Hazard Chemicals

- **Explosives**
- Water and Air Reactives
- High Hazard Corrosives
- Poisons via inhalation and touch



# Explosive Chemicals

- Peroxide-formers
- Nitro organics
- Organic peroxides
- Contaminated compounds (unfortunate mixtures)



# Nitro Organics

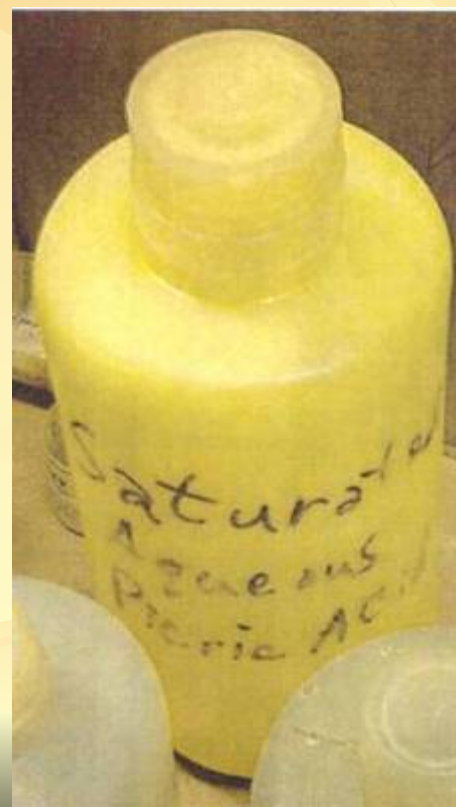
- Trinitrotoluene (TNT)
- 2,4-Dinitrophenol
- Trinitrophenol (Picric Acid)
- Metal Picrates



# Picric Acid – Trinitrophenol

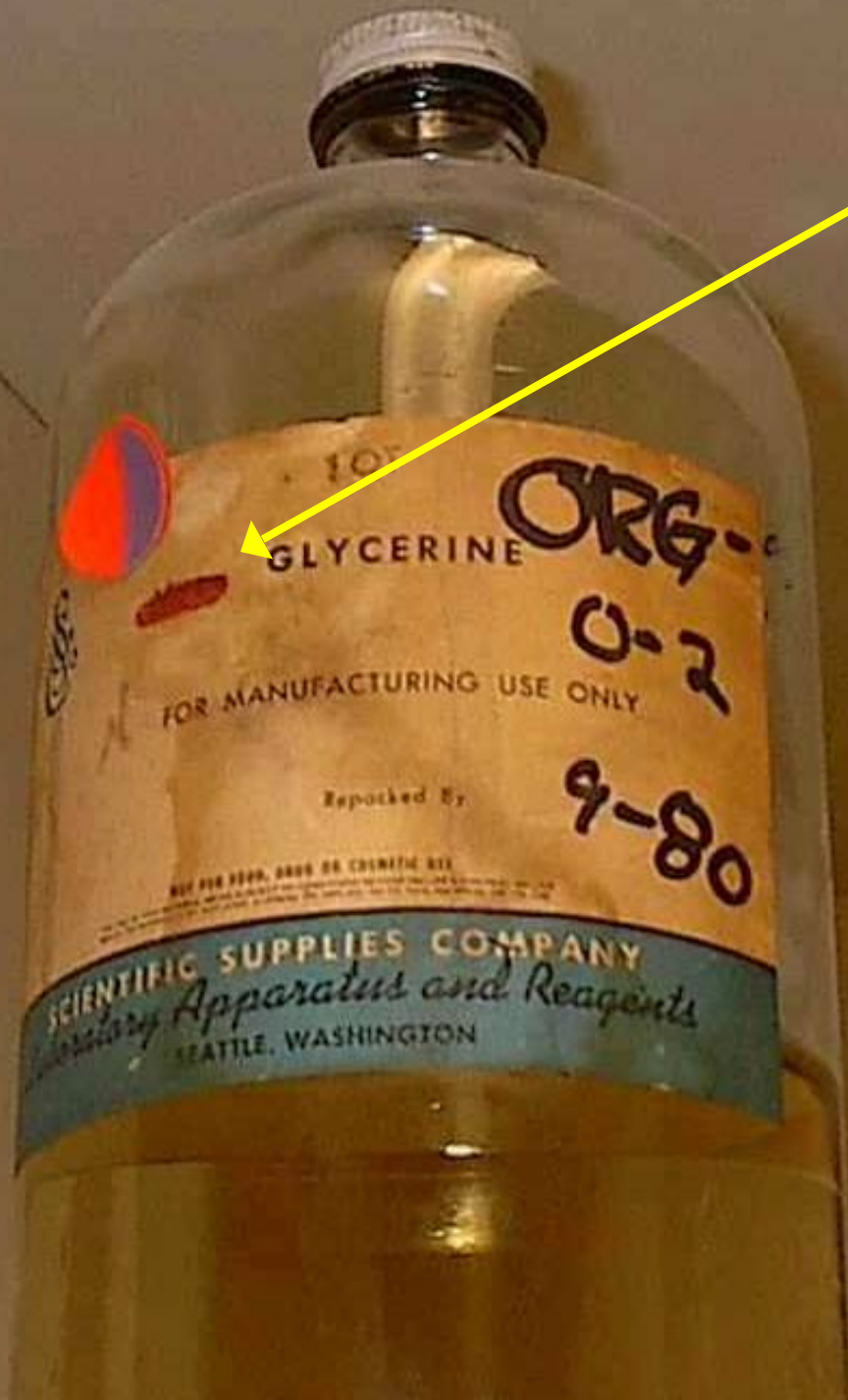
## (Constituent of Bouin's Fluid)

- Shock-sensitive high explosive when dry or especially in contact with metals (like the cap below)
- Found in medical labs (stains brain cells) and schools





Hand-written  
word "Nitro"  
In middle school



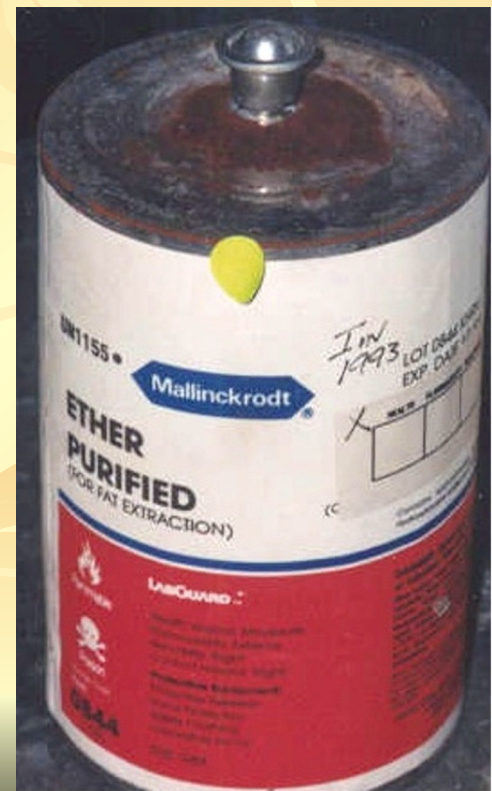
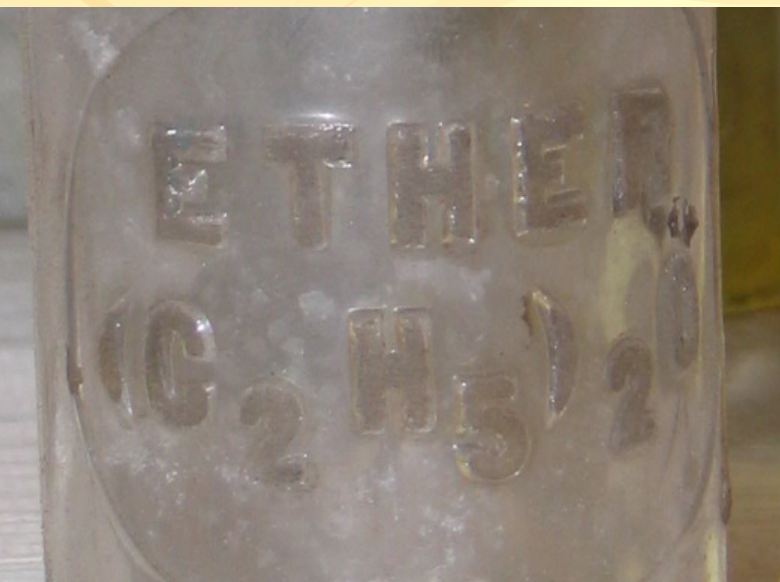
**Collodion = ether  
+ nitrocellulose  
high haz when dry**





# Peroxidizable Solvents

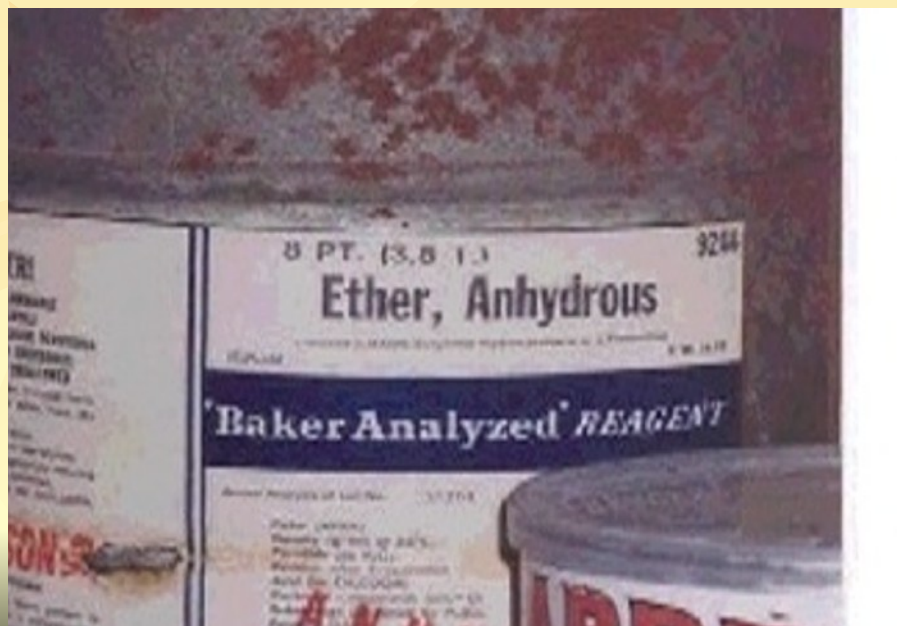
- Peroxides form in reaction with oxygen (auto-oxidation)
- Can test solvents for peroxides, if  $>100$  ppm = peroxidized
- Need to label them with date opened



