Incorporating Basic Chemical Hygiene Concepts into the Secondary Education Methods Course for Pre-service Science Teachers

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Boo

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4403. Teaching Science in Middle and High Schools (3). F:S.
N ED: Junior Writing in the Discipline (WID)

s course is for the prospective middle/high school science teacher and it focuses o
ective instructional strategies for teaching principles associated with major school
ence disciplines. **Emphasis is placed on planning, science process skills, inquiry-
sed instruction, hands-on/minds-on activities, improvising materials,
monstrations, and assessment techniques. Special emphasis is also placed on th
rth Carolina Standard Course of Study and the Next Generation Science Educatio
ndards.** A minimum of 15 hours of experience in public school classrooms will be
quired as part of this course. It is STRONGLY ADVISED that all other requirements
licensure (except student teaching) be completed prior to this course. [Dual-listed
h GS 5403.] Dual-listed courses require senior standing; juniors may enroll with
rmission of the department. Prerequisite: RC 2001 or its equivalent.

Next Generation Science Education Standards

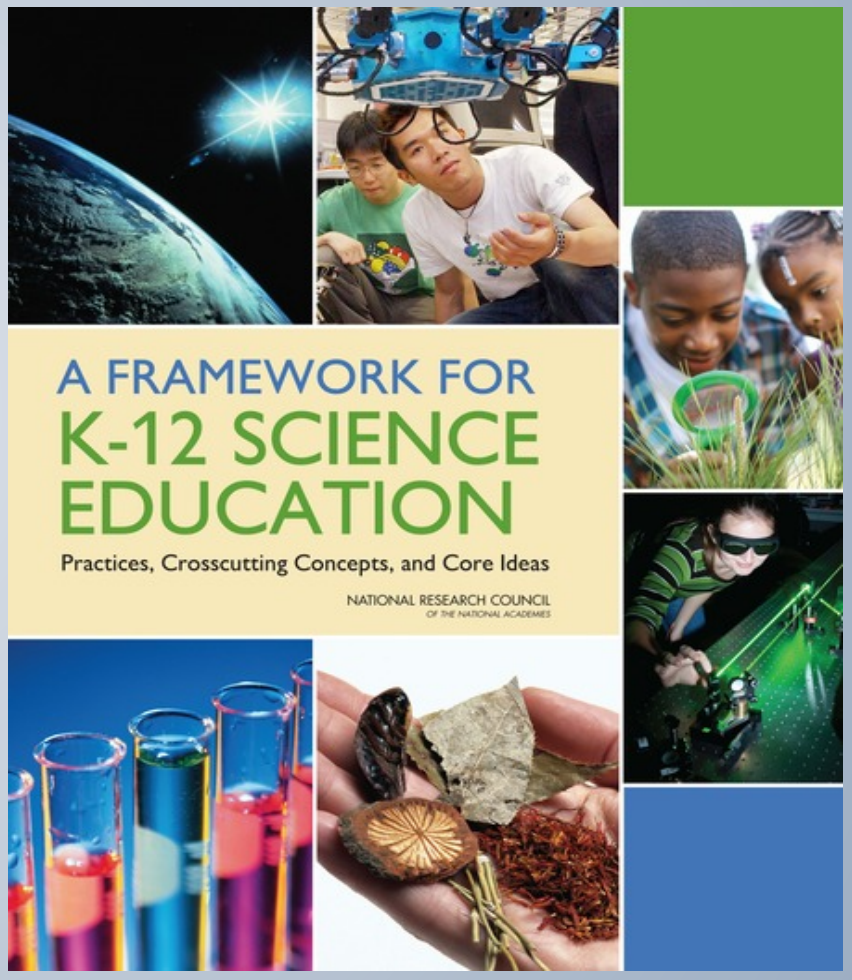
› Why Update?

- Reduction of the United States' competitive economic edge
- Lagging achievement of U.S. students
- Essential preparation for all careers in the modern workforce
- Scientific and technological literacy for an educated society

http://www.nextgenscience.org/need-standards

A Framework for K-12 Science Education

- Released In July of 2011 by the National Research Council (of the National Academy of Sciences)
- This was the first of two steps for creating their, "Next Generation Science Standards"
- The Standards would be based on 3 "framework" dimensions – Practices, Crosscutting Concepts, and Core Ideas



Framework

Dimension 1: Scientific & Engineering Practices

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Dimension 2: Crosscutting Concepts

atterns. Observed patterns of forms and events guide organization and classification, and the
rompt questions about relationships and the factors that influence them.

ause and effect: *Mechanism and explanation*. Events have causes, sometimes simple,
ometimes multifaceted. A major activity of science is investigating and explaining causal
elationships and the mechanisms by which they are mediated. Such mechanisms can
hen be tested across given contexts and used to predict and explain events in new contexts.

