Hazard and Risk Assessment for Chemical Demonstrations

Presenter
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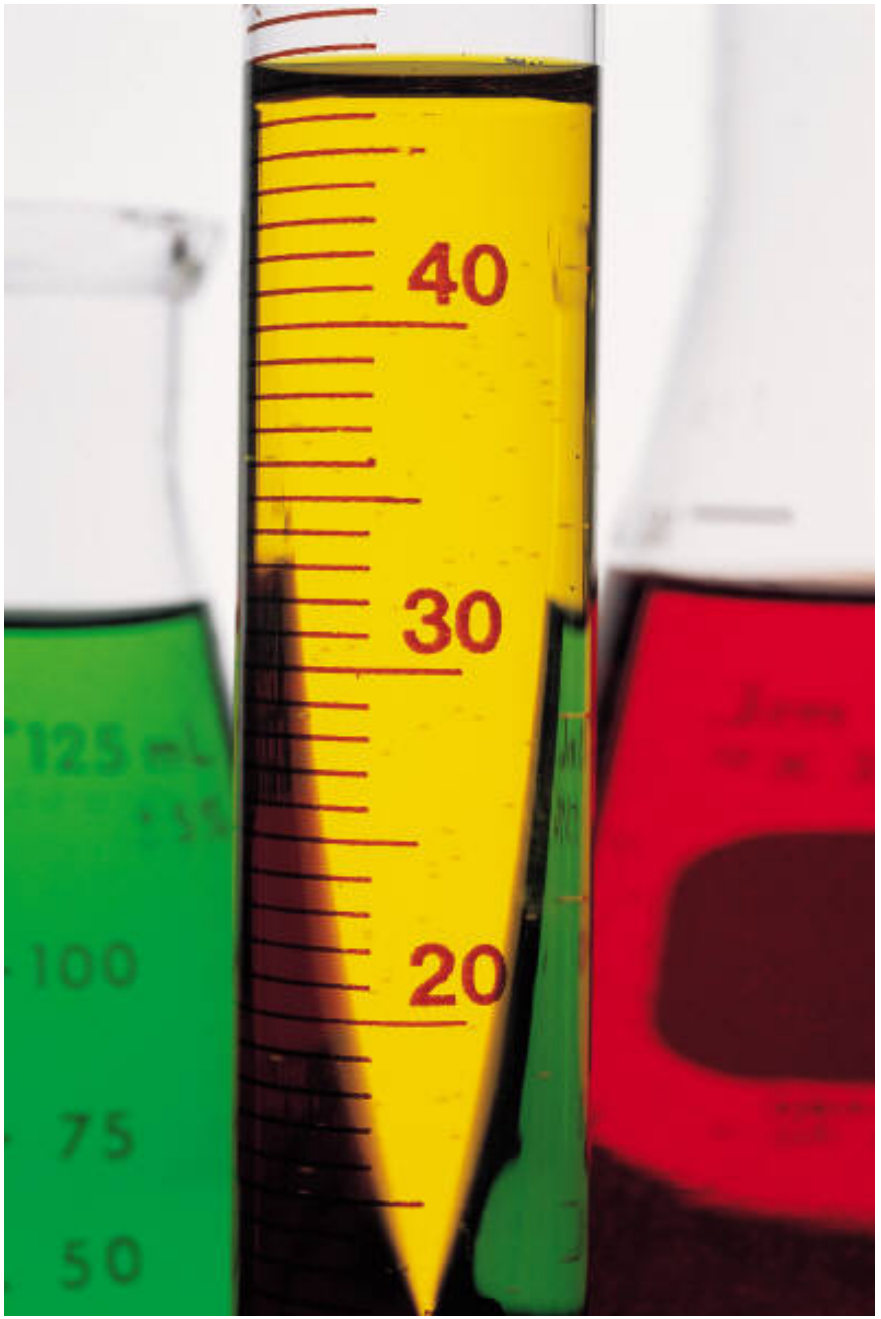
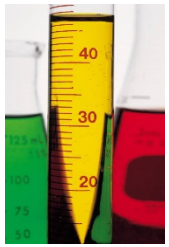
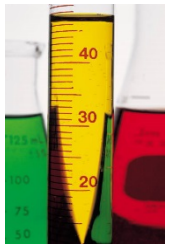
BCCE ELEVATING CHEMICAL EDUCATION UNIVERSITY OF NORTHERN COLORADO 2016





