EXPLORE SCIENCE

2018

Explore Science: Let's Do Chemistry

Safety Guide

www.nisenet.org/chemistry-kit

NISE NETWORK
NATIONAL INFORMAL STEM EDUCATION

ACS Chemistry for Life®

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Edited by David Sittenfeld

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Explore Science: Let's Do Chemistry is a close collaboration of members of the National Informal STEM Education Network (NISE Network) and the American Chemical Society (ACS). The NISE Network team includes educators, scientists, and researchers from the Museum of Science in Boston, the Science Museum of Minnesota, Arizona State University, the Sciencenter in Ithaca, New York, and the University of Wisconsin-Madison. The ACS team includes chemists, science communicators, and educators from the association. Additional advice, expertise, and oversight are contributed by the ACS Committee on Chemical Safety, the ACS Committee on Community Activities, the Children's Creativity Museum in San Francisco, the Children's Museum of Houston, The Franklin Institute, the Lawrence Hall of Science at the University of California Berkeley, the Museum of Life and Science in Durham, North Carolina. We would especially like to thank everyone who provided helpful review and feedback to this guide.

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The NISE Network

The National Informal STEM Education Network (NISE Network) is a community of educators and scientists dedicated to supporting learning about science, technology, engineering, and math (STEM) across the United States. The Network creates resources and coordinates activities on a national and regional level, while Network partners coordinate and implement project activities locally. We achieve our reach and impact through the participation of over 600 partner organizations in Network activities, including museums, universities, and other organizations that provide informal learning opportunities for public audiences. Together, Network partners engage 11 million people each year in high-quality STEM learning.

NISE Network partners engage public audiences in learning about current science, technology, math, and engineering in all 50 states and Puerto Rico.

American Chemical Society

The American Chemical Society (ACS) is the world's largest scientific society, with more than 150,000 members in over 140 countries. ACS is recognized as a leading publisher of authoritative scientific information, with over 50 peer-reviewed journals and a comprehensive digital databases of disclosed research in chemistry and related sciences. In its role as a scientific society, ACS serves as a catalyst for innovation, strengthens science education, advances sustainability, and influences public policy. As a professional organization, ACS empowers its members to advocate for chemistry, elevate their career potential, expand their networks, inspire future generations, and improve the scientific understanding of all people. The American Chemical Society promotes National Chemistry Week and other public educational activities.

ABOUT THIS GUIDE

Explore Science: Let's Do Chemistry is a close collaboration of members of the National Informal STEM Education Network (NISE Network) and the American Chemical Society (ACS). Planning about safety and safe practices has been integral to developing the *Let's Do Chemistry* kit activities and facilitation materials. By understanding and following the instructions and protocols embedded in the activities, demonstrated in the training videos, and called out in the facilitator guides you will minimize risk to participants, staff, and volunteers. This guide is designed to highlight safe practices, help you identify and mitigate risks, and provide prudent practices you can implement to plan a safe event.

Everything around us is made of chemicals, so all substances have chemical properties and, as such, potential associated hazards and risks. Some of the historical outputs of chemistry, such as pollution, episodes of chemical contamination, and various high-profile accidents, have led to negative attitudes about the use of chemicals among members of the public and in popular media. But this does not mean that chemistry activities are inherently dangerous or risky! In creating the *Let's Do Chemistry* kit, it was important for us to demonstrate that chemistry can be done safely in a public setting. The activities in the *Let's Do Chemistry* kit were specifically selected and designed with safety in mind. Most of the activities in the kit use everyday materials that pose very few safety hazards. Where greater hazard or risk do exist specific safety practices are highlighted (here in this guide) and in the facilitator guides associated with the activities.

While we have taken great care in the design of all the kit materials, we encourage you to carefully think about:

- What **hazards** exist and what associated risks may arise from these hazards?
- How to **minimize risks** through protocols we have designed into the activities and training materials.
- How **safe practices and protocols** should best be communicated with facilitators, participants, and others.