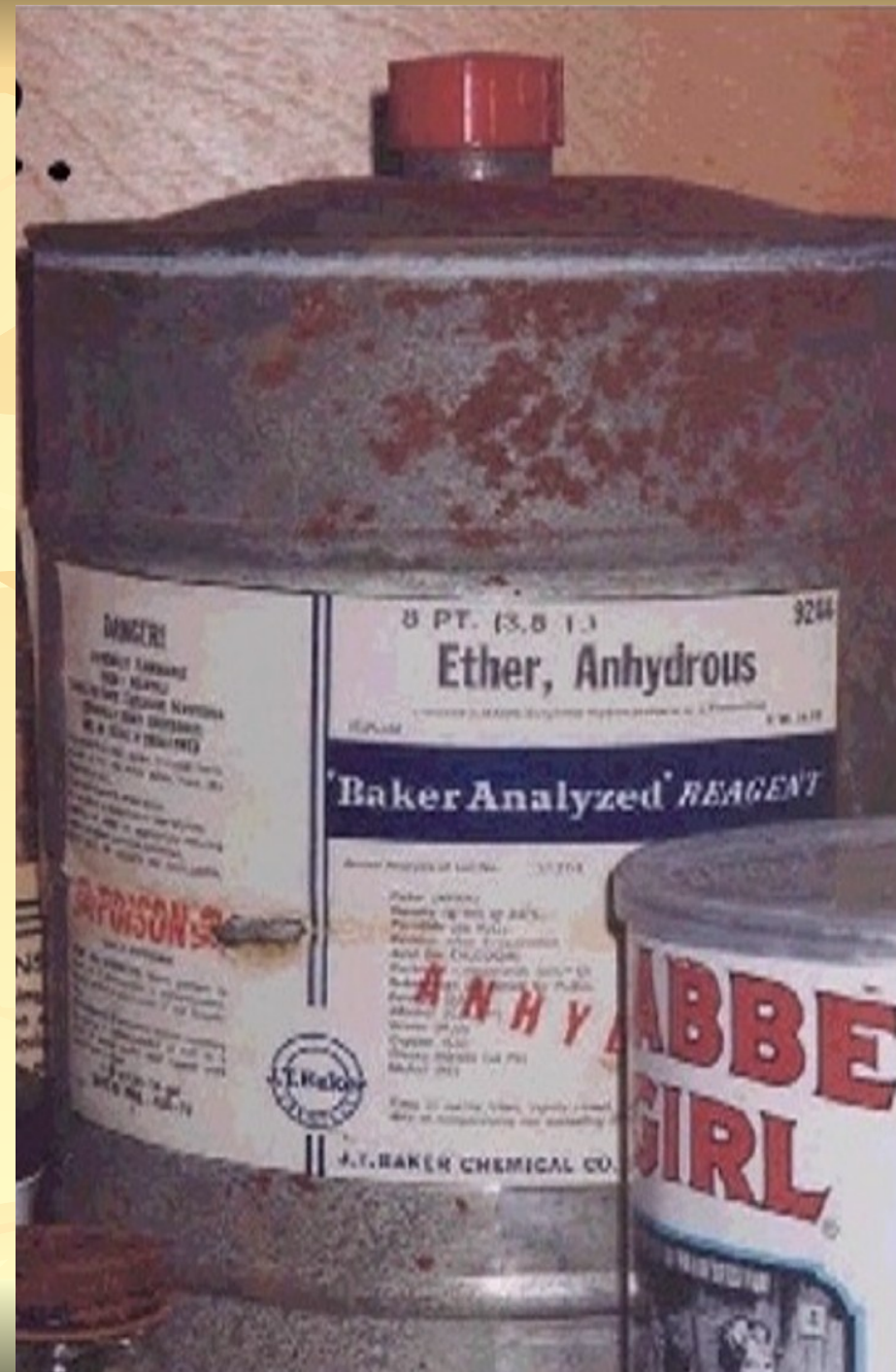


# Some Peroxidizable Solvents I've Seen

- Peroxides w/o concentration
  - Isopropyl Ether
  - Potassium Amide
  - Potassium Metal
  - Sodium Amide
- Peroxides if concentrated by evaporation & distillation
  - Acetaldehyde
  - Benzyl Alcohol
  - Cyclohexene
  - Diethyl Ether (Ethyl Ether)
  - Dioxane
  - Methyl Isobutyl Ketone
  - Tetrahydrofuran
  - Vinyl Ether



Isopropyl and  
Ethyl Ethers =  
Peroxide formers





**Isopropyl ether crystals from bottle in  
preceding photo - exposed to sunlight**





**Exploding isopropyl ether peroxide  
crystals (auto detonated)**



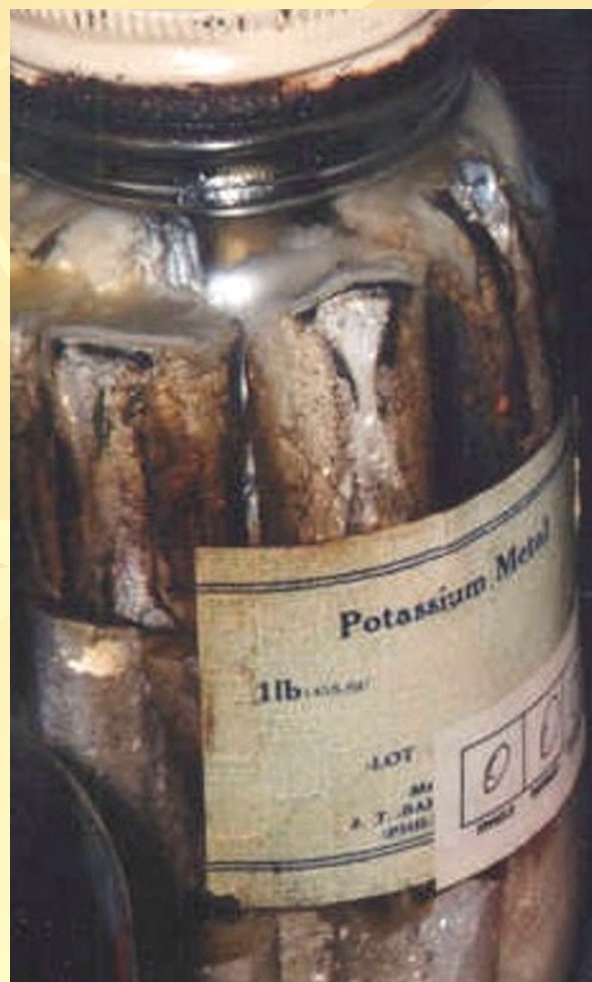
# A Note on Petroleum Ether

- Very common solvent
- NOT explosive
- NOT a true ether
- More like paint thinner



# Potassium Metal

## Peroxide Former & Water Reactive





# Potassium Metal ( $K_2$ ) – Color Key

- Silver – Potassium metal -Water Reactive
- White – P. Hydroxide – corrosive &  $H_2O$  reactive
- Yellow/Orange – P. Superoxide
  - Water reactive, corrosive, unstable
- Red – P. Ozonide - Highly reactive, explosive





# Identifying Potential Explosives the wrong way!

**What happens when peroxidized ether is distilled**

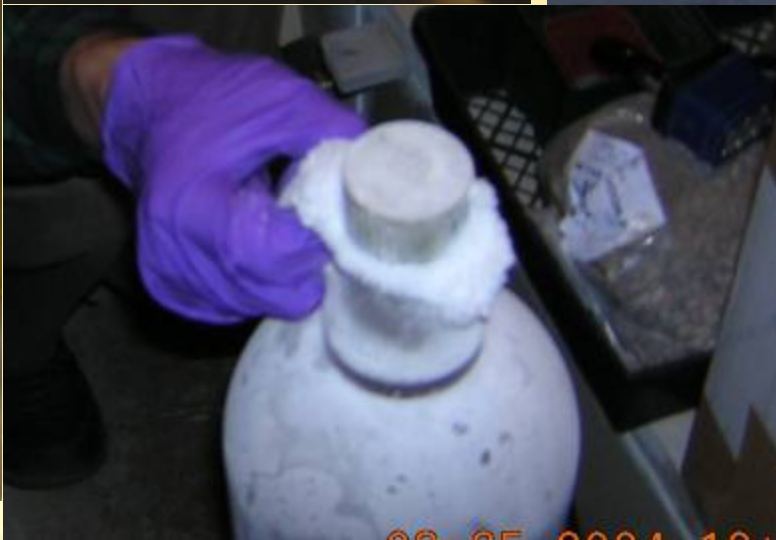


# ID-ing Potential Chem Explosives

- Most will be stored in the flammables cabinet
- **Never** touch the **cap** of an unexamined bottle
- Carefully move bottles to see labels
- Crystals on acid bottle is normal, crystals on brown glass bottle may be explosive peroxides
- Look on Chemical List for words “Explosive”  
“Explodes” “Bomb squad”