cale, proportion, and quantity. In considering phenomena, it is critical to recognize what is
elevant at different measures of size, time, and energy and to recognize how changes in scale,
roportion, or quantity affect a system's structure or performance.

ystems and system models. Defining the system under study—specifying its boundaries and
aking explicit a model of that system—provides tools for understanding and testing ideas tha
pplicable throughout science and engineerin**g**.

nergy and matter: Flows, cycles, and conservation. Tracking fluxes of energy and matter into
f, and within systems helps one understand the systems' possibilities and limitations.

tructure and function. The way in which an object or living thing is shaped and its substructur
etermine many of its properties and functions.

tability and change. For natural and built systems alike, conditions of stability and determina
f rates of change or evolution of a system are critical elements of study.

Dimension Three: Disciplinary Core Ideas

- The core disciplinary ideas are in four domains –
  - Physical sciences
  - Life sciences
  - Earth and space sciences
  - Engineering, technology, and applications of science
- Safety is mentioned in the core ideas for the ETS as part of optimizing design, finding solutions, and the interdependence of the parts of this area

Get to Know the Standards

I am interested in knowing how the standards address teaching chemical safety to our K-12 students. I do not see this concept present anywhere.

Thank you for your interest in the Next Generation Science Standards. The NGSS describe content standards for science, and are based on the content from the National Research Council's Framework for K-12 Science Education. Lab safety standards are typically state dependent, and are used in addition to science content standards.

Scientific & Engineering Practices

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

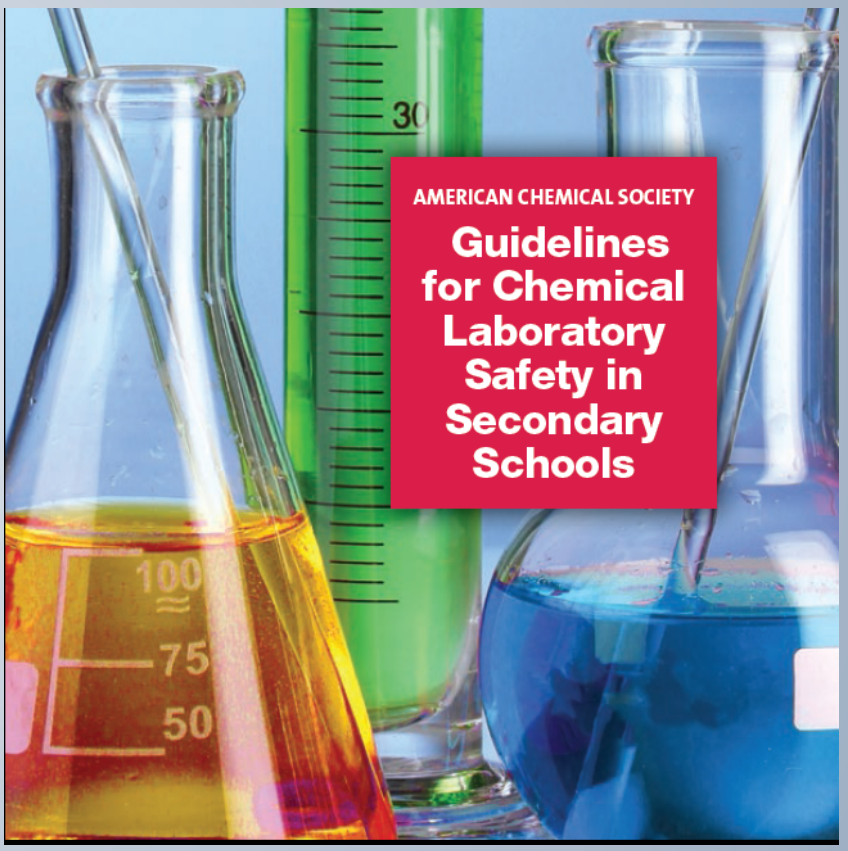
nension 1: Practices

nension 1 describes (a) the major practices that scientists employ as they investiga
l build models and theories about the world and (b) a key set of engineering practi
t engineers use as they design and build systems. ***We use the term "practices"***
ead of a term such as "skills" to emphasize that engaging in scientific investigat
uires not only skill but also knowledge that is specific to each practice.

ilarly, because the term "inquiry," extensively referred to in previous standards
uments, has been interpreted over time in many different ways throughout the
nce education community, part of our intent in articulating the practices in
nension 1 is to better specify what is meant by inquiry in science and the range of
nitive, social, and physical practices that it requires. ***As in all inquiry-based***
proaches to science teaching, our expectation is that students will themselves
age in the practices and not merely learn about them secondhand. Students
not comprehend scientific practices, nor fully appreciate the nature of scientific
wledge itself, without directly experiencing those practices for themselves.