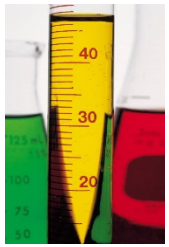
Developing a Risk Assessment

- Demonstration Selection
  - Consider pedagogical value, scale, location
- Information
  - Ask & answer five basic questions
- Information Organization
  - Consider experience of presenter, clarity of hazard communication, and hierarchy of controls



Ask & Answer Five Questions

Gathering Information

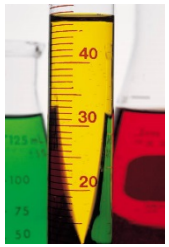


Does this demo require the use of a fume hood or other local ventilation system?

- If yes, specify for preparation and/or just for demonstration
- If needed for demo, ensure that one is available at the site
- No hood = no demo
- Indoor vs. outdoor, etc.
- Section 6 on the SDS may help here

[Demo Guidelines: 5 & 7]

ONE

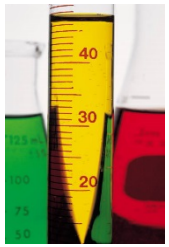


What PPE/safety equipment is appropriate for the chemicals and processes in this demo?

- List and include in the materials required prep sheet
- Include PPE for presenter and observers
- Section 8 of an SDS might help with PPE

[Demo Guidelines: 6, 8 & 12]

TWO

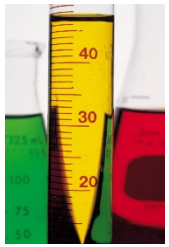


Are there specific chemical or physical reactivity hazards associated with the use of the chemicals involved?

- Fire, pressure, temperature, etc.
- Gases generated on mixing, incompatibility issues of reactants or products
- List and ensure these are communicated to users and/or audience as needed
- Look in Section 10 on the SDS

[Demo Guidelines: 6, 7, 8, 13, 14, 15, 16 & 17]

THREE

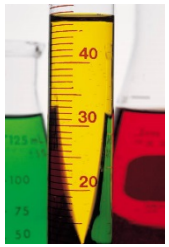


What waste disposal protocols are required to dispose of the created or leftover solutions?

- Include instructions to collect or dispose on site
- Are labeled waste containers required?
- Can they be transported?
- Section 13 on the SDS (usually vague)

[Demo Guidelines: 11 & 17]