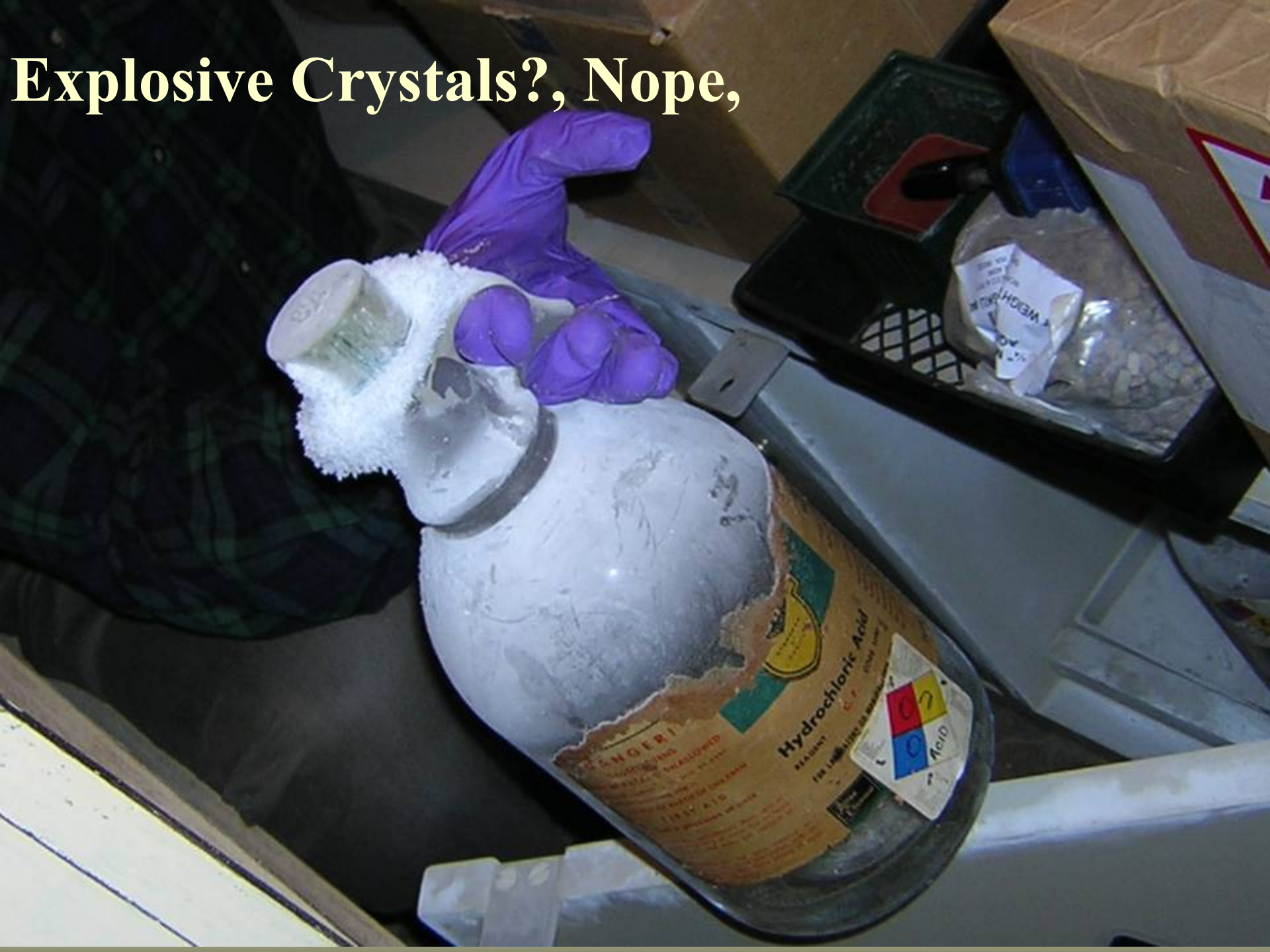


# Crystals on Bottles – Explosive?





**Explosive Crystals?, Nope,**

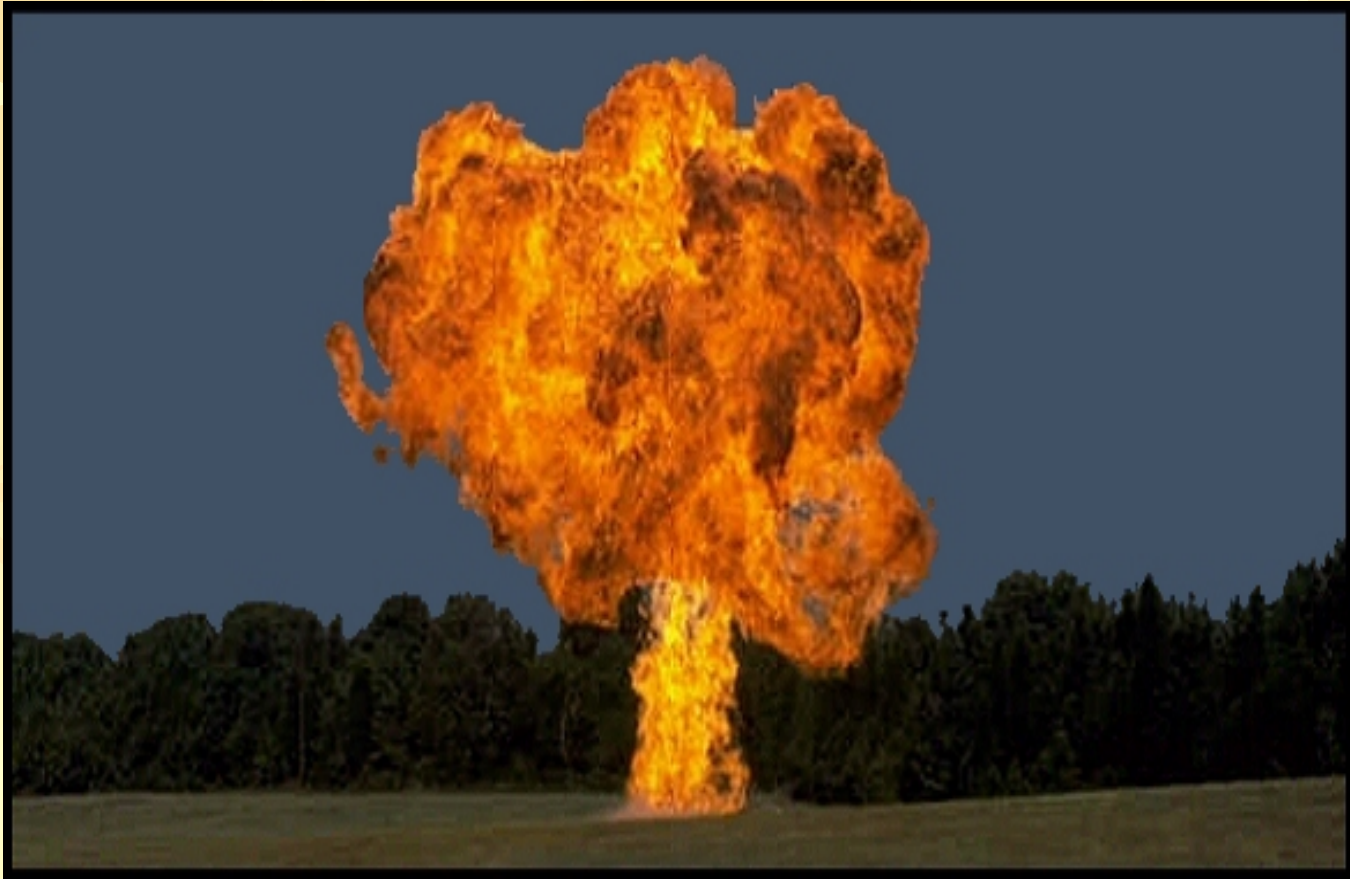




## Tetrahydrofuran

**Highly explosive peroxide crystals.  
Crystals on acid bottle, no big deal.  
Crystals on solvent cap, assume explosive  
& don't touch!!!**

# Three 5 gal. containers of peroxidized Tetrahydrofuran





# What's in a name?

May be clues to a compound's nature

- Dinitro-, Trinitro- = explosive if organic
- Nitrate, chlorate, bromate = oxidizer
- Per = oxidizer if inorganic
  - Perchlorate, permanganate, peroxide, persulfate, perborate
- Chromate, Dichromate = toxic, oxidizer
- Sulfide, cyanide = poison gas if acidified
  - Note, cyanates aren't cyanides, lower risk

# High Hazard Chemicals

- *Explosives*
- **Water and Air Reactives**
- High Hazard Corrosives
- Poisons via inhalation and touch

# Water and Air Reactives

- Air reactive = Phosphorus
- Highly water reactive
  - Lithium metal (less than other three)
  - Sodium metal
  - Potassium metal
  - Calcium carbide (miner's lamp)
- Moderately water reactive
  - Calcium metal
  - Magnesium metal

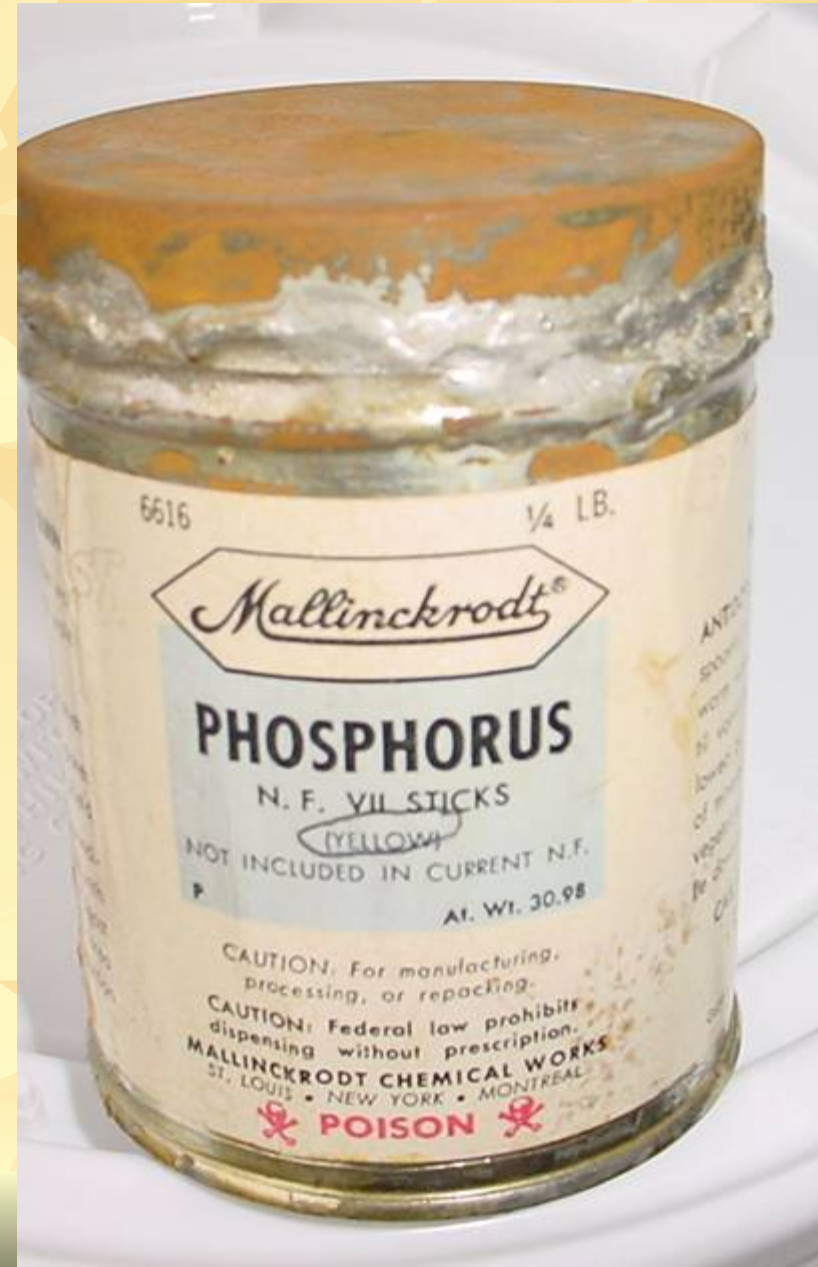
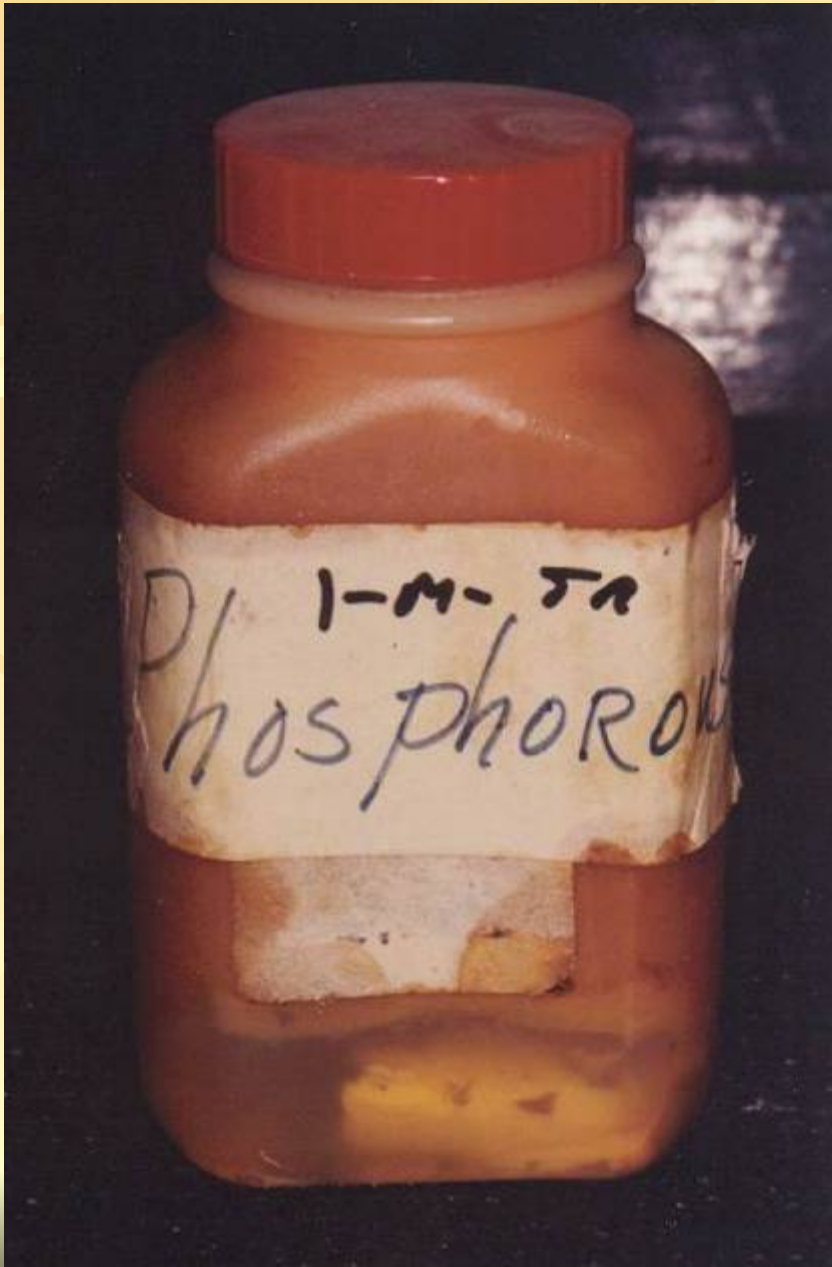