The New CCS Guidelines

- The new Guidelines from the CCS can be the "Framework" for how states integrate safety into the standards as part of Dimension 1: Practices
- As I look through the book, the information that I have been providing to our pre teachers in the methods class mirrors the content



HS Guidelines

General

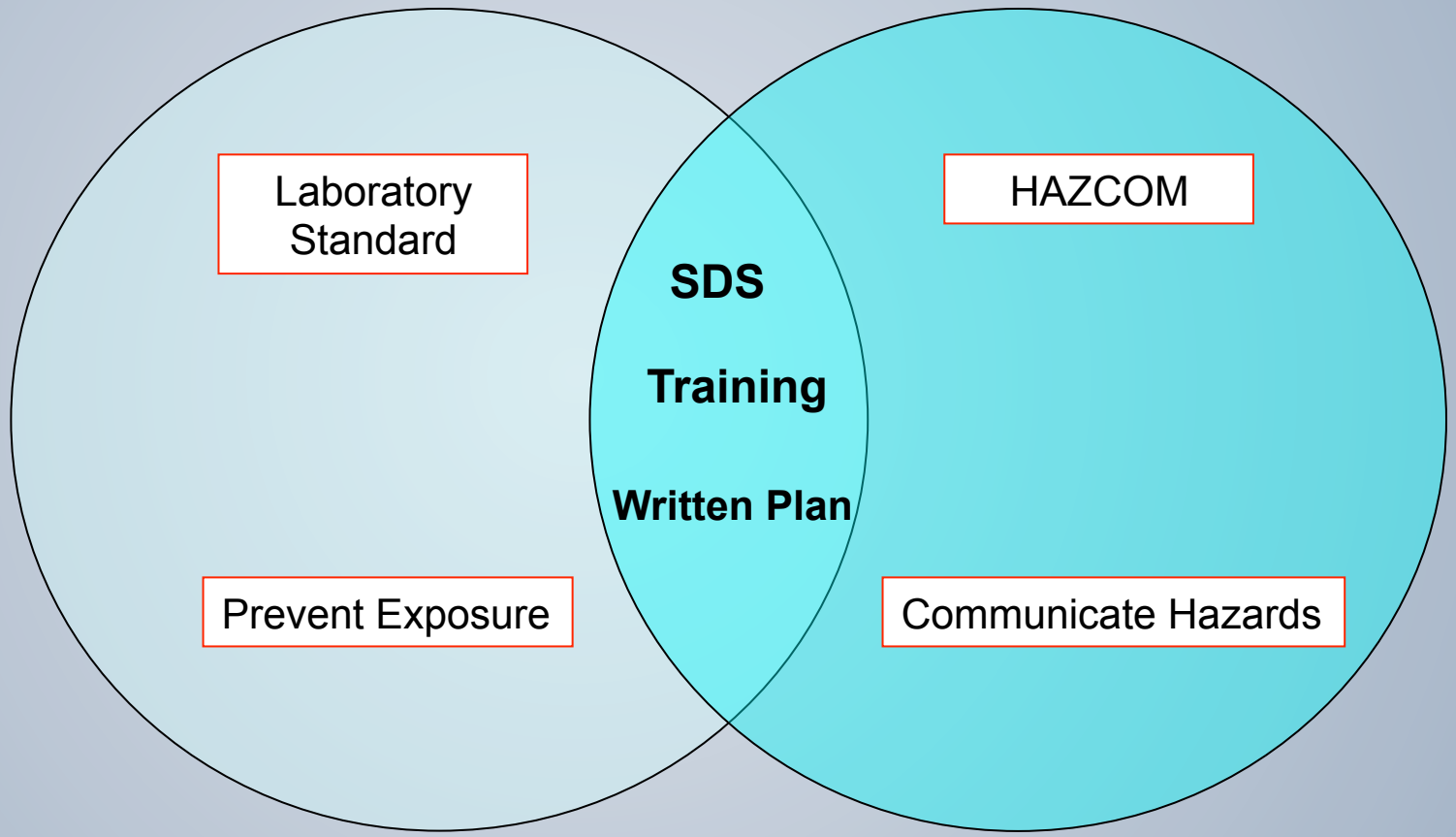
- I want the lecture to be a reference for them
  - Start with CSB video, "After the Rainbow"
  - The concepts of "due diligence" and negligence are covered
  - The NFPA 45 2015 Regulations as applicable to risk assessment
  - Q & A
- New the next time I lecture
  - The new CHED Demonstration Guidelines
  - The new CCS Guidelines for Chemical Laboratory Safety in Secondary Schools

In addition to the General Topics Specific Topics Covered (1 – 2 hours)

- Laboratory Regulations
- Hazard & Risk
- GHS
- Information
- Managing Chemicals Safely
  - PPE
  - Storage
  - Labeling
  - Waste

Laboratory Regulations:

Lab Standard & HAZCOM



Laboratory Scale
1910.1450(b)

Is chemical handling designed to be easily and safely manipulated by 1 person?