Safety planning goes beyond just chemical safety. This guide is primarily intended to inform event organizers about how to use the kit activities in the safest way possible from a chemical safety perspective. The chemical safety guidelines outlined here are meant to supplement general facility and event safety guidelines, and do not supersede or replace institutional plans and protocols for dealing with emergencies. Many of these general safety guidelines are alluded to here and in the accompanying *Explore Science: Let's Do Chemistry Planning and Partnership Guide*, but you should always communicate with the people in your institution who manage safety-related protocols and policies and coordinate event logistics with them to ensure the safest possible outcome.

Overall, communication is a core chemistry safety strategy. This guide and the other safety resources in the *Let's Do Chemistry* kit have been written to help you, as an event organizer, communicate how the materials and protocols used at your event are safe for everyone involved. By following and actively

sharing the safety guidelines for the kit activities, you will provide a safe science experience for participants, staff, and volunteers.

"RAMP"-ing up safety

In collaboration with the American Chemical Society (ACS), the *Let's Do Chemistry* activity development team thought carefully how to design and incorporate safe practices and protocols into each of the kit activities. ACS has adopted a safety framework referred to as "RAMP" (Hill and Finster, 2016)[1]. RAMP is intended to raise awareness of chemical safety practices and risk assessment, and is built around four core elements:

Building on this framework, the *Let's Do Chemistry* activities reflect each of these core RAMP considerations and include both embedded design components and recommended practices and protocols.

Once again, we encourage you to also think carefully about:

- What **hazards** exist and the associated risks that may arise from these hazards,
- How to **minimize** risks through protocols we have designed into the activities and training materials, and
- How **safe practices and protocols** should best be communicated with facilitators, visitors, and others.

[1] Hill, R. & Finster, D. (2016). *Laboratory safety for chemistry students*. Hoboken, New Jersey: John Wiley & Sons.

LET'S DO CHEMISTRY KIT SAFETY PRACTICES AND PROTOCOLS

Event organizers should be thoroughly familiar with safety issues specific to each of the *Let's Do Chemistry* activities. As part of the planning process, organizers should review all of the specific safety information provided in this guide as well as in the individual activity guides and training materials.

Start with the activity and facilitator guides! The guides provide information about specific safe practices and precautions for each activity. The activity guides always specify when personal protective equipment (PPE) such as goggles and gloves are required. The guides also identify safety risks that may arise, such as the use of possible allergens and sensitizers, loud noises, or projectiles (as in the "Rocket Reactions" activity). Finally, the guides describe facilitation techniques and protocols that can help to manage the activity so that it is as safe as possible.

Watch the training videos. See these chemical safety practices in action! Each training video describes and demonstrates the activity and specifically utilizes and highlights any safety concerns or recommended safe practices. The training videos demonstrate how to safely set up the activity, what to do with excess or leftover solids and liquids that may be generated, and how to handle disposal issues. The videos are available online, so you can easily share links in advance with staff, volunteers, and other facilitators.

Read and use labels. Correctly labeled chemical containers help facilitators and participants successfully do an activity and communicate relevant safety information. Label pipettes and other tools that may correspond to specific chemical reagents. For example, squeeze bottles or transfer pipets for sodium carbonate or vinegar in the "Nature of Dye" activity should clearly convey which reagent each pipette or eyedropper should be used with in order to avoid cross-contamination. While most of the *Let's Do Chemistry* activities use familiar substances and none of the materials are highly flammable, rapid oxidizers, or strong corrosives, it's important to clearly label every container and tool you use, whether provided in the kit or otherwise. Be sure to write all information clearly so others will be able to read it, and use a smudge-proof pen! You don't want information to become useless if it gets wet. Some specific labeling materials that work well are permanent markers (like Sharpie™ brand markers) and water-resistant stickers or freezer tape. Permanent pens and sticker labels are provided in the *Let's Do Chemistry* kit.