# White Phosphorus

- **Pyrophoric (air reactive)**
- **Stored under water**
- **If water drops below sticks**
- **Spontaneously ignites in air**



# Yellow Phosphorus – air reactive



# Red Phosphorus

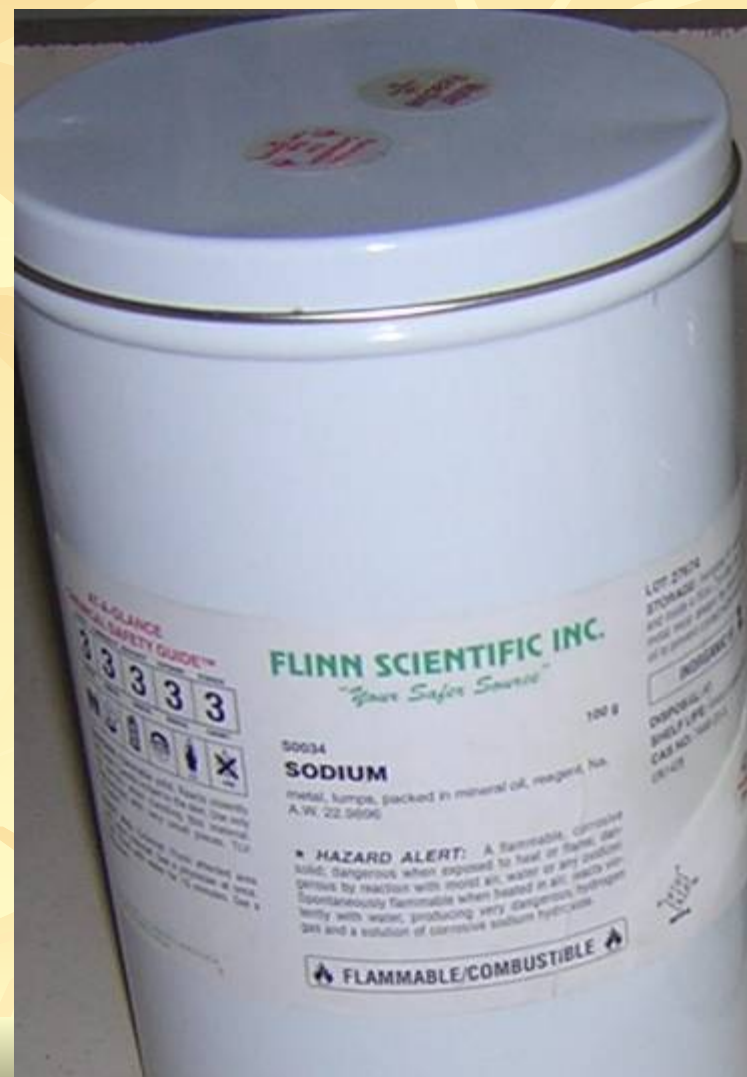
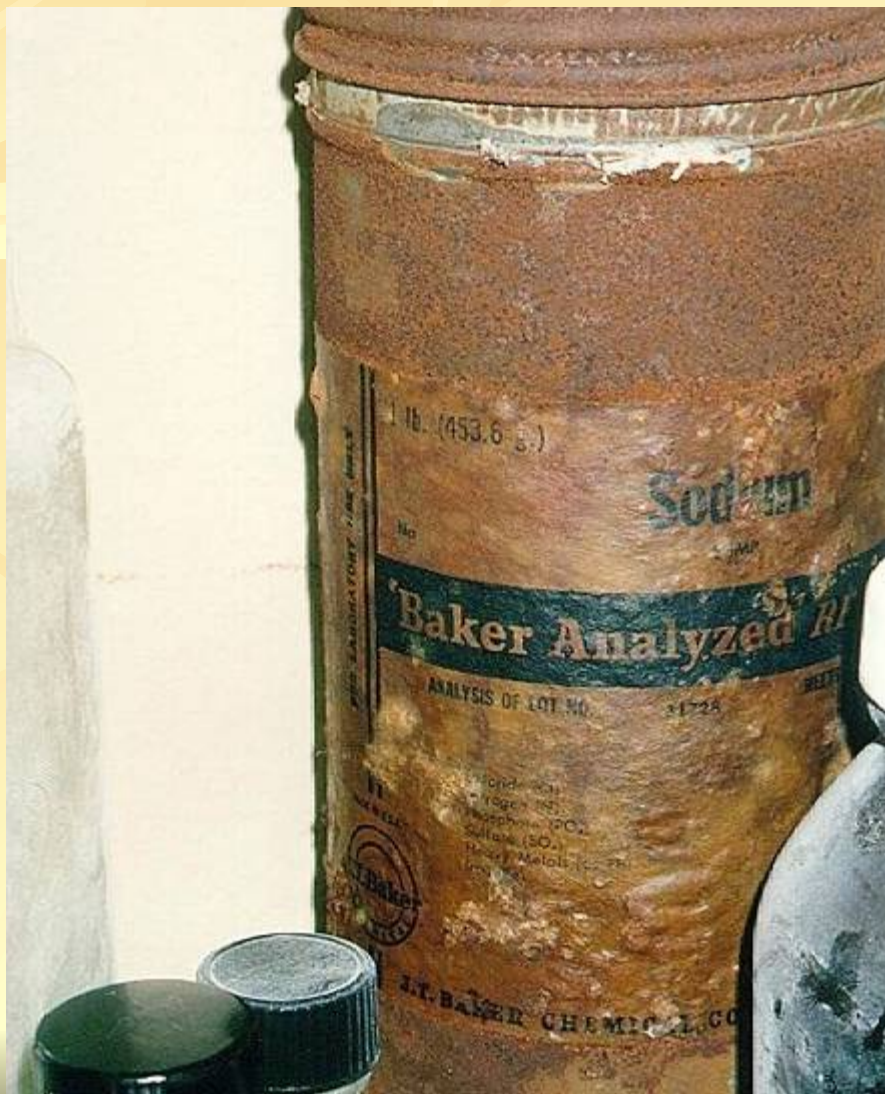
- It's on the side of safety match boxes
- Poisonous
- Not pyrophoric
- Flammable solid





# Sodium Metal

## highly water reactive



# Sodium – Safe Amount in Storage

- Flinn Scientific is chemical supplier for many schools
- Good safety record
- They sell sodium and potassium in small can with 5 pieces
- Safest way to buy and store these



# Calcium Carbide reacts with water to make acetylene (welding) gas





# High Hazard Chemicals

- *Explosives*
- *Water and Air Reactives*
- **High Hazard Corrosives**
- Poisons via inhalation and touch

# Perchloric Acid

- Highly corrosive
- Reacts violently w/ solvents
- Incompatible with metals
  - Forms explosive salts
- Oxidizes organic materials like wood
- Shelves are made of wood and metal



# Chemical Clues in Acid Cabinet

- Note plastic bottle
- Note white flakes on adjacent bottle
- What's going on here?





# Hydrofluoric Acid

- Anesthetic: acid doesn't burn on contact
- Deep tissue and bone disintegration
- Extreme pain, can cause gangrene, amputation
- Highly corrosive, dissolves glass
- Used in Art & Chem classes for glass etching



# Hydrofluoric (HF) Acid Spill 1995

- Tech spilled 200 mls of HF on both thighs.
- Burns to 9% of his body, despite washing his legs
- No calcium gluconate gel was applied
- Contaminated clothing not removed during rinse
- Right leg was amputated 7 days after the incident.
- Died from multi-organ failure 8 days later.