NO

Cannot use lab standard

YES

Does lab support or simulate a production process?

YES

Cannot use lab standard

NO

Does the lab produce materials for commercial use?

YES

Cannot use lab standard

NO

Are protective practices and equipment available?

Are multiple chemicals or procedures used?

OK to use Lab Standard

Laboratory Use
1910.1450(b)

The Chemical Hygiene Officer

- You must have one for your school
- Unless otherwise designated, your Principle is the CHO
- You cannot be designated as the CHO without providing you the necessary professional training

The Science Reflector

NFPA 45 – 2015 Edition

Fire Protection for Laboratories Using Chemicals

NFPA 45 Free Access

› 12.2 Instructor Responsibilities

Where instructors are performing demonstrations o students are conducting experiments using hazardou materials, the instructor shall be required to perform documented hazard risk assessment, provide a safety briefin to students, provide adequate personal protective equipmen (PPE), and place a safety barrier (as required) betwee students and the demonstration or experiment to preven personal injury.

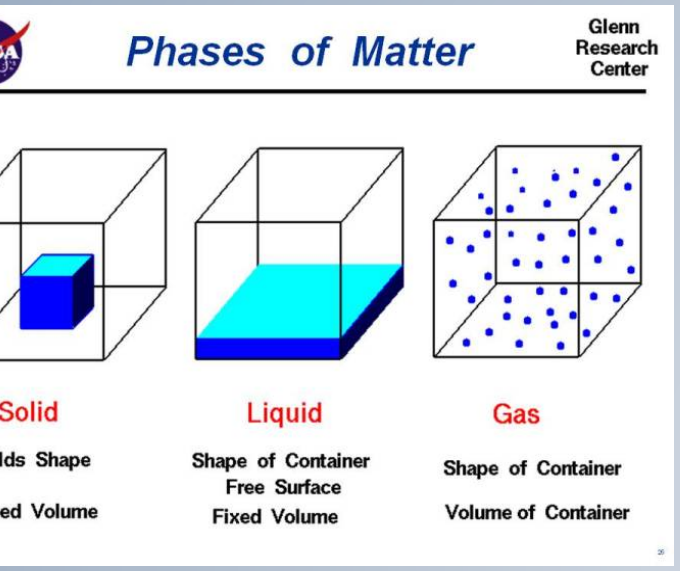
Hazard & Risk

- Define
- Hierarchy of Controls
- A basic risk assessment process using five questions
  - Does this experiment require the use of a fume hood or other local ventilation system?
  - What PPE/safety equipment is appropriate for the chemicals and processes in this experiment?
  - Are there specific chemical or physical reactivity hazards associated with the use of the chemicals involved?
  - What waste disposal protocols are required to dispose of the created or leftover solutions?
  - Are unusual emergency response protocols necessary for work involving this experiment?

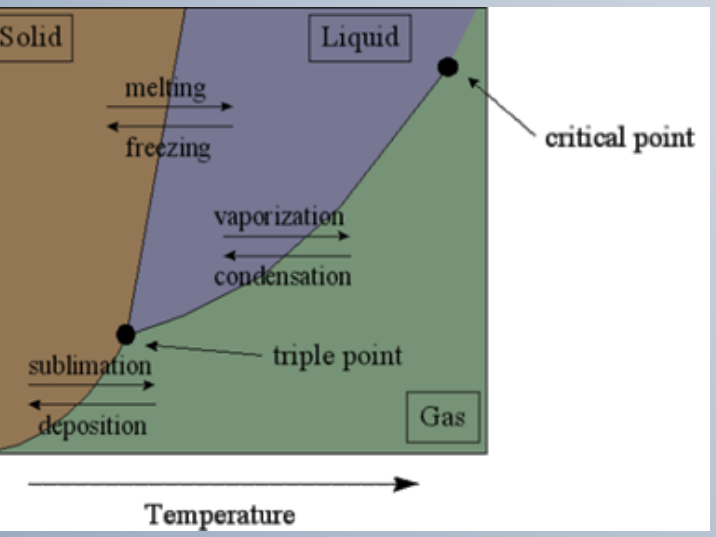
GHS

- Brief introduction
- Label elements
- Where to locate the P and H codes
- Where to locate in HAZCOM
- How to read an SDS
- Additional things as general information or for reference