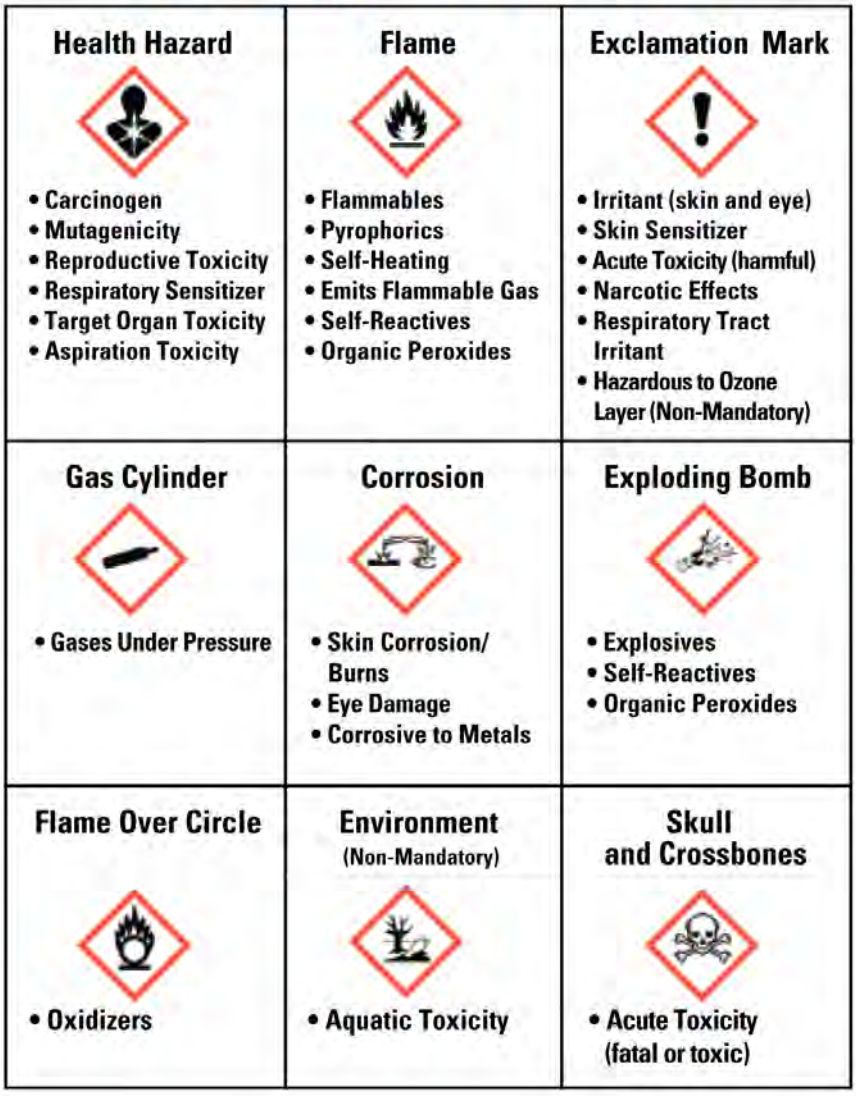
Always include:

- The full name of the chemical. Use the full name rather than just an abbreviation, popular name, or chemical formula. For example, use "sodium carbonate" rather than "Na_2CO_3" or "soda ash."
- Any relevant hazard information others should know.

If you plan to store a solution or materials, you can also add information about who prepared it and the date it was prepared.

More information may be required at certain institutions. For example, some institutions require that containers be labeled using Hazard Communication Standard (HCS) labels or pictograms such as the ones below, with the relevant hazards clearly indicated. More information about these standards can be found at www.osha.gov. For the substances provided in the *Let's Do Chemistr*y kit, only two of the hazards in the pictograms are relevant (except for dry ice, which is not provided in the kit and is discussed in more detail later in this guide.) The vegetable oil in the "Cleaning Oil with Chemistry" activity is a flammable liquid, and certain other substances can be mildly irritating to the skin, such as the sodium carbonate and cochineal dye.

HCS Pictograms and Hazards



GENERAL CHEMICAL SAFETY GUIDELINES, PROTOCOLS, AND PRECAUTIONS

The activities in the *Let's Do Chemistry* kit were specifically selected and designed with safety in mind. Most of the activities in the kit use everyday materials that pose very few safety hazards. Where greater hazard or risk do exist specific safety practices are highlighted (here in this guide) and in the facilitator guides associated with the activities. The *Let's Do Chemistry* kit activity guides provide specific information about protocols and practices that need to be observed. This section provides more general guidelines that should be observed when facilitating these and any other chemistry activities.