FOUR

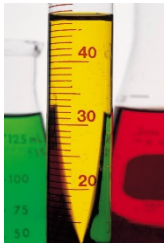


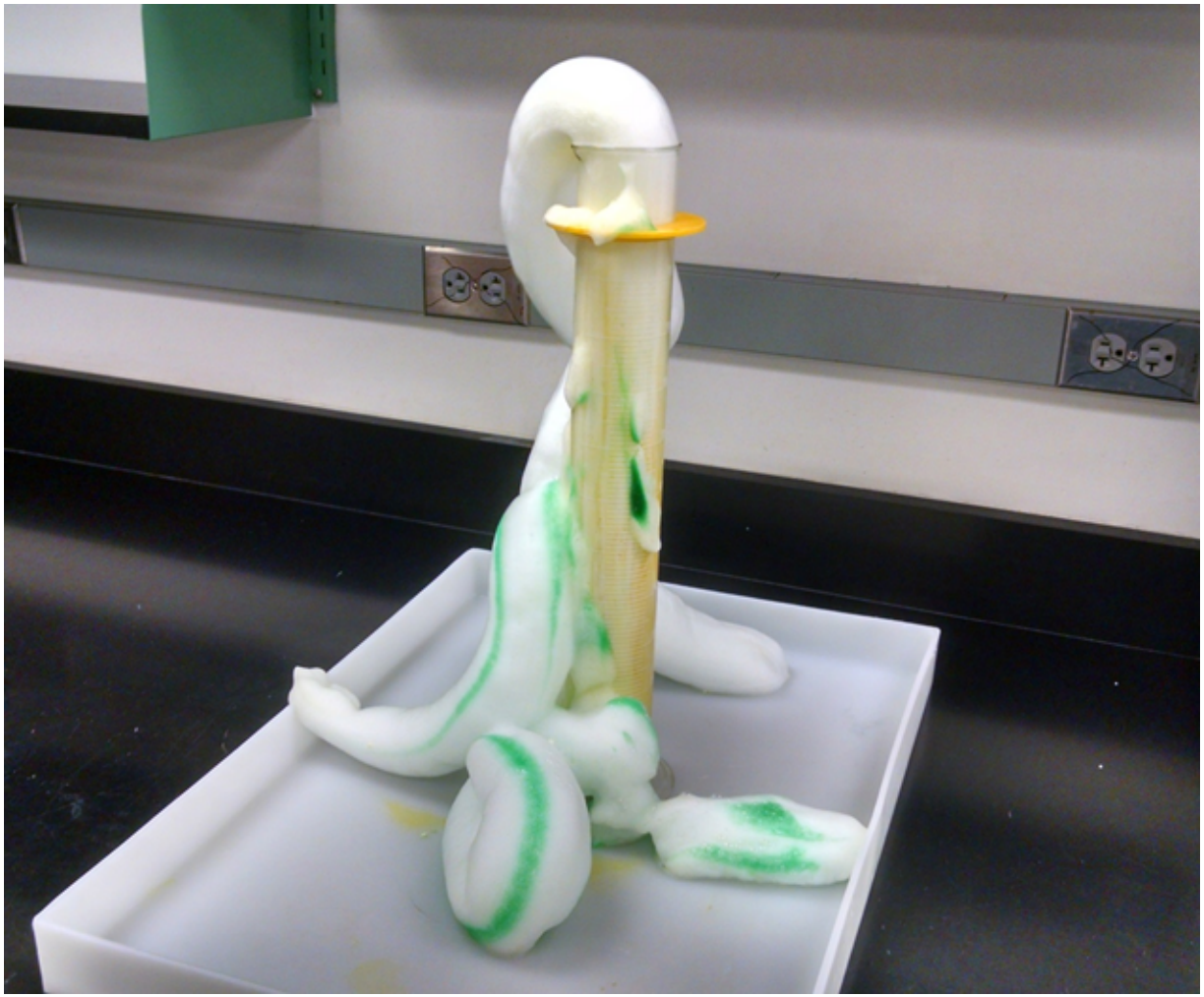
Are unusual emergency response protocols necessary for work involving this demonstration?

- That is, special spill cleanup, fire extinguishers, portable eyewash solutions, etc.
- List and include on the materials required prep sheet
- Sections 4 – 7 on the SDS

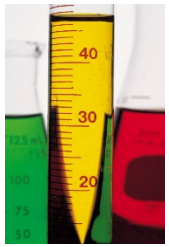
[Demo Guidelines: 6, 8, 9 & 10]

FIVE





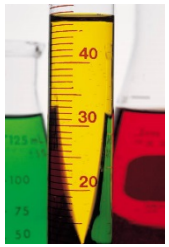
Elephant's Toothpaste



Pedagogy?

- OHS/GHS/Risk assessment
- Reaction writing
- Lewis structures
- Mass and % w/v
- Molarity
- Ideal gas equation/ gas stoichiometry
- Catalysts
- Kinetics