STATES OF MATTER



ww.grc.nasa.gov/WWW/K-12/airplane/state.html



/sites.tenafly.k12.nj.us/~shilfstein/phase_diagrams.htm

	Traditional Definitions	GHS Definitions
Gas	Takes both the shape and volume of its container [particles are far apart with much empty space]	…a gas is a substance mixture which at 50° (122°F) has a vapor pressure greater than kPa (2.96 atm); or is completely gaseous a 20°C (68°F) and a standard pressure of 101.3 kPa (1 atm).
Liquid	Has definite volume, but takes the shape of its container [particles are close, but can move past one another]	…a liquid is a substan mixture that is not a and which has a melt point or initial meltin point of (68°F) or less standard pressure of 101.3 kPa (1 atm).
Solid	Rigid, posses definite shape and volume [particles tightly packed and cannot move]	…a solid is a substanc mixture that does no meet the definitions liquid or a gas.

Safety Data Sheets

- OSHA Brief

OSHA BRIEF

Hazard Communication Standard: Safety Data Sheets

The Hazard Communication Standard (HCS) (29 CFR 1910.1200(g)), revised in 2012, requires that the chemical manufacturer, distributor, or importer provide Safety Data Sheets (SDSs) (formerly MSDSs or Material Safety Data Sheets) for each hazardous chemical to downstream users to communicate information on these hazards. The information contained in the SDS is largely the same as the MSDS, except now the SDSs are required to be presented in a consistent user-friendly, 16-section format. This brief provides guidance to help workers who handle hazardous chemicals to become familiar with the format and understand the contents of the SDSs.

The SDS includes information such as the properties of each chemical; the physical, health, and environmental health hazards; protective measures; and safety precautions for handling, storing, and transporting the chemical. The information contained in the SDS must be in English (although it may be in other languages as well). In addition, OSHA requires that SDS preparers provide specific minimum information as detailed in Appendix D of 29 CFR 1910.1200. The SDS preparers may also include additional information in various section(s).

Sections 1 through 8 contain general information about the chemical, identification, hazards, composition, safe handling practices, and emergency control measures (e.g., fire fighting). This information should be helpful to those that need to get the information quickly. Sections 9 through 11 and 16 contain other technical and scientific information, such as physical and chemical properties, stability and reactivity information, toxicological information, exposure control information, and other information including the date of preparation or last revision. The SDS must also state that no applicable information was found when the preparer does not find relevant information for any required element.

The SDS must also contain Sections 12 through 15, to be consistent with the UN Globally Harmonized System of Classification and Labeling of Chemicals (GHS), but OSHA will not enforce the content of these sections because they concern matters handled by other agencies.

A description of all 16 sections of the SDS, along with their contents, is presented below:

Section 1: Identification

This section identifies the chemical on the SDS as well as the recommended uses. It also provides the essential contact information of the supplier. The required information consists of:

- Product identifier used on the label and any other common names or synonyms by which the substance is known.
- Name, address, phone number of the manufacturer, importer, or other responsible party, and emergency phone number.
- Recommended use of the chemical (e.g., a brief description of what it actually does, such as flame retardant) and any restrictions on use (including recommendations given by the supplier).

- With so many hazard and precautionary statements, how can you kn them all? The short answer for this question is that you do not need memorize the "code" as the text of the statement is always required information that accompanies a hazardous chemical. That being said you happen see an H code or P code by itself somewhere, there is a quick way to at least identify the basic classification represented.
- All hazard codes begin with the letter "H" followed by three digits. T first digit after the H indicates whether the hazard is physical (2--), health (3--), or environmental hazard (4--). You can also learn to recognize groupings within class. For example, codes 220 to 230 indicate some type of flammability hazard.
- All precautionary statements begin with the letter "P" followed by th digits. Here the first digit after the P indicates something general (1- for prevention (2--), for response (3--), for storage (4--), or somethin for disposal (5--).

2. HAZARDS IDENTIFICATION
2.1 Classification of the substance or mixture

- **GHS Classification in accordance with 29 CFR 1910 (OSHA HCS)**
  - Oxidizing liquids (Category 3), H272
  - Corrosive to metals (Category 1), H290
  - Skin corrosion (Category 1A), H314
  - Serious eye damage (Category 1), H318
  - For the full text of the H-Statements mentioned in this Section, see Section 16

SA SDS Product #438073

What does it really mean to say that the hazard is a Category 1 or Category 4?
This depends on which hazard you are talking about and the range from high to lo for that hazard
Manufacturers have to designate their chemicals into a category for each hazard based on known information
In the GHS system lower #'s = greater hazar