Safety guidelines when preparing chemistry activities and demonstrations

Look at the Safety Data Sheets and other specific safety information ahead of time. Safety Data Sheets (SDS) are provided for each chemical used in the *Let's Do Chemistry* kit. If something unexpected happens, these resources can be very useful. Look them over before facilitating an activity, so that you know what to do or where to look again if such a situation ever arises. Make sure that you have these materials in an easily accessible location during your event.

Store materials safely. Think carefully about where you will store activity materials and/or containers used to store waste that may result from doing the activities. Never store chemicals in a refrigerator or any area that is dedicated for food! More information about storage and disposal is provided later in this guide, specifically for dry ice.

Safety guidelines when doing chemistry activities and demonstrations

Follow safety protocols. Safety and disposal methods described in the activity write-ups, videos, and other training materials should always be followed properly. Failure to do so could potentially create dangerous circumstances.

Communicate safety clearly. While most of the materials included in the *Explore Science: Let's Do Chemistry* activities are quite benign in terms of safety and environmental impact, it's always important to communicate safe practices clearly and proactively.

Use personal protective equipment (PPE). Keep in mind that chemical reagents often present increased risk to mucous membranes (eyes, nose, and mouth). Facilitators and participants should always wear goggles and gloves as specified and noted in the activity guides. These measures can help to reduce risk

and prevent injury to visitors and facilitators. It's very important that facilitators also model and follow these guidelines so that participants know they are truly important. However, always remember that eye protection and gloves are intended as backups to safe practices.

Wash hands! Wash your hands **before and after** you present an activity or program that uses potentially hazardous chemicals. Also wash your hands before and after using the bathroom during the time period while you are facilitating the activity.

Make sure everything looks right. If you ever notice that chemicals look, smell, or seem different from how they should, do not use them!

Clean up spills right away. Clean up spills immediately to avoid secondary risks. If glassware breaks, make sure to dispose of it by sweeping it into a box, and then clean up any associated spills. Using plastic beakers and vessels, like those in the kit, will reduce the risk of breaks and spills. More details on spills are provided later in this guide.

Additional safety guidelines for facilitating chemistry activities

Public science events, such as National Chemistry Week or other events or activities at science centers and museums, raise important safety considerations beyond what chemists might need to think about in their own lab. Because participants—who often include children—may not be familiar with chemistry experiments and activities, it's essential to make sure that these guidelines and safe practices are observed. Always follow and model prudent practices when doing chemistry activities.

Model and communicate. Always remember that we are not only following safety guidelines to protect ourselves and visitors participating in or watching the program, but also because part of our job is to model safe practices.

Deliver safety instructions proactively. Any participant approaching an activity that requires safety glasses and/or gloves should be instructed to wear these protections before any other instructions are given. It's important to bring safety into the conversation from the outset!

Use initial interactions to model safety. In the "Nature of Dye" activity, for example, walking participants through the use of a transfer pipette provides a nice opportunity to emphasize safety. (Don't squirt your neighbor!)

Use positive language. When communicating safety protocols with participants who are very young or who may have special needs, one useful strategy is to use **positive language**. Make sure to communicate what you want the participant to do ("We're going to wear our safety goggles so we can begin this activity together") rather than what you don't want them to do ("Don't start yet!").

Be ready to talk about safety with participants. Our participants expect us to be the experts in facilitating these activities and working with the materials in a safe manner. This means that we must be able communicate *why* what we are doing is safe. Participants are likely to ask you about safety, and that is a good thing!

Layer safety into the activity. For example, the "Building a Better Battery" activity includes a number of discrete steps that the participant will complete. This provides an opportunity for facilitators to emphasize safety along the way during each step.

Be adaptable. If a demonstration or part of an activity does not seem to be working in the way you expect it to, or the participant doesn't seem to be able to do the activity safely, facilitators should move on and do something else. It's OK not to do the entire activity if something seems amiss. There are many other opportunities to learn about chemistry!

Involve everyone in safety conversations and take turns. Caregivers should be engaged during interactions and must follow safety protocols themselves. Do not hesitate to ask for their help if a young participant is not following safety instructions! If required, all members of the group must observe safe practices and use personal protective equipment. If a group is too large for all members to safely participate at once, then some may need to wait until there is enough space and materials for the activity to be conducted safely.