Eldridge, D., *J. Chem. Educ. 2015, 92, 1406-1408.*

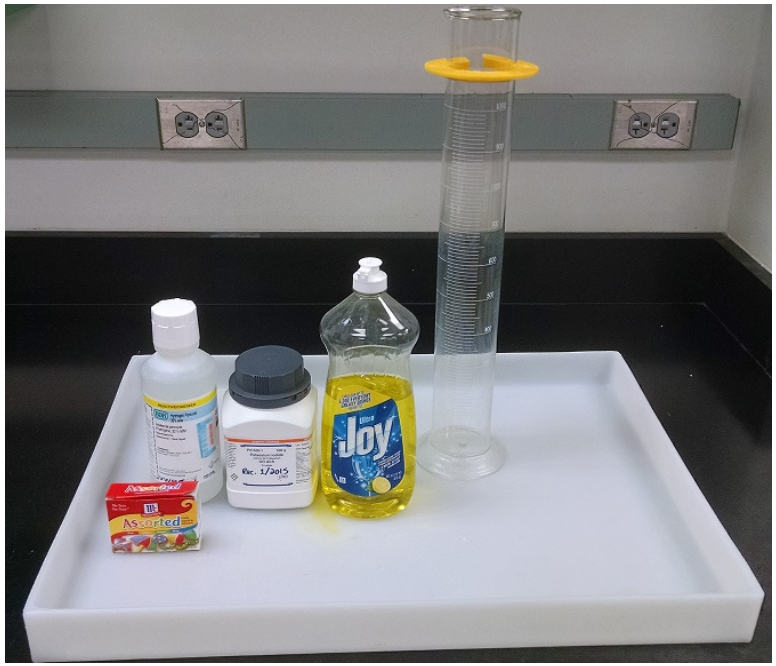


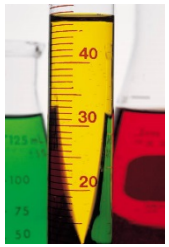
Elephant's Toothpaste

- A slightly yellow solution is created in a 1 L cylinder. When a scoop of white solid is added a foam resembling toothpaste rises out of the opening
- Chemicals required for the demo
  - 150 mL 30% hydrogen peroxide
  - potassium iodide (solid)
  - food color (optional)
  - 25 mL dish soap (Joy is best)
- Equipment required
  - scoopula
  - spill tray to contain est. volume of foam generated
  - 1 L cylinder

Danger

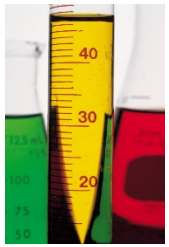
Signal word: Danger





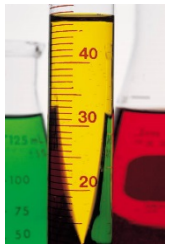
The Chemistry

- **Observations:**
  - **Potassium iodide catalyses the rapid decomposition of hydrogen peroxide. In the presence of soap, the rapidly generated oxygen from the decomposition will create mounds of fine suds filled with oxygen gas.**
- **Equations**
  - $2\ H_2O_2\ (aq) \rightarrow 2\ H_2O\ (l) + O_2\ (g) + \text{heat}$
    - $H_2O_2 + I^-\ (aq) \rightarrow H_2O\ (l) + OI^-\ (aq)$
    - $H_2O_2\ (aq) + OI^-\ (aq) \rightarrow H_2O\ (l) + O_2\ (g) + I^-\ (aq)$



Ask & Answer the Five Questions

Gather Information

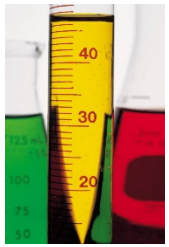


Fume hood required?

- Preparation: No. There is no preparation for the demo other than gathering the materials together.
- Demo: Normal room ventilation is sufficient for demo. Even though the TWA is low on both H_2O_2 and KI, however the time of use is very short. Avoid direct inhalation when pouring or scooping

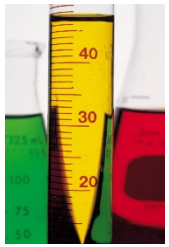
What PPE/Safety Equipment is needed?

- Wear nitrile gloves and chemical splash goggles.
- For preparation and demo: chemical splash goggles; nitrile gloves; eyewash/shower
- minimum of 10' distance for audience.



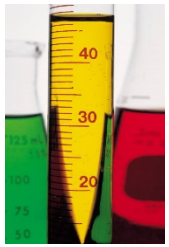
Are there specific chemical or physical reactivity hazards associated with the use of the chemicals involved?