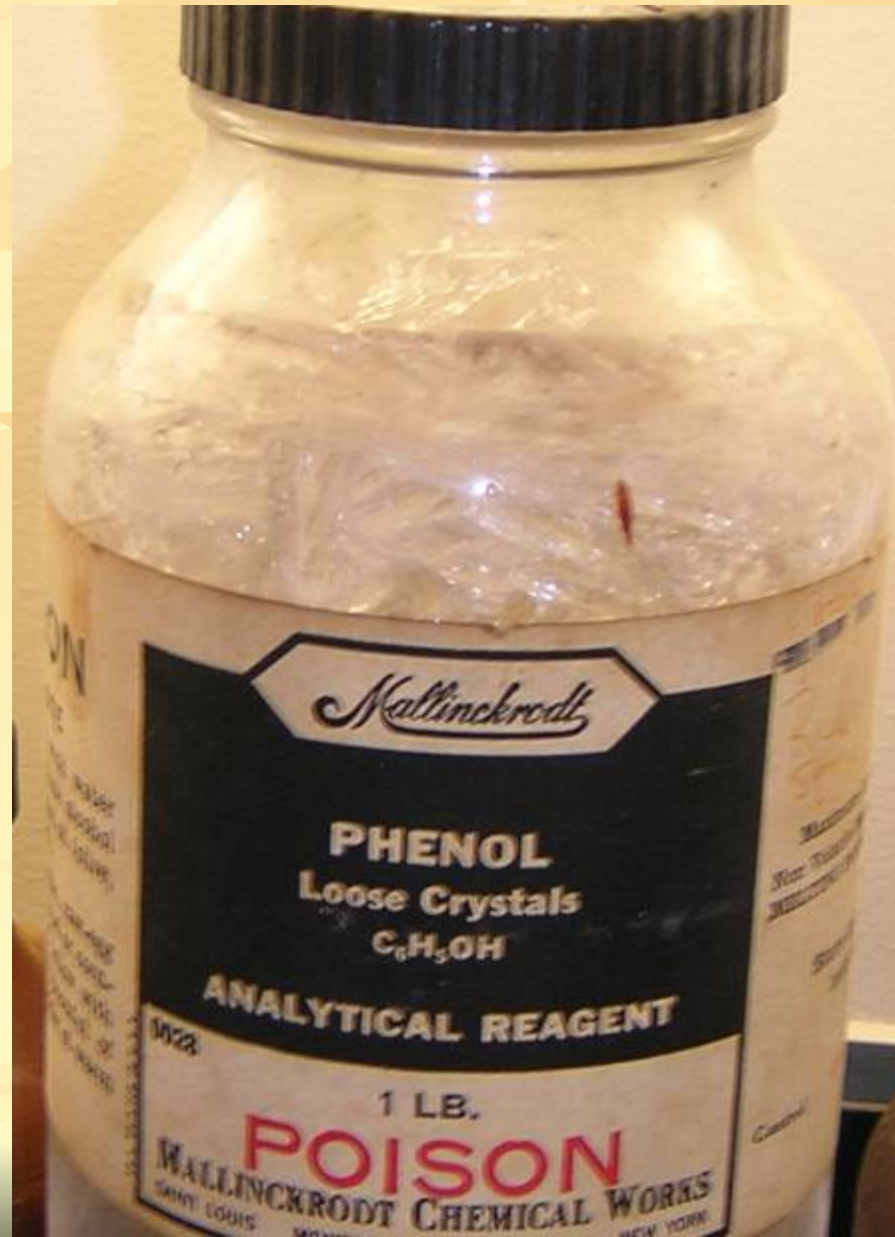


# High Hazard Chemicals

- *Explosives*
- *Water and Air Reactives*
- *High Hazard Corrosives*
- **Poisons via inhalation and touch**



# Skin Contact Toxins



# Bromine

- Evaporates at room temp
- Highly corrosive
- Powerful oxidizer



Orange thick cap = volatile  
poison, corrosive oxidizer





03.22.2004 09:09



# OK, we can see the need

- Now let's fix it
- Nebraska School Chemical Cleanout Campaign can help



**Become A Chemical Investigator**  
**Take a critical in-depth look around.**  
**Just like me, be ruthless!**



# Where do we start snooping?

- Act like this is a brand new school for you





# Assessing Chem Mgmt Practices

- Numerous issues to assess:
  - High-risk chemicals on site?
  - Excessive amounts of chemicals on site?
  - Degraded chemicals and containers?
  - Spill plan & clean-up materials?
  - Proper storage & disposal of haz chemicals?
  - Teachers trained in chemical hygiene?

# What are the Challenges?

- Finding time to inventory your stocks
- Staying safe and prepared
- Identifying ones to go
- Finding space to safely store the ones you need
- Finding \$\$\$ to dispose of unneeded chemicals



# Pause before you begin

- Before you enter the room
- Assess the risks
- Assess your safety options
- Best if you're not alone





# Be Alert As You Enter



- Keep eyes open & wits about you
- Pause before opening doors or moving bottles
- Look for chemical **and** physical hazards

# Rusty Hinges?

- Leaking acids
- Leaking iodine



**Is this the only eye wash?  
better not be...**





Site Audits Take a Long Time to Complete  
You need to look at Every bottle





# Look Everywhere!



# In the Stockroom





# In the Cabinets



# On Shelves





# On Tables





# In and Under the Hood



# In Drawers





# In Boxes





# In the Refrigerator in the Lab



## And the One in the Break Room



# By the Sink





# By the Other Sink



# Under the Sink





# On the Benches





# On the Carts



# In Corners

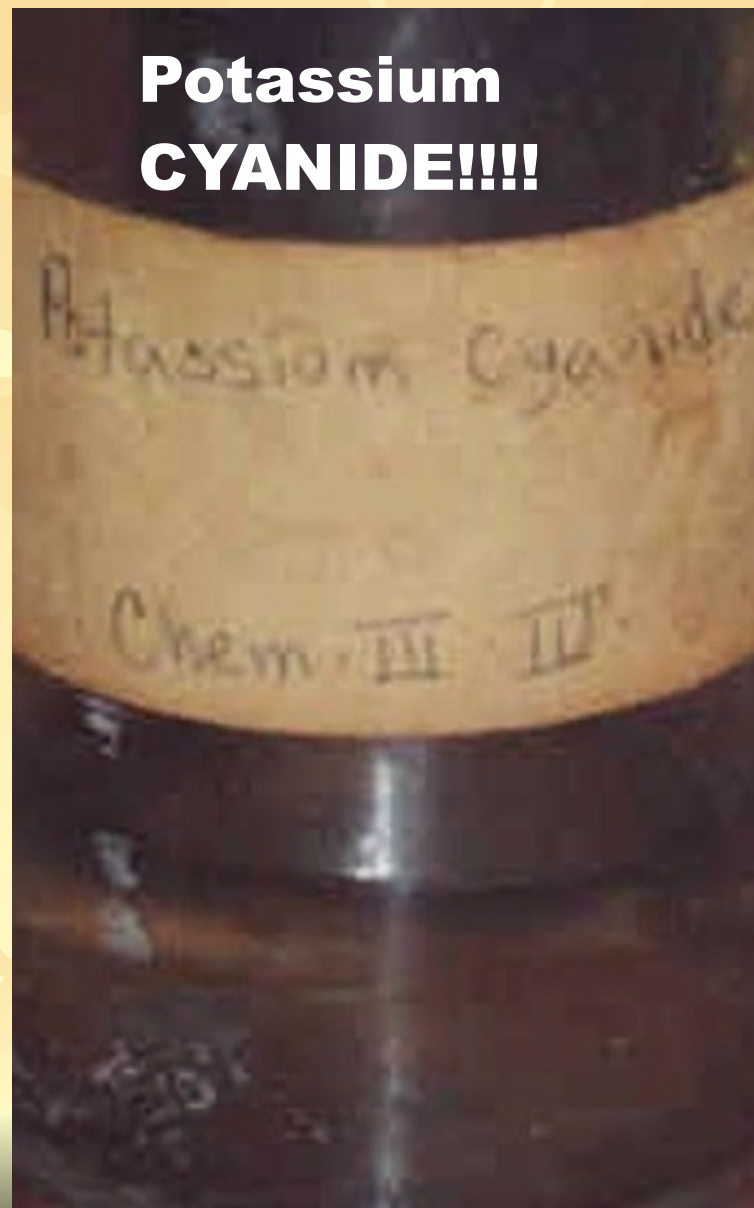




# In Bookcases by students



**Potassium  
CYANIDE!!!!**





Look High



# Look Low





# Check the Backyard



just kidding... this isn't a school



# How to track your inventory

- Compound name
- Number of containers
- Capacity of containers
  - Don't track amount in the containers
  - It'll be full again at some time (or gone)
- When a container is emptied, save it
- Don't adjust inventory if it will be refilled

# School Chemicals Database

## Info on 975 Chemical Compounds

Search:

1 2 3 4 5 6 7 8 9 10 ... >> | (View All) | ...You are viewing page

Chemical Name	Acute Exposure Hazard	Chronic Exposure Hazard	Environmental Toxicity	Hazard Rank	Minimum Grade Level Restrictions
Abscisic Acid	No acute toxicity data reported	No confirmed human disease-related or reproductive hazard data reported	No fish toxicity data	1	Elementary demonstrations only
Acetal	Explosive. Peroxide forming compound. Flammable. Slightly toxic by ingestion & skin contact. Irritant.	No confirmed human disease-related or reproductive hazard data reported	No fish toxicity data	5	Ban Candidate
Acetaldehyde	Explosion risk from peroxide formation. Flammable. Slightly toxic by inhalation, ingestion and skin contact. Irritant to eyes.	Liver function impairment	Toxic to fish	5	Ban Candidate
Acetamide	Slightly toxic by ingestion	No confirmed human disease-related or reproductive hazard data reported	Non-toxic to fish	2	Junior High

Found at the King County Rehab the Lab website  
<http://lhwmp.org/HWApp/projects/schools/ChemList.aspx>

Acetanilide	Slightly toxic by ingestion. Irritant	No confirmed human disease-related or reproductive hazard data reported	No fish toxicity data
Acetic Acid (<1 Molar)	Irritant. No acute toxicity data reported at this dilute concentration.	No confirmed human disease-related or reproductive hazard data reported	Non-toxic to fish
Acetic Acid (>6 Molar)	Combustible liquid and vapor. Corrosive. Toxic by skin contact. Slightly toxic by ingestion.	Erosion of teeth. Chronic lung impairment.	Non-toxic to fish
Acetic Acid (1 Molar to 6 Molar)	Corrosive. Slightly toxic by skin contact and ingestion.	Erosion of teeth. Chronic lung impairment	Non-toxic to fish

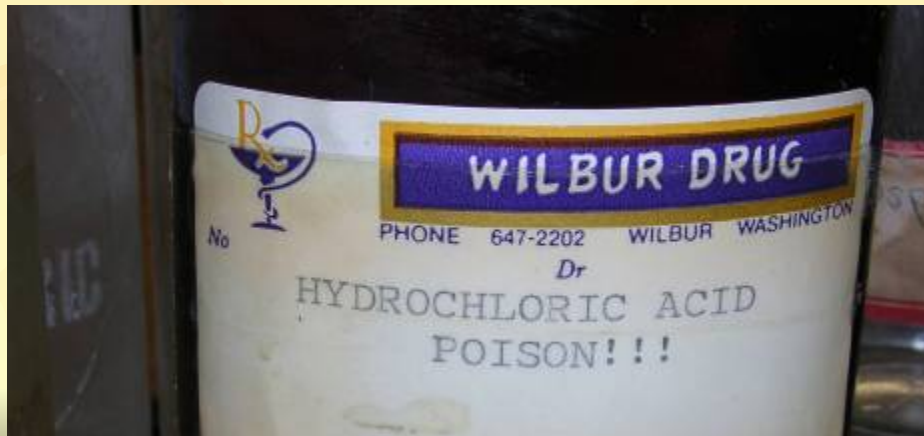


# Deciding What Needs to Go



# Dispose of Chemicals that are really:

- Dangerous
- Decrepit
- Excessive
- Useless
- Incognito



# Haz Rankings Link to Grade Levels

- Hazard Rank **0** = safe for all grades
  - 26 chemicals, e.g. Vinegar, Sugar, Starch
- Hazard Rank **1** = elementary demos & above
  - 19 chemicals e.g. mineral oil, rubbing alcohol
- Hazard Rank **2** = junior high & above
  - e.g. cobalt nitrate, ethanol, gram's iodine stain
- Hazard Rank **3** = high school & above
  - e.g. concentrated acids & bases, hexane



# Haz Rankings Link to Grade Levels

- Hazard Rank **4** = advanced placement chem
  - 119 chemicals with limited utility & high hazards
  - Requires chemical hygiene plan & approval
  - e.g. Formalin, lead chloride, bromine water
- Hazard Rank **5** = ban candidates
  - 201 chemicals w/ no reported usefulness, high hazards and easy exposure routes
  - e.g. Arsenic, pure cyanide, mercury, explosives

# Let's walk through the process

- Find & inspect all chemical storage areas
- Are there other areas with stored chemicals?
- Identify the highest risk chemicals
  - Hazard level 4 & 5 in the database
- Ensure incompatible chemicals are segregated
- Mark those that need to be disposed
  - Right side good, left side bad on shelves
  - Signage clearly indicating this

# Chemical Assessment

## Safety First



Teacher gave me these gloves to clean up a small chemical spill at their high school.