General safety precautions when training and working with facilitators and guest educators

It's important that safety is emphasized in your training process and that every facilitator or guest educator takes ownership over the safe implementation of their activity or demonstration. For example, the overview presentation provided in the *Let's Do Chemistry* kit briefly describes some of the safety practices and protocols in this guide and in the activity training materials.

Practice makes perfect. Event organizers should never attempt an activity, or train facilitators, unless they have gone through the entire process of setup, demonstration, and disposal themselves. Organizers should feel comfortable facilitating each activity on their own, so that they are able to adequately instruct facilitators and participants.

Discuss safety with facilitators and guest educators during training. It is important to remind facilitators that both the participants' safety and the reputations of the participating institutions are at stake. Failure to observe basic safety protocols can result in negative attitudes towards chemistry, injuries, or even potential fines from authorities.

Informal learning environments are different. Remind facilitators that working with participants in a public educational setting is different from working in one's own lab or in a formal educational setting. While scientists in a lab usually know that there are safety protocols and are familiar with working with potentially hazardous reagents, science centers and other informal learning institutions are free-choice learning environments serving a wide range of visitors, many of whom may be unfamiliar or even uncomfortable with chemistry.

Encourage facilitators to ask safety questions and practice communication about chemical safety. Everyone should be given the opportunity to ask questions about safe facilitation and chemical safety practices, both during the training and at other times. If you don't know an answer, talk to someone identified in the next section so you can provide the needed information.

Assigning facilitators to activities

Another thing to think about is which activities should be assigned to various facilitators, given their experience, and their comfort with facilitation and chemistry safety practices.

What kind of volunteers/facilitators will be involved? Are there activities that you think will work better if a more senior volunteer or educator is present or nearby? For example, "Rocket Reactions" involves many small projectiles potentially launching at the same time as participants experiment with reactions. Activities such as "Rocket Reactions" and "Sublimation Bubbles" require facilitators to be very vigilant from a safety perspective, so you may want to assign more experienced facilitators or pair up educators to provide a little extra support.

Ask event volunteers which activities they are most comfortable facilitating. Given the specific safety considerations, assign activities based on the facilitators' experience and stated preference.

Are there certain activities that need to be facilitated by staff, rather than by volunteers or guest educators, because of institutional or event location policies? For example, some institutional safety committees may require that only members of the museum staff use dry ice or cryogenic liquids in hands-on activity settings. In some cases, these staff must first go through a training process that is overseen and approved by the educator's manager. The "Sublimation Bubbles" activity, which uses dry ice, might require special staffing considerations.

Are permission and/or training forms required for volunteers or facilitators to handle any particular substances? If so, address these issues well in advance so that volunteers and facilitators have time to complete the documents or training. For example in the *Let's Do Chemistry* kit, we have provided additional information that describes the risks and safety protocols for working with dry ice for the "Sublimation Bubbles" activity. Your institution may choose to require that any facilitator read and sign that information form or go through some other kind of special training.

Engage and communicate with the right people

As mentioned earlier, it's important that you understand the specific considerations for each activity or demonstration included in your event by consulting the activity guides in the L*et's Do Chemistry* kit (or any other programs write-ups you plan to include). This will help you decide where various activities should be physically located and who should facilitate them.

The policies and practices for what is allowable in a given setting will vary by institution and location. It is better to **engage the right people well ahead of time** so that they know you are using vetted protocols and thinking about safety proactively. You don't want to bring these issues up when you are in the last phases of your planning. You know your institution or the facility that will host your event best, but here are some suggestions of people you may want to talk with when planning your event.

- **Safety committee or officer.** Contact them and let them know you'll be doing the event and which activities you are planning to use.
- **Security or public safety staff.** Let them know what is happening in the event from a safety perspective. For example, they may want to know where you are storing the SDS sheets in case there is an emergency in the building. They also can tell you important information about the location of fire extinguishers, eye wash stations, safety showers, etc.
- **Facilities or custodial staff**. Coordinate the disposal of chemicals and other potentially hazardous substances with others involved in planning or cleaning up after your event. These colleagues may have an understanding of what substances are OK/not OK to dispose of down the drain or with solid waste in your location.