	Range - Highest hazard to Lowest hazard
Explosives	Unstable Explosive > Div 1.1 > Div 1.2 > Div 1.3 > [1.4 ? 1.5] > 1.6
Flammable Gases	Category 1 > Category 2
(+Chemically Unstable)	Category A > Category B
Flammable Aerosols	Category 1 > Category 2 > Category 3
Oxidizing Gases	Category 1
Gasses Under Pressure (classified by physical state when packaged)	Compressed gases, Liquefied gases, Refrigerated liquefied gases, Dissolved gases
Flammable Liquids	Category 1 > Category 2 > Category 3 > Category 4
Flammable Solids	Category 1 > Category 2
Self-Reactive Substances	Type A > Type B > Types C & D > Types E & F> Type G
Pyrophoric Liquids	Category 1
Pyrophoric Solids	Category 1
Self-Heating Substances	Category 1 > Category 2
Substances which, in contact with water emit flammable gases	Category 1 > Category 2 > Category 3
Oxidizing Liquids	Category 1 > Category 2 > Category 3
Oxidizing Solids	Category 1 > Category 2 > Category 3
Organic Peroxides	Type A > Type B > Types C & D > Types E & F> Type G
Corrosive to Metals	Category 1
Acute Toxicity (oral, dermal, inhalation)	Category 1 > Category 2 > Category 3 > Category 4 > Category 5
Skin Corrosion/Irritation	Category 1 > Category 1A > Category 1B > Category 1C > (Skin Corrosion)
	Category 2 > Category 3 (Irritation)
Serious Eye Damage/Eye Irritation	Category 1 (Serious Eye Damage)
	Category 2A > Category 2B (Eye Irritation)
Respiratory or Skin Sensitization	Category 1 (substance is classified as)
	Sub-Category 1A > Sub-Category 1B
Germ Cell Mutagenicity	Category 1 (A & B) > Category 2
Carcinogenicity	Category 1 (A & B) > Category 2
Reproductive Toxicology	Category 1 (A & B) > Category 2 > Additional Category
Target Organ Systemic Toxicity – Single Exposure	Category 1 > Category 2 > Category 3
Target Organ Systemic Toxicity – Repeated Exposure	Category 1 > Category 2
Aspiration Toxicity	Category 1 > Category 2
Hazardous to the Aquatic Environment	Short-Term (Acute) - Category 1 > Category 2 > Category 3
	Long-Term (Chronic - Category 1 > Category 2 > Category 3 > Category 4

GHS Classification in accordance with 29 CFR 1910 (OSHA HCS)

Nitric acid; CAS 7697-37-2

	Range (worst is lowest #)	What does it mean?
xidizing liquids	Category 3 Range 1 to 3	Any substance or mixture which, in the 1:1 mixture, by mass, of substance and cellulose exhibits a pressure of rise tim that of a 1:1 mixture of 65% HNO_3(aq) and cellulose
in corrosion	Category 1A Range 1, 1A to 1C	**(2)** Reversible adverse effects on corne iris, conjunctiva **(A)** Irritant Subcategory 2A Reversible in 21 days
rious eye damage	Category 1 Range 1 to 2	Transient target organ effects - Narcotic effects
rrosive to Metals	Category 1	A substance or a mixture that by chem action will materially damage, or even destroy, metals is termed 'corrosive to metal'

GHS Classification in accordance with 29 CFR 1910 (OSHA HCS)

Isopropyl alcohol; CAS 67-63-0

	Range (worst is lowest #)	What does it mean?
Flammable liquids	Category 2 Range 1 to 4	Flash point* ≥ 23°C (73°F) and ≤ 60°C (140°F)
Eye irritation	Category 2A Range 1, to 2(A,B)	**(2)** Reversible adverse effects on cornea, iris, conjunctiva **(A)** Irritant Subcategory 2A Reversible in 21 days
Specific target organ toxicity - single exposure - Central nervous system	Category 3 Range 1 to 3	Transient target organ effects - Narcotic effects

*Flash Point – The lowest temperature at which a combustible liquid or solid produces sufficient vapor near its surface to generate an ignitable mixture with air.