Familiarity breeds contempt –  
and children. —Mark Twain

**Where's the goggles,  
gloves, lab coat?**



**Nitrile gloves are  
supple & chemical  
resistant.**

**Change  
immediately if  
visually  
contaminated!**



# Protective clothing

- Safety glasses
- Gloves
- Funky clothes
  - Stockrooms are dusty
- Splash resistant goggles
- Chemical resistant clothes & shoes





# Start with the Flammables

- Safely stored?
- No incompatibles?
- Well labeled?
  - Name & hazard
- Only those you need?
- If I see scorch marks, I ask “what happened?”



# Flammables must be in cabinets

## Limit is one gallon in classroom



# Check Flammables Cabinet Carefully

- Do the chemicals match the curriculum?
- Peroxidizable solvents will generally be here
- Never handle bottles by cap
- Take your time!





# Move glacial acetic acid and formic acid to the flammables cabinet

Mix these, could get flaming acid



# Assessing the corrosives





# Acids & bases, common yet very dangerous





# Safety glasses inadequate by corrosives



**Sodium hydroxide burns eyes!!**





**Corrosives near? Wear Goggles!!!**





**Curses!**

**Foggy Goggles!**



# Acids & Hydroxides = incompatible

- Acids rust metal
- Acids need to be in locked non-metal cabinet
  - SciMatCo makes a great one
- Liquid bases need to be in locked cabinet
- All hydroxide liquids are corrosive bases
  - Bases don't corrode metal much
- They react with each other generating heat and corrosive vapors

# Know your corrosive cap colors



## ACIDS

- Red – Nitric acid
- Yellow – Sulfuric
- Blue – Hydrochloric
- Brown – Acetic
- Black – Phosphoric

## BASES

- Green – Ammonium hydroxide



# Metal Acid Cabinets

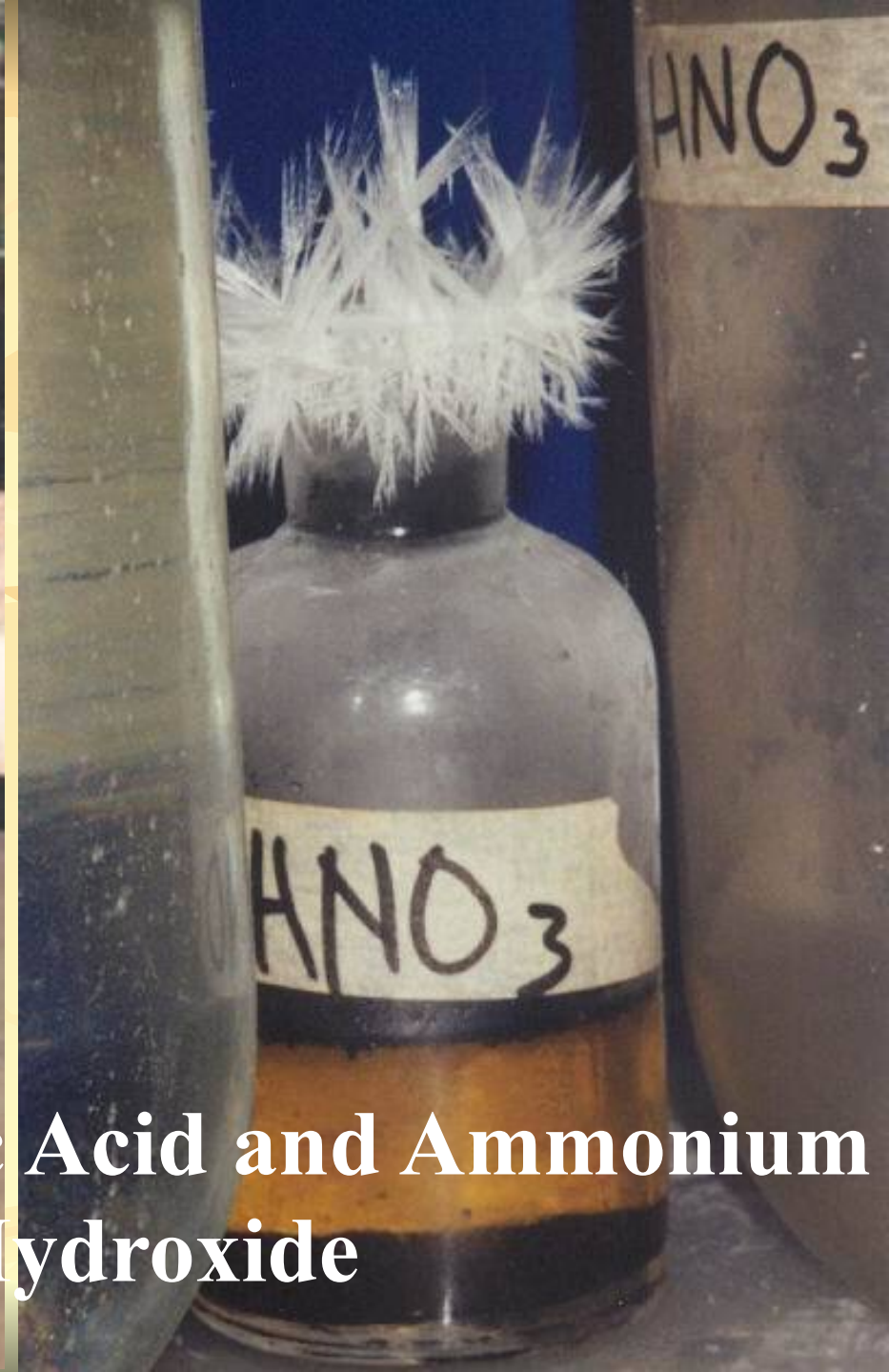
## Serious risk of shelf collapsing



**Rusting  
shelf clips  
could lead to  
collapse and  
acid release**







**Leaking Nitric Acid and Ammonium Hydroxide**



# Ammonium chloride crystals (ammonium hydroxide and hydrochloric acid)



# Nitric Acid

## Number One problem acid

- Eats its cap in 7 – 10 years
- Extremely corrosive
- Powerful oxidizer
- Check all red caps for integrity









Nitric acid, oxidizer and corrosive. Fumes ate through plastic cap then oxidized cardboard box. Extreme fire risk!  
Six pounds of cyanide right above it.  
Earthquake could mean gas chamber for 500 students



## Sodium hydroxide

rounded white crystals all over the place





# Dry Chemicals Shelves

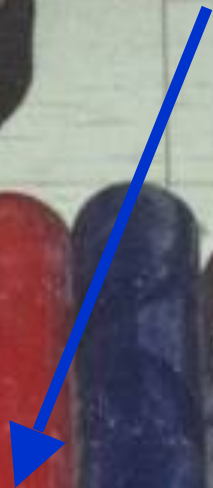
## General Housekeeping is a Clue

- Look for mercury & mercury compounds
- Generally safety glasses are acceptable here
- Look for gas cylinders
- Look for ancient chemicals





**Chlorine!**

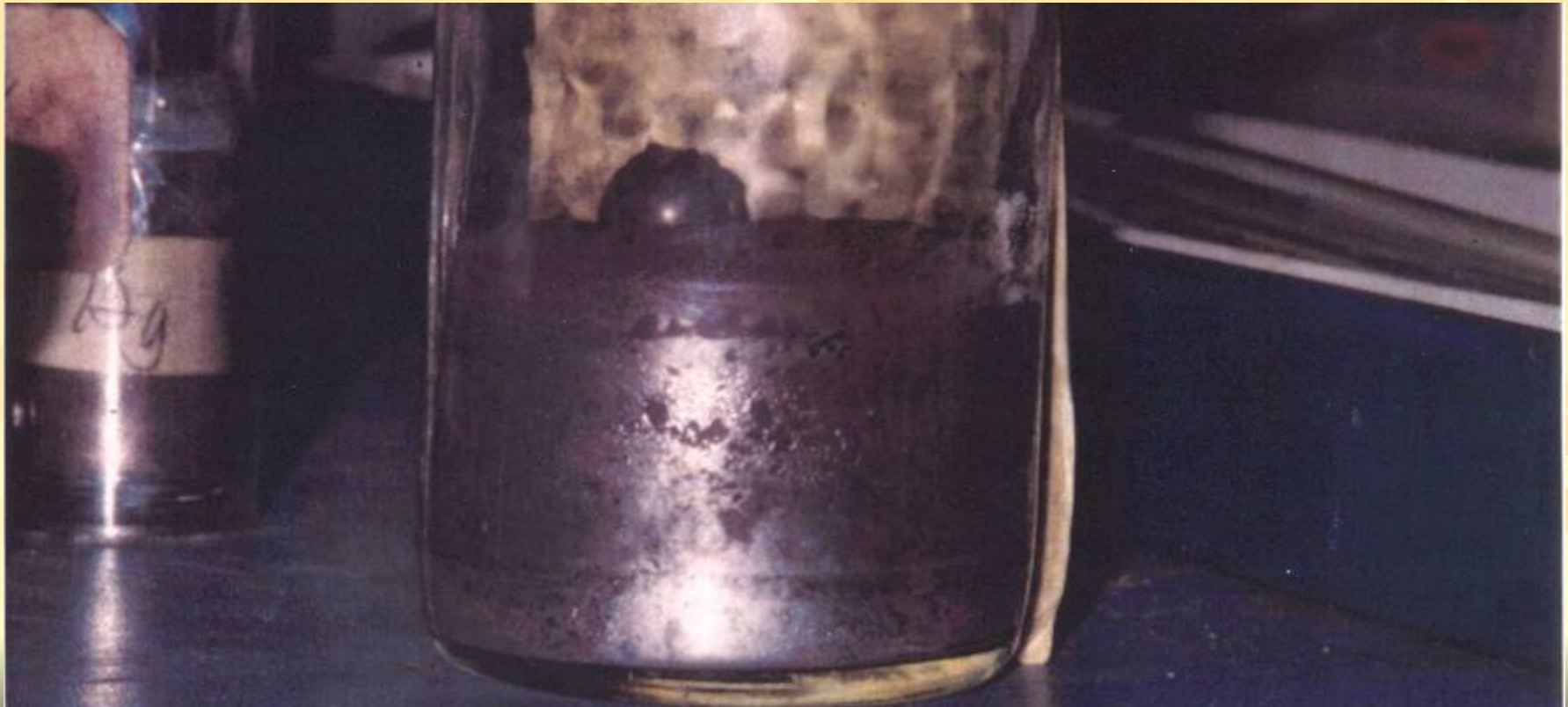


**The "Box O Gases"**



# What I Ask When I See This #1

- For mercury, cadmium, arsenic compounds
  - Do you use this compound?
  - Could you drop this demo?