Make a physical floor plan

After familiarizing yourself with the specific safety considerations for each activity, a good next step is to make a draft floor plan with various activities well in advance of your event. Here is just one example of what your event setup might look like:

How will you structure your event setup so that people can enter, exit, and move through the space safely? Be sure to think about access to emergency exits, where electrical outlets or cords might be an issue, and how you will ensure accessible pathways and routes for visitors to move around during your event.

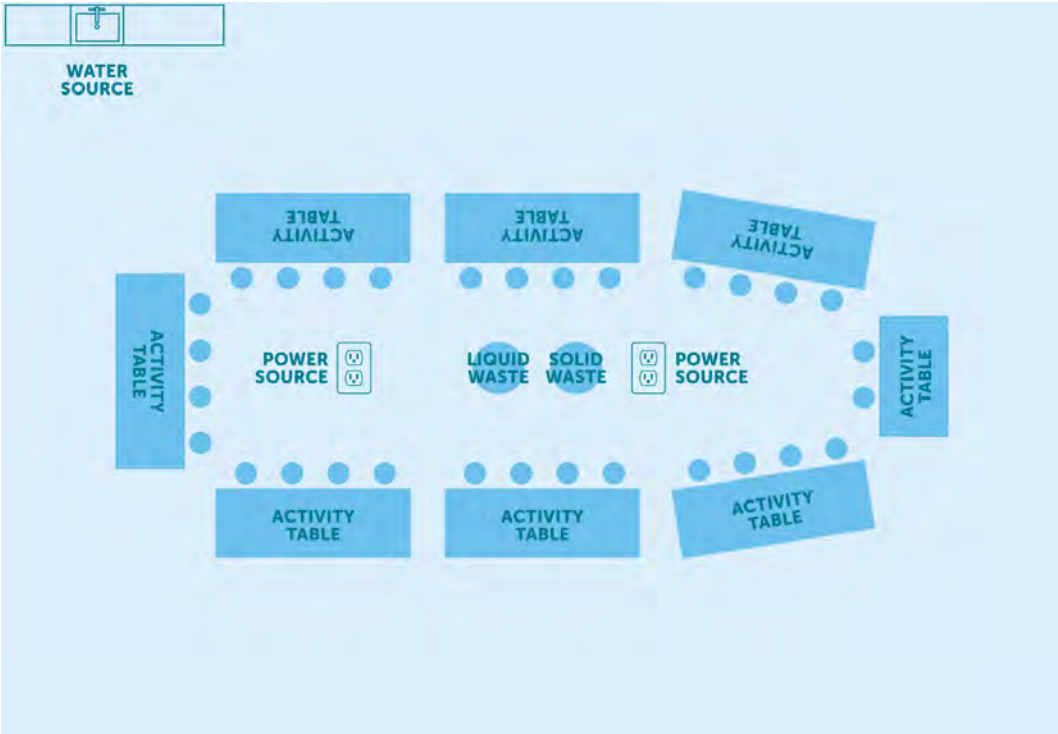
If you are doing large-scale chemistry demonstrations, be sure to establish safe distances from the demonstrator as well as aisles for people to enter and exit during the event. If flame or cryogenic liquids are to be used, a good guideline is to leave 10 feet between the demonstrator and the audience. Also think carefully about how the audience members can access the emergency exits if a large and potentially hazardous demonstration is happening.

Which activities present particular safety considerations? For example, in the *Let's Do Chemistry* kit, the "Sublimation Bubbles" activity uses dry ice, and the "Rocket Reactions" activity requires a lot of

space and coordination. These activities should be located in sections of the event space that are easier to control. “What’s In the Water” and “Sublimation Bubbles” also use larger quantities of water, so you may want to have a convenient water source nearby. If there isn’t a source of water that can easily be accessed, you might consider having a large carboy or jugs of water handy.