- **Potassium iodide is a catalyst for the reaction.**
  - **Ensure physical separation of H_2O_2 & KI prior to actual demo.**
- **Great quantities of heat and steam are generated.**
  - **Use borosilicate glass**
  - **Do not let audience members "play" with foam or come close to the demo as it proceeds.**
- **Great quantities of oxygen are generated.**
  - **Keep open flames away**



Are there specific chemical or physical reactivity hazards associated with the use of the chemicals involved?

- **Incompatibilities**
  - **hydrogen peroxide (SA SDS): zinc, powdered metals, copper, nickel, brass, iron and iron salts.**
  - **potassium iodide: Strong reducing agents, nickel, strong acids, and its alloys, steel (all types and surface treatments), aluminum, alkali metals, brass, magnesium, zinc, cadmium, copper**
- **30% hydrogen peroxide is an oxidizer and very corrosive to tissue**
- **What could change the physical hazards of this demo?**

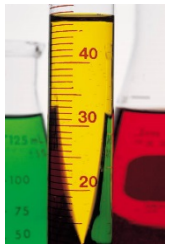


What waste disposal protocols are required to dispose of the created or leftover solutions?

- No materials that are considered hazardous waste are generated. There should be no unused materials that are not in the original containers. All solutions can be flushed down the drain, but always confirm with local agencies.

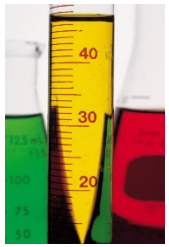
Are unusual emergency response protocols necessary for work involving this demonstration?

- None outside normal precautions for working with chemicals as listed in other sections. Very small amounts of iodine may be produced.



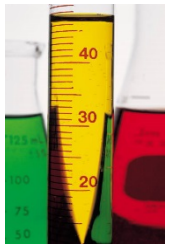
Create Assessment

Assemble Information



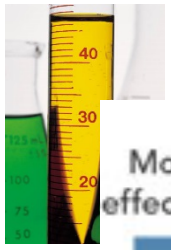
Determining Hazards

- **A well-outlined procedure**
- **Include all chemicals required (w/ CAS #)**
- **Include the physical hazards of the process *and the chemicals***
- **Be mindful of known incompatibilities & previous documented incidents**
- **Include the pre-demo preparation instructions as well as the demonstration instructions**
- **Section 2 on the SDS will list the GHS hazards**
- **Remember "No information" or "N/A" on the SDS does not mean "safe"**



Understanding Risk

- The purpose of the “risk assessment” is not to simply restate how to prepare and perform the demonstration
- Pedagogical information can be included esp. to gage whether the educational value justifies the risk
- The purpose of the risk assessment is to uncover both obvious and latent hazards and communicate the necessary barriers or controls that prevent harm to the demonstrators and audience
- Ask “What can go wrong?” and “How can my controls prevent it?”



Hierarchy of Controls

Most effective

Least effective

Elimination — Physically remove the hazard

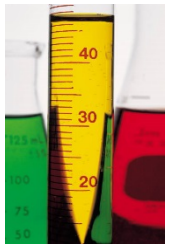
Substitution — Replace the hazard

Engineering Controls — Isolate people from the hazard

Administrative Controls — Change the way people work

PPE — Protect the worker with Personal Protective Equipment

CDC

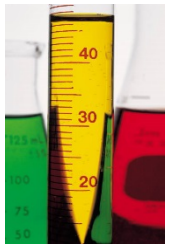


Beyond the SDS

- **ChemIDPlus Advanced is the National Institutes of Health search tool which indexes many chemical safety databases. Particularly useful databases indexed are at the site are shown below with direct links provided.**
  - **CAMEO Chemicals: The National Oceanic and Atmospheric Administration's reactivity prediction tool lets you investigate potential reactive hazards between chemicals *in silico*.**
  - **eChemPortal – Here you can find GHS data if it is available. Look for** 

  - **HSDS: The Hazardous Substance Database**
  - **Laboratory Chemical Safety Summary (LCSS) in PubChem**

    LCSSs for about 5000 of the most common laboratory chemicals – includes standard SDS information as well as known incompatibility reactions between specific chemicals.