# What I Ask When I See This #2

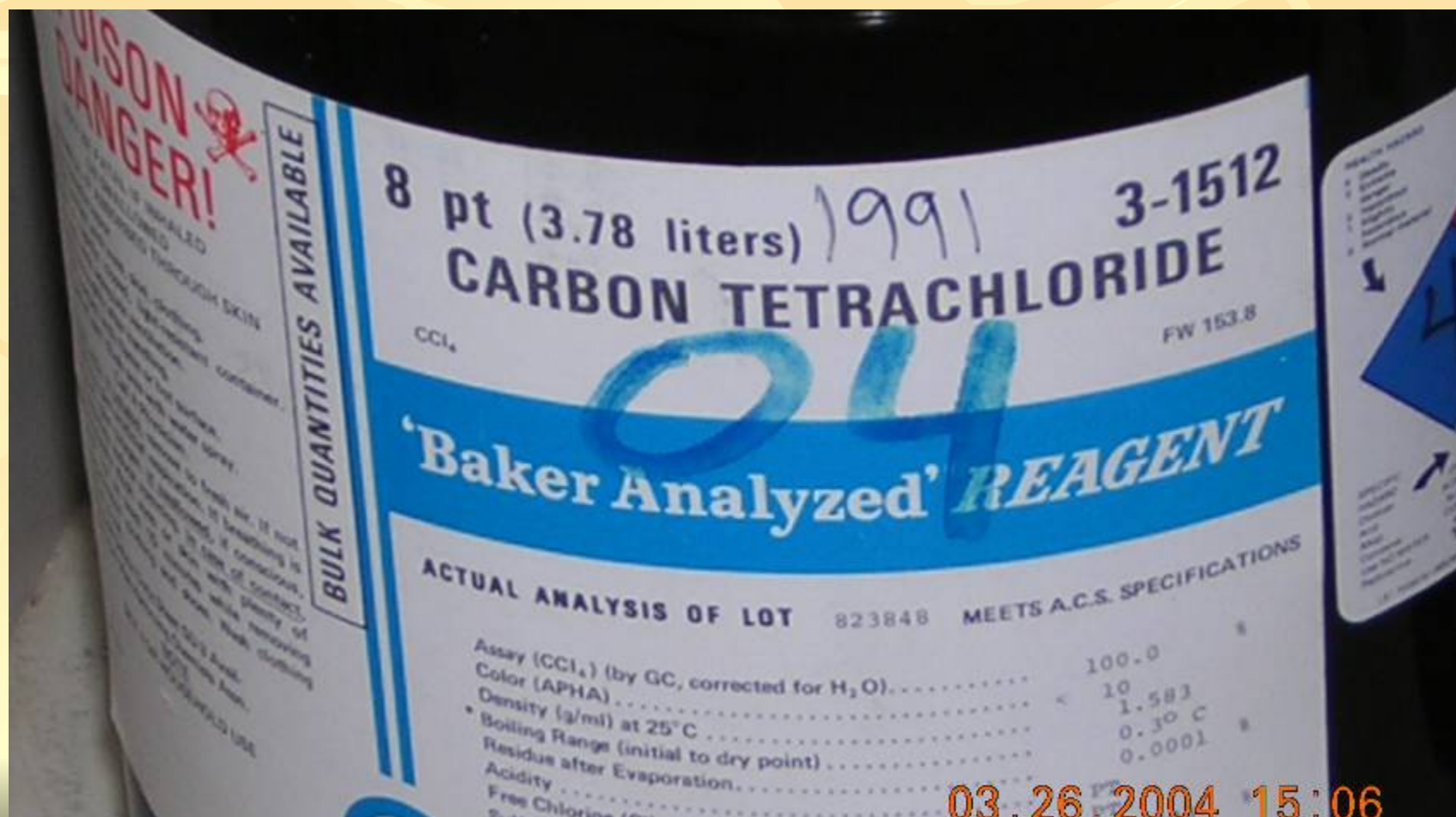
- Do you teach organic chemistry here?
  - If not, many of the higher hazard solvents can go





# What I Ask When I See This #3

- Are you using this compound? Why?



# What I Ask When I See This #4

- How much lead nitrate a year do you use?
  - 454 grams per pound, how many years supply is it?





# What's Wrong With This Picture?

Flammable liquid stored in standard freezer





- Flammable liquid in standard freezer
- Oxidizer by flammable liquid
- Cold inhibits the preservative, so speeds formation of peroxides
- Chloroform reacts with light to form phosgene gas, a chemical warfare agent



# Spill Response

- Are you prepared? Typically no.
- What could spill?
  - Corrosive acids & bases, flammables, mercury, etc.
- Do you have written plan?
- Do you do hands-on training?

# Suggested Spill Supplies

- Personal Protective Equipment
  - Gloves, goggles, sturdy shoes, lab coat/apron
- Acids
  - Kitty litter, 4 lbs. sodium carbonate, pH paper test
- Bases
  - Kitty litter, 2 lbs. citric acid, pH paper test
- Solvents
  - Kitty litter/absorbent pads
- Small broom, dustpan, collection container with lid



# Chemical Storage Recommendations

- Segregated storage system most in use is from Flinn Scientific, Inc.
- Schools don't have the shelves to fully do it
- I simplified and consolidated it to make it work in the limited space you have
  - Storage scheme is included in your CD

# Problem?

## Bottle as structural support



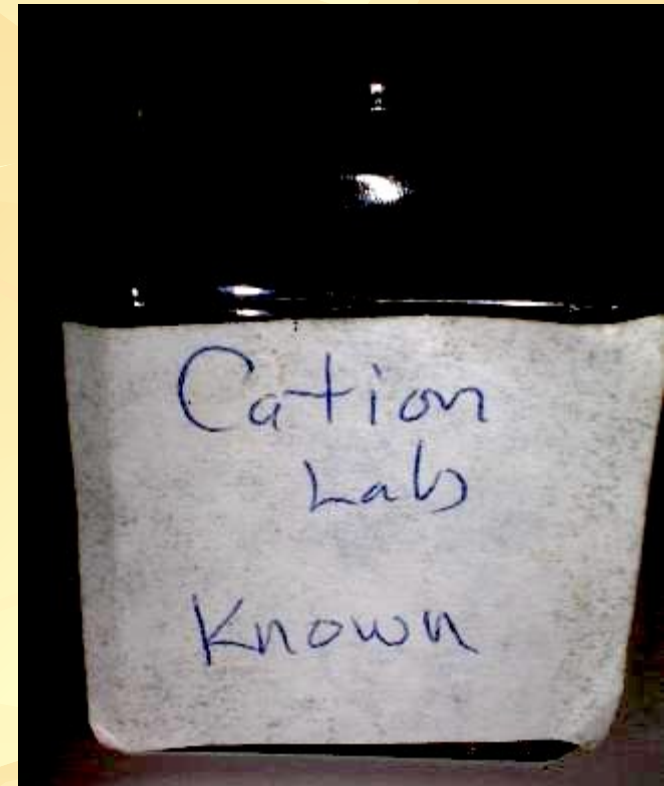
**Good cupboards, good shelving, but still storing on counter.**