Where will liquid and solid waste containers be stored during your event? The primary liquid waste-generating activities are “The Nature of Dye” and “Sublimation Bubbles.” The longer “Cleaning Oil With Chemistry” activity produces large quantities of solid waste. While there are containers provided for liquid waste in the activities, you should think carefully about where you will store solid waste and when you will need to refresh liquid waste containers using sinks that are approved for this purpose.

What locations will be used for liquid and solid waste disposal, and how will people access these locations while the event is happening? You should verify this with the relevant people at your institution or host facility and make sure they recommend the appropriate sink to use.



ADDITIONAL SAFETY TIPS FOR THE *LET'S DO CHEMISTRY* KIT ACTIVITIES

The activities in the *Let's Do Chemistry* kit were specifically selected and designed with safety in mind. Most of the activities in the kit use everyday materials that pose very few safety hazards. However a few of the activities do require extra caution. Event organizers should be as familiar as possible with the activities and safety precautions. We recommend that you go through the entire process of setup, demonstration, and disposal. Organizers should feel comfortable facilitating each activity on their own, so that they are able to adequately train and instruct facilitators and participants. This section provides some additional safety tips for some of the Let's Do Chemistry kit activities. Refer to the activity guides for additional information.

"Rocket Reactions" requires personal protective equipment and a lot of space.

This activity should be carefully monitored. All visitors in the vicinity need to wear eye protection. Ensure that participants can enter and exit the space safely and that everyone can see what is happening as they approach the space.

"Chemistry Makes Scents" includes strong-smelling substances.

Make sure to use the materials in a large, well-ventilated location to prevent the smells from becoming a concern.

"Nature of Dye" uses soda ash (sodium carbonate) and vinegar (dilute acetic acid) solutions that can be mild skin irritants.

If contact with the skin occurs, the affected areas should be rinsed thoroughly with water. If contact with an eye occurs, the eye should be flushed with water for at least five minutes. Consult the Safety Data Sheets for more information.

"Gum and Chocolate" uses foods that can be allergens.

Facilitators or visitors who are allergic should not participate. Participants should be asked if they have any health concerns about ingesting chocolate or gum before starting the activity.

"Cleaning Oil With Chemistry" is quite messy.

Care should be taken when deciding where to do this activity because the oil is slippery and spills can be difficult to clean up. More details are provided in the next section. While none of the activities involve open flame, vegetable oil is highly flammable. Large amounts of liquid vegetable oil must be put into a closed container before being deposited into solid waste, thus preventing it from soaking paper towels or other potential flame hazards as part of the waste stream.

The "Sublimation Bubbles" activity uses dry ice—solid carbon dioxide.

Dry ice sublimates into gas at -78º C, presenting both risks for frostbite and potential asphyxiation if not handled properly. Please make sure that facilitators follow the instructions presented in the activity guides and in this Chemical Safety Guide very carefully.

- **Make a plan for dry ice well ahead of time!** Beyond the information in the activity guides, it is essential that event organizers *plan well ahead of time* how and from whom dry ice will be obtained, where it will be stored, when it will be used, and how it will be disposed of.
- **Get your dry ice from a reputable source such as a local welding supply company, gas company, ice supplier, ice cream shop, or supermarket**. Make the arrangements well in advance. Having the dry ice delivered to your event location can simplify this process. Your purveyor may also be able to advise you on safe storage and transport practices.
- **Obtain dry ice as close to your event start time as possible** (but make arrangements to do so well ahead of time). The dry ice will sublimate away, so for both storage and safety reasons, less storage time is preferable. It sublimates at 10%, and you can lose 5 to 10 pounds to sublimation every 24 hours. Carry it in a well-insulated container, such as an ice chest.
- **Drive with windows open.** If you need to transport the dry ice yourself, the windows of the vehicle used to transport it must be left open to vent away sublimating CO2. This will help prevent asphyxiation by providing access to fresh air.
- **Dry ice pellets are preferable to large blocks of dry ice, both for safety and convenience.** If only blocks are available, then time must be dedicated before the event to break the ice into small chunks that can be used when facilitating the activity. **Do not break the dry ice while facilitating the activity!**
- **Ten pounds of pellets should be sufficient to last through several hours' worth of activities if obtained the day of the event.** However, event conditions (outdoor conditions/high humidity/number of participants you'll serve, etc.) can impact this, so you may want to obtain more. You can ask your purveyor for advice. Don't forget that you also will need dry ice for your facilitator training, so if you are doing your training on a different day you will also need to obtain dry ice for that event or do the dry ice-specific training on the day of the event.
- **Prepare for handling/transporting large containers of dry ice.** Thick gloves and other kinds of protection, such as towels, should always be used when handling any container holding dry ice to prevent frostbite. Loose towels can be used to slow the sublimation of dry ice while it is in a vehicle or a storage location.
- **Never store dry ice in a container that is tightly closed.** Generally, it will come in a loose or vented cardboard or styrofoam box. If lids are tightly closed, pressure builds up as the dry ice sublimates and can cause the container to rupture. Depending on the amount, it can be placed into a large refrigerator-sized cooler or well-insulated space (with a vented lid) until it is time for