Design a Word Doc with Simple Macros To Organize Information

Ventilation Requirements:

- ☐ hoods for preparation
- ☐ hoods for demonstration
- ☐ demonstration must be performed outside

Emergency Equipment Requirements:

- ☐ standard lab ER equipment
- ☐ eyewash/shower
- ☑ spill kit

Type

Choose an item.
solvents
acids
multi

- ☐ fire e

Waste

- ☐ labeled waste container(s) needed
- ☐ neutralize and dispose

PPE Requirements (Demonstrator):

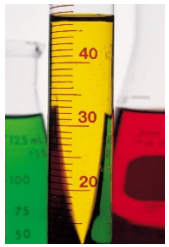
- ☐ gloves
  - Type
  - Type
  - Type
- ☐ eyewear
  - Type
  - Type
- ☐ lab coat
  - Type

Reactivity Precautions:

- ☐ flammable solvents
- ☐ corrosives
- ☐ oxidizers
- ☐ incompatible wastes

Checkboxes and Dropdown Menus are easy to add

- ☑ Easy to Add
- ☑ Easy to Use
- ☑ ...but they do not replace research



Ventilation Requirements:

- ☑ hoods for preparation
- ☐ hoods for demonstration
- ☐ demonstration must be performed outside

Emergency Equipment Requirements:

- ☑ standard lab ER equipment
- ☑ eyewash/shower
- ☑ spill kit
  - Type (kitty litter: non-organic)
- ☐ fire extinguisher

Waste Requirements:

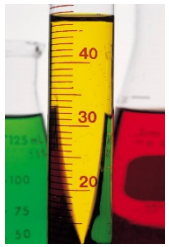
- ☐ labeled waste container(s) needed
- ☑ neutralize and dispose

PPE Requirements (Demonstrator):

- ☑ gloves
  - butyl rubber (nitric acid)
  - polyethylene (hydrochloric acid)
  - Type
- ☑ eyewear
  - chemical splash goggles (demonstrator)
  - eyewear for audience (yes)
- ☑ lab coat
  - cotton

Reactivity Precautions:

- ☐ flammable solvents
- ☑ corrosives
- ☑ oxidizers
- ☑ incompatible wastes

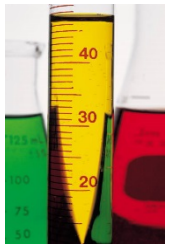


On Due Diligence…

The point is that being able to demonstrate 'due diligence' is not about *having* a thing (a policy or a system or a heap of procedures and checklists) it is about *doing* a thing.

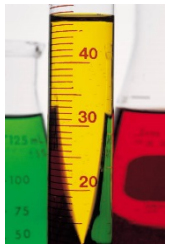
Demonstrating due diligence is about *being* diligent. And diligent is defined as "*showing persistent and hard-working effort in doing something*". So, demonstrating due diligence is focused on *doing*; it is an *activity thing*.

Geyer, M. *Due Diligence is about Effort, Not just Ticking Boxes*



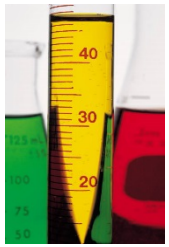
Formation of a Silver Mirror

Do your own Evaluation of Published or Internet Demonstrations



Issues Noted with a Published Procedure

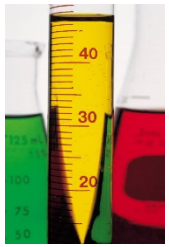
- Instructed to pour waste down the drain
- No guidance for working with nitric acid as an oxidizing acid
- No guidance on the hazards of silver(I) nitrate (low TWA)
- VERY large scale
- Amounts of prepared solutions will be in excess
- No mention of glove/goggle type
- No mention of hood use