Managing Chemicals SAFELY

Segregation Based on Hazard Classes

- Flammables (red)
- Oxidizers (yellow)
- Corrosives (blue)
  - Acids
  - bases
- Highly Reactive (yellow, white)
- Extreme Toxics/Regulated Materials (blue, green)*
- Low Hazard (black)

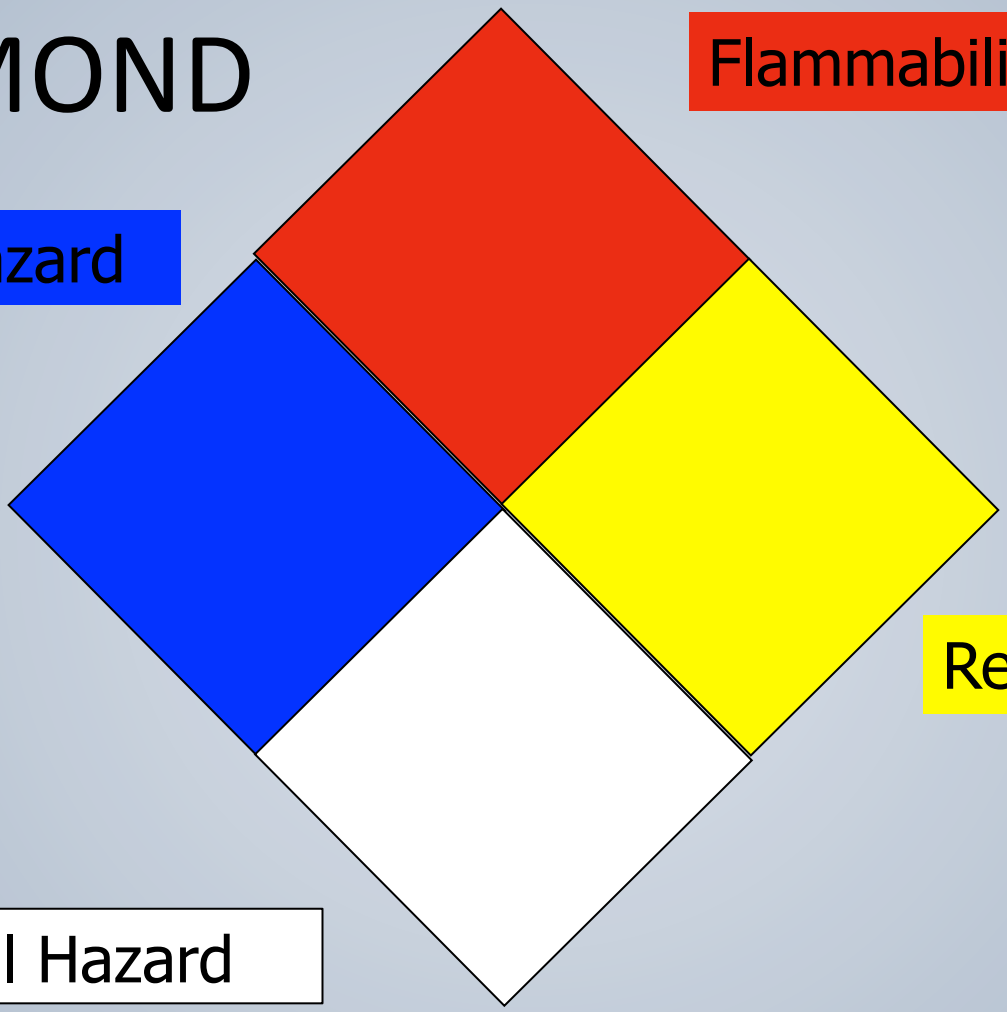
*Be careful with color schemes – they can vary from company to company or lab to

The quantity of flammables on hand in a unit must be kept to a minimum. Only in unusual circumstances will the maximum quantities be permitted. The following guidelines were adopted by the State of North Carolina for use in State agencies on the recommendation of the Deputy Commissioner of Insurance:

NFPA 704 DIAMOND

Flammability Hazard

Health Hazard



Reactivity Hazard

Special Hazard

Hazard Rating	
4	Severe
3	Serious
2	Dangerous
1	Minor
0	Slight

How Do I Start?
First Steps

- Prior to ***any work***, decide if you are comfortable with the following required steps
  - Completing an inventory of all chemicals you inherit
  - Evaluating the hazards of the chemicals
  - Evaluating the condition of the chemicals
  - Deciding what to keep and what to remove
- DO NOT handle or move chemical containers in bad condition without researching the hazards
- Wear correct PPE
- If you are not comfortable with the above steps, contact your supervisor for disposal
- Removal of hazardous materials is absolutely the responsibility of your employer

Steps to Determining Hazard Classes

- Check the label first to see what GHS is telling me. If it is an older bottle, find a GHS SDS and check the H codes. Sigma Aldrich has very good SDS sheets
- Note any special storage conditions based on incompatibilitie given in Section 10
- If more information is needed on compatibility, check NOAA's site – CAMEO Chemicals [Complete instructions on Computer Aided Management of Emergency Operations can be found here]
- Yet more information can be found at ChemIDPlus Advanced