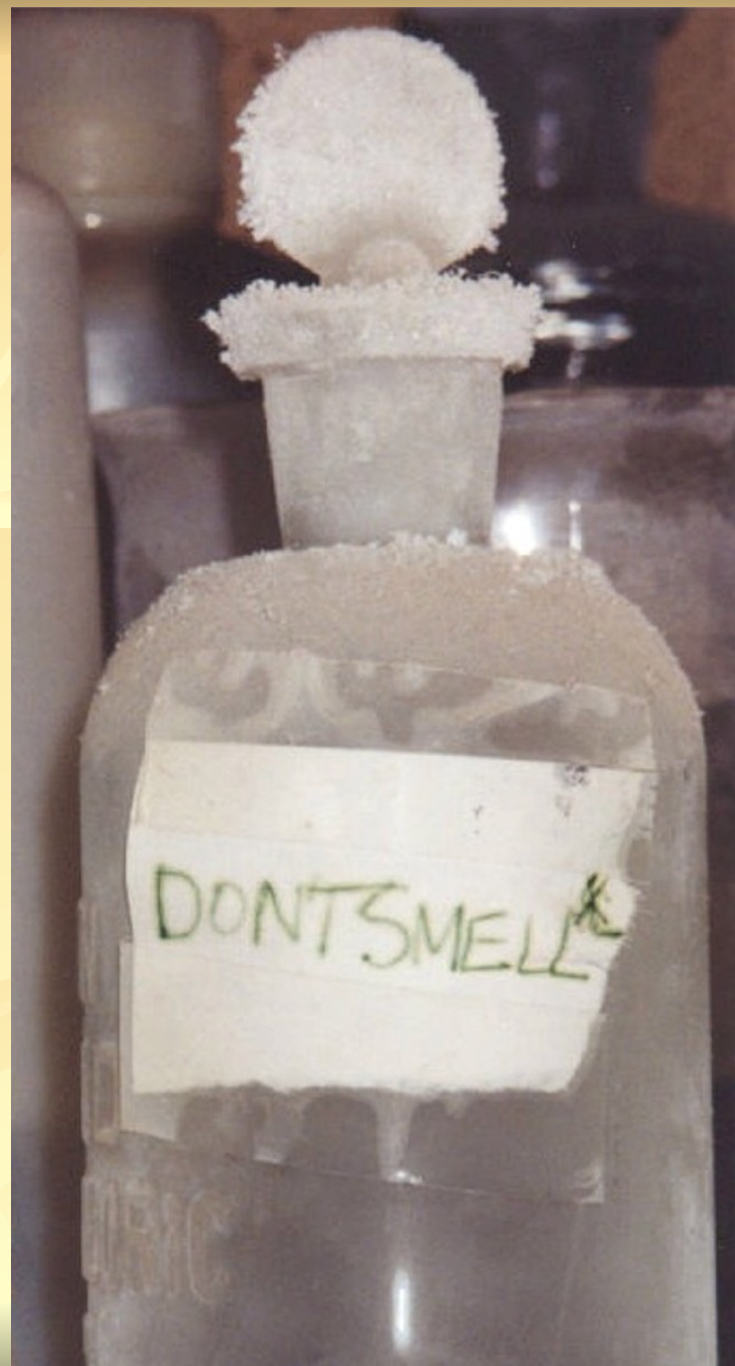




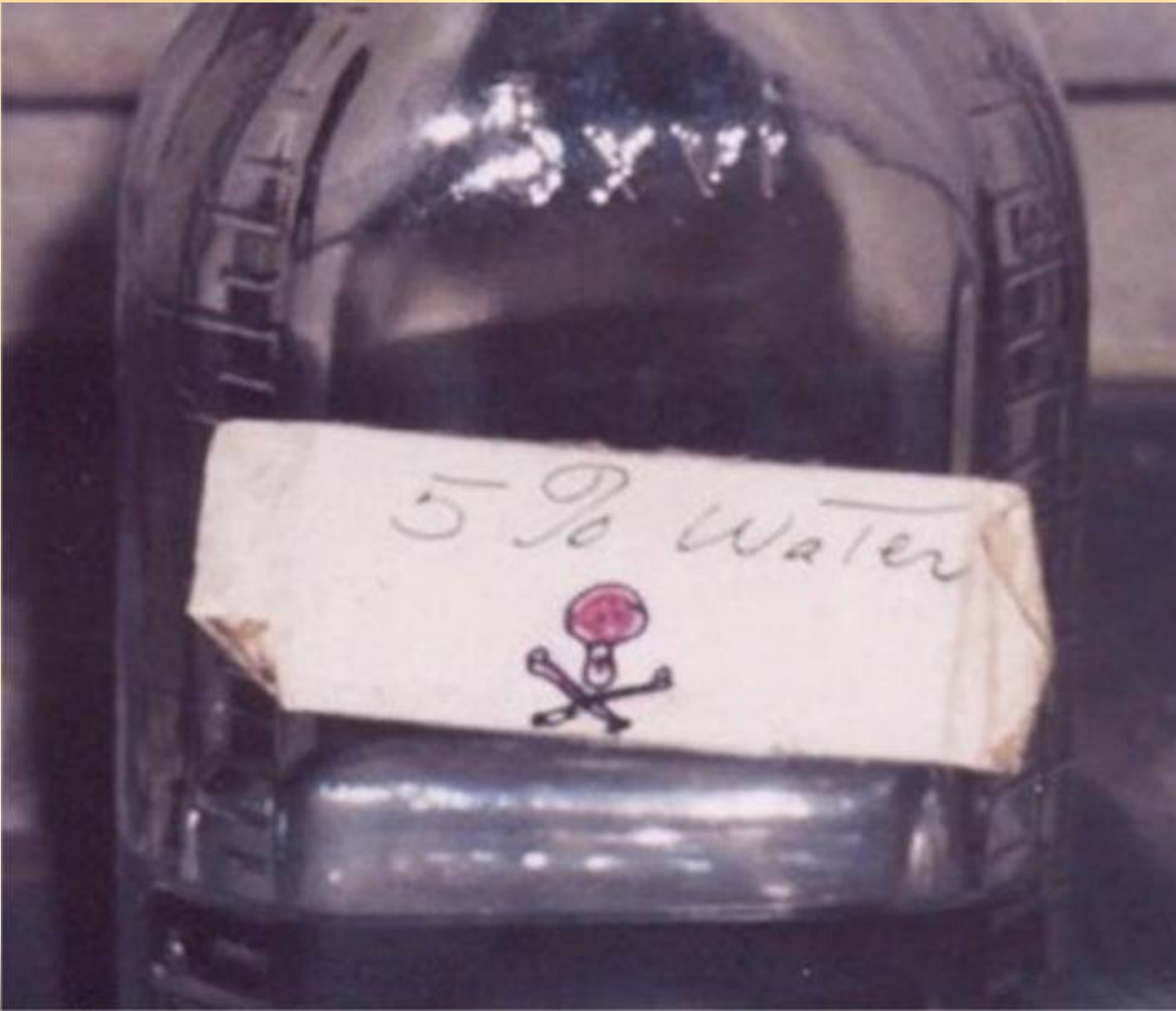
# Can You Properly Manage Unknowns?

- Can't respond to spills
- Can't guarantee proper PPE
- Can't dispose of it properly unless you know its hazards
  - Very expensive to test





# What's the other 95%?





# Chemical Waste Disposal



# What's Hazardous Waste?

- It's a waste
  - No longer needed or useful
- It's hazardous
  - Is on a list or has hazardous characteristics
- Regulations
  - Resource Conservation & Recovery Act (RCRA) 40CFR
  - Clean Water Act, Clean Air Act, DOT regs



# Hazardous Waste Characteristics

- **Ignitable** (<140 degree flash point)
- **Oxidizer** (nitrates, chlorates, chromates, “per-” inorganics)
- **Corrosive** (pH < 2.0 or pH > 12.5)
- **Reactive** (w/ air or H<sub>2</sub>O or produces cyanide or sulfide gas when acidified)
- **Toxic** (Listed heavy metals, pesticides and organic toxins)



# Hazardous Waste Cheat Sheet

## Non-Hazardous Combinations

Aluminum (Al)  
Ammonium (NH<sub>4</sub>)  
Calcium (Ca)  
Copper (cupric, cuprous) (Cu)  
Iron (ferric, ferrous) (Fe)  
Lithium (Li)  
Magnesium (Mg)  
Manganese (Mn)  
Nickel (Ni)  
Potassium (K)  
Sodium (Na)  
Strontium (Sr)  
Zinc (Zn)

+

Acetate (C<sub>2</sub>H<sub>3</sub>O<sub>2</sub>)  
Bicarbonate (H<sub>2</sub>CO<sub>3</sub>)  
Borate (BO<sub>3</sub>)  
Carbonate (CO<sub>3</sub>)  
Chloride (Cl)  
Iodide (I)  
Phosphate (PO<sub>4</sub>)  
Silicate (SiO<sub>2</sub>)  
Sulfate (SO<sub>4</sub>)  
Tartrate (Organic)  
Thiosulfate (S<sub>2</sub>O<sub>3</sub>)

= Non-Hazardous

Must be combined to be accurate  
Calcium + Chloride = CaCl<sub>2</sub>

# Hazardous Waste Cheat Sheet –pt. 2

## P- List Chemicals

Arsenic Trioxide ( $\text{AsO}_3$ )

Adrenaline / Epinephrine ( $\text{C}_9\text{H}_{13}\text{NO}_3$ )

All Pure Cyanide (first name, space, cyanide)

Beryllium Powder (Be)

Carbon Disulfide ( $\text{CS}_2$ )

Dinitrophenol ( $\text{C}_6\text{H}_4\text{N}_2\text{O}_5$ )

Endothall

Nicotine ( $\text{C}_{10}\text{H}_{14}\text{N}_2$ )

Nitric Oxide/Nitrogen Oxide (NO)

Osmium Tetroxide ( $\text{OsO}_4$ )

Sodium Azide ( $\text{NaN}_3$ )

Strychnine ( $\text{C}_{21}\text{H}_{22}\text{N}_2\text{O}_2$ )

Vanadium Pentoxide ( $\text{V}_2\text{O}_5$ )

Warfarin ( $\text{C}_{19}\text{H}_{16}\text{O}_4$ )

## Potential Explosives

Bouin's Solution (dry)

Collodion (dry)

Dinitrophenol

Ethyl Ether

Isopropyl Ether

Nitroglycerin

Picric Acid

Potassium (discolored)

Tetrahydrofuran

Dioxane

Trinitro - anything

Cumene

Cyclohexene

## TCLP Metals

Arsenic (As)

Barium (Ba)

Cadmium (Cd)

Chromium (Cr)

Lead (Pb)

Mercury (Hg)

Silver (Ag)

Selenium (Se)

**Can it go down  
the drain?**



**Probably not...**

**Does it?**



**Absolutely**



# Sewer Regulations

- Treatment plant regulates, link with them
- pH limits usually 6 to 9
- Low PPM **local** metals limits
- No haz waste allowed without approval
- No post-process dilution
  - Unless you have written OK from sewer utility

# Heavy Metals Sewer Limits

Can dilute copper sulfate go down the drain? No...

- $0.1 \text{ M CuSO}_4 = 6.35 \text{ g/L Copper} = 6530 \text{ mg/L (ppm)}$
- Sewer limit is  $8.0 \text{ mg/L copper} = 0.0001 \text{ M Cu}^{+2}$
- Arsenic limit =  $4.0 \text{ mg/L}$
- Cadmium =  $0.6 \text{ mg/L}$
- Chromium =  $5.0 \text{ mg/L}$
- Lead =  $4.0 \text{ mg/L}$
- Mercury =  $0.2 \text{ mg/L}$
- Nickel =  $5.0 \text{ mg/L}$
- Silver =  $3.0 \text{ mg/L}$
- Zinc =  $10.0 \text{ mg/L}$



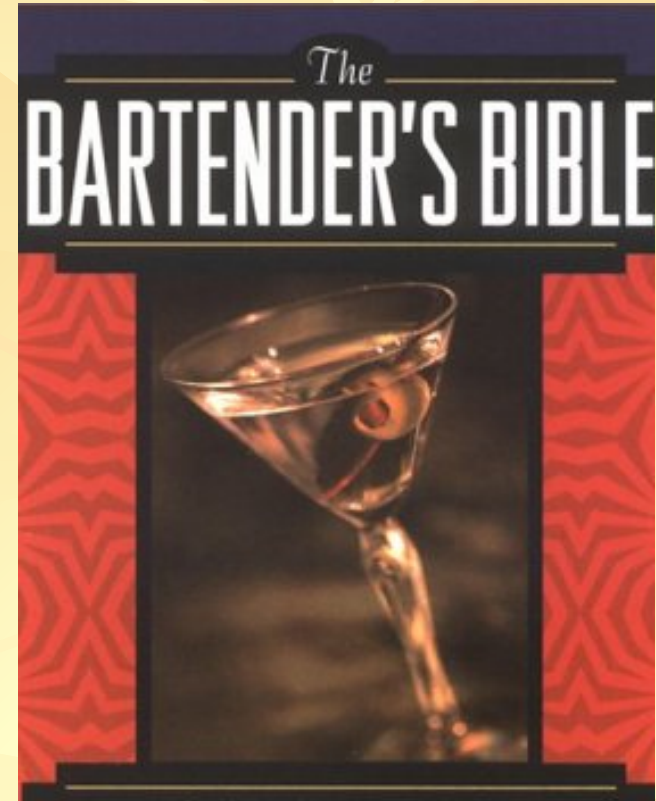
# Treatment of Acids & Bases

- Elementary neutralization of waste acids and bases is allowed
- Must be tracked on log sheet each batch
- Must be counted toward generator status
- Must meet sewer limits before discharge
  - Can't do it with hydrofluoric, perchloric acids due to toxic by-products from neutralization
- Not recommended for glacial acetic acid or ammonium hydroxide due to fumes



# Alcohol Management

- Ignitable if  $>24\%$
- Not allowed down drain
- Martini is about 35%
  - Returned drink = Haz Waste?
- Dilution just to get to  $<24\%$  is not allowed



# Does It Go Up the Fume Hood?



- Yep.
  - OK if it's water or an empty container
  - Empty = can't pour more out of it
- ← The always empty collection bottles

**If liquids are  
collected,  
they must be  
segregated  
by hazard  
class**



**How to turn \$200 worth of disposal  
costs into \$1200, just by not  
segregating waste**



## Haz Waste Disposal Getting started

- Start by linking with the Nebraska School Chemical Cleanout Campaign (NE SC3)

Keep Nebraska Beautiful  
3201 Pioneers Blvd., Ste 118  
Lincoln, NE 68502  
402.486.4562

# Wash Your Hands Before Leaving



# Don't get complacent out there





# Questions?

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