Well Known Issues

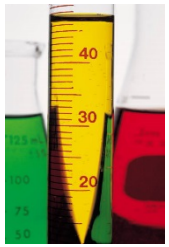
- **Fulminating Silver chemistry is complex with the likely explosive compounds noted as silver(I) nitride (Ag_3N) or silver(I) imide (Ag_2NH)**
  - **Klinger, G., Scheele, R., Steele, M., Exploding reagent. *Battelle Wash. Pacific Northwest Laboratories, Richland. C & E News* (8 Jan 1996) Vol. 74, No. 2, pp. 2.**
  - **School fined over chemistry explosion. BCC News. 2003. http://news.bbc.co.uk/2/hi/uk_news/england/tyne/3083899.stm**
  - **Vernon, R. Explosion and fire in the UCR organic chemistry stockroom. CHAS 29. The 231st ACS National Meeting, Atlanta, GA, March 26-30, 2006**

[1]SciTech Archive



Down the Drain Disposal?

- **Procedure advises down the drain disposal an oxidizing acid without neutralization**
  - **Solution should be neutralized with HCl (silver will ppt). The solution can then be labeled "hazardous waste" with the contents clearly labeled.**
- **Theoretically, this solution should not create fulminating silver because the silver complex, $[Ag(NH_3)_2]^+$, has been reduced to the metal by the sugar, however, I would not want to store it waiting for waste collection!**
- **Silver is a heavy metal (1 of the RCRA 8)**
  - **EPA allowable limit is 5.0 ppm**
  - **Solution is likely outside the pH range for drain disposal**



Procedure advises down the drain disposal for silver solution and claims to be following best practices of the day (1992)

DATE: 07/07/92 ACCT: 544727-01
INDEX: N/A CAT NO: S18125 PO NBR: N/A

SILVER NITRATE
SILVER NITRATE
SILVER NITRATE

MATERIAL SAFETY DATA SHEET CA8960

FISHER SCIENTIFIC
CHEMICAL DIVISION
1 REAGENT LANE
FAIR LAWN NJ 07410
(201) 796-7100

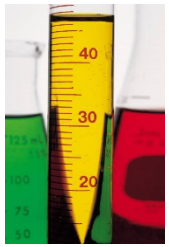
EMERGENCY NUMBER: (201) 796-7100
CHEMTREC ASSISTANCE: (800) 424-9300

DISPOSAL

DISPOSAL MUST BE IN ACCORDANCE WITH STANDARDS APPLICABLE TO GENERATORS OF HAZARDOUS WASTE, 40 CFR 262. EPA HAZARDOUS WASTE NUMBER D001.
100 POUND CERCLA SECTION 103 REPORTABLE QUANTITY.

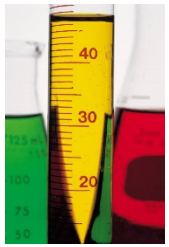
SILVER - REGULATORY LEVEL: 5.0 MG/L (TCLP-40 CFR 261 APPENDIX II)
MATERIALS WHICH CONTAIN THE ABOVE SUBSTANCE AT OR ABOVE THE TCLP REGULATORY LEVEL MEET THE EPA TOXICITY CHARACTERISTIC, AND MUST BE DISPOSED OF IN ACCORDANCE WITH 40 CFR PART 262. EPA HAZARDOUS WASTE NUMBER D011.

1992 Fisher Scientific MSDS



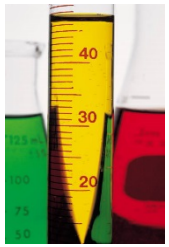
Are unusual emergency response protocols necessary for work involving this demonstration?

- **If any *black* ppt is noticed in the *standing solution* of silver(I) nitrate, ammonia, and potassium hydroxide prior to the demo**
  - **DO NOT TOUCH, EVACUATE & CALL HAZMAT**
- **Procedure advises "bleaching" skin with sodium thiosulfate to fade staining from silver(I) nitrate solution.**
  - **Rather: Wear nitrile gloves for the process and DO NOT add chemicals to skin**



General Controls

- The recipe calls for making a liter of most of the solutions. The individual solutions may be stored safely.
- Order 0.1 M silver(I) nitrate to avoid inhalation hazard from using solid
- Use smaller scale
- Use Flinn Scientific Publication No. 91322 method



Thanks are in Order…

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- **A. R. Smith Department of Chemistry, Appalachian State University**