Storing Chemicals Safely

- Hazard classes
- Incompatibilities
- General
- What not to do - photos

In General…

- Store chemicals in containers made from compatible materials
- Store chemicals in cool rooms – locked!
- Store chemicals with secondary containment when possible
- Label secondary containers well***
- Do not store chemicals in direct sunlight
- Check containers on a regular basis
- Maintain an up-to-date inventory and SDSs
- Do not store flammables in domestic refrigerators
- Do not store chemicals above eye level
- Do not buy more than you can use in a reasonable timeframe
- Do not accept chemical “donations” from the public

Storage

chloride

oride

hloride

ulfate

chloride

sulfate

Corrosives

Bases

potassium hydroxide

sodium hydroxide

Acids

sulfuric acid

hydrochloric acid

nitric acid*

*nitric acid on the DHS list

Inorganic Acids

acetic acid

Organic Acids

Flammables

ethanol

methanol

Oxidizers

silver nitrate

lead(II) nitrate

calcium nitrate

Wood

High Toxicity

um chloride

d(II) nitrate

aluminum c
copper(II) c
copper(II) su
hydrochloric
Magnesium
zinc
calcium chlo
silver nitrate
ammonium
calcium nitra
barium chlo
lead(II) nitra
magnesium
acetic acid
potassium h
nitric acid
sulfuric acid
ethanol
methanol
sodium hydr

HAZARDS IDENTIFICATION

Classification of the substance or mixture

GHS Classification in accordance with 29 CFR 1910 (OSHA HCS)

Oxidizing solids (Category 2), H272
Acute toxicity, Oral (Category 4), H302
Acute toxicity, Inhalation (Category 4), H332
Serious eye damage (Category 1), H318
Reproductive toxicity (Category 1A), H360
Specific target organ toxicity - repeated exposure (Category 2), H373
Acute aquatic toxicity (Category 1), H400
Chronic aquatic toxicity (Category 1), H410

For the full text of the H-Statements mentioned in this Section, see Section 16.

From the Sigma Aldrich SDS for lead (II)nitrate

GHS Label elements, including precautionary statements

Pictogram

Signal word — Danger

Hazard statement(s)

H272	May intensify fire; oxidiser.
H302 + H332	Harmful if swallowed or if inhaled
H318	Causes serious eye damage.
H360	May damage fertility or the unborn child.
H373	May cause damage to organs through prolonged or repeated exposure.
H410	Very toxic to aquatic life with long lasting effects.

Transporting Chemicals

› Use secondary containment

› Use a sturdy cart with lips

Secondary Labels

OSHA's Hazard Communication Standard (HCS), at 29 CFR 1910.1200(f)(5) states "*... the employer shall ensure that each container of hazardous chemicals in the work place is labeled, tagged or marked with... (i) Identity of the hazardous chemicals...and (ii) Appropriate hazard warnings, or alternatively, words, pictures, symbols or combination thereof,...to...provide the employees with the specific information regarding the physical and health hazards of the hazardous chemicals.*"

Secondary Labels – Pure Chemicals

- Chemical Name
- Chemical Abstracts Registry Number (CAS)
- Hazards
- Target Organs
- NFPA Ratings
- First Aid

Hazardous Waste
Treatment of Waste

- Hazardous waste is regulated by the Environmental Protectio Agency (EPA) and there are very stringent regulations on waste treatment
- In most states, you may adjust the pH of aqueous solutions of common inorganic acids and bases in containers
- The final pH should be between 5 and 8
- Whether or not you can put these down the drain depends on the local water treatment facility
- Talk to your Principle about what your State, local, and schoo rules are on wastes

Hazardous Waste In the Lab - Basics

- Label the container as you fill it
- The label must contain the words “Hazardous Waste”
- Names should be used – NOT formulas
- Make sure the container is compatible with the chemical(s)
- Leave 10% headspace for expansion
- Lids should be in place and tight at all times other than in transf
- ECO Funnels from CP Lab Safety are very nice if you can afford them
- Use secondary containment
- Be very cognizant of incompatibilities and have multiple containers if needed

Need Information?

Need Help?

- National Institute for Occupational Health & Safety (NIOSH) - School Chemistry Laboratory Safety Guide
- American Chemical Society – Committee on Chemical Safety
- American Chemical Society – Chemical Health and Safety Resources
- American Chemical Society – Guide for Chemical Spill Response Planning in Laboratories
- American Chemical Society – Division of Chemical Health & Safety (DCHAS)

Professional Development

- AACT is the American Association of Chemistry Teachers
- Science & Safety
- NSTA
- CHED and BCCE Conferences

Questions?

›Thanks to the GS 4403 Instructors (Dr. Geib and Ms. Toran) for giving me time in their packed curriculum!

›Thanks (as always) for the support from my university and department – Especially our chair, Dr. Cartaya