your event, but like all chemicals it should not be placed in an appliance or location that is used for food! **Always store dry ice in a location that is not accessible to the public!**

- **Be sure to clearly label the presence of dry ice to others**, *including an appropriate hazard safety label.* It's very important for people to know that the dry ice is there and who they should contact with questions.
- **Do not carry dry ice in a passenger elevator if at all possible.** It is better to avoid being in a small contained space with dry ice. If you must bring it into an elevator, try to ensure that no one else is in the elevator with you.
- **During the event:**
    - Only use dry ice in an open or well-ventilated room or outdoors.
    - It is better to have only small amounts of dry ice (a pound or two) out at a given time. The hot/cold bag included in the activity kit works well for this purpose. You can periodically refresh your activity's supply from a larger supply that is not accessible to the public.
    - Make sure someone is physically with the dry ice at all times. It should never be left by itself in the public zone!
    - Goggles must always be worn by facilitators and participants for the "Sublimation Bubbles" activity. Other tools, such as gloves and tongs, should always be used by facilitators as described in the "Sublimation Bubbles" activity guide.
    - Participants should never, ever touch dry ice with their hands. When facilitating the activity, facilitators should establish a verbal contract with the visitor that they will not touch it.
    - Never, ever put dry ice into a container that can be closed. The small carafes used in the "Sublimation Bubbles" activities do not have tops and this is intentional. Do not allow participants or facilitators to put a top on these containers.

- **Disposal of dry ice after your Explore Science: Let's Do Chemistry event**:
    - The best way to dispose of dry ice to to let it sublimate away in a large, well-vented room that is not accessible to the public.
    - Dry ice should never be disposed of in a container that can be easily closed or poses other kinds of risks. Do not put it into a trash can or in a sink—this could damage the container, crack pipes, or cause other dangerous situations.

- **If contact with skin or eyes occurs, call for help!** If a safety official or caregiver is available, they should be the ones to directly assist the person who is injured. The affected area should immediately be placed under WARM (less than 40º C, or 104º F) running water for 15 minutes or longer to prevent frostbite or other damage. **Do not rub the affected skin area. Do not use hot water or dry heat.** This could cause further tissue damage.

Preventing and dealing with spills

Spills can and will happen during events. Virtually all of the liquid reagents in the *Let's Do Chemistry* kit present low toxicity risk, are small in volume, and can be cleaned up without too much concern. However, spills should be avoided wherever possible because they can be slippery and also disrupt the safe flow of all of the activities. For this reason, it's essential to have a plan in place!

Preventing spills is the best strategy. It's important to be mindful of issues such as the location of liquid reagents on tables. The event organizer should make sure that containers are not placed on the edges of tables and that tables are organized so that the risk of spills is minimized.

Talk to facilitators about spills. Make sure in your orientation that you discuss how spills will be addressed at your event, so facilitators know what will happen if a spill occurs and how to prevent spills during facilitation.

Have a spill clean-up kit ready. All event locations where activities will be carried out should be equipped with a simple spill control kit, which includes paper towels and plastic garbage bags. It is also good practice to have signs and/or stanchions on hand in case larger spills occur, so that traffic can be re-routed safely.

Think ahead of time who to call/notify if a spill occurs. The most common hazard is slippage in a location where there may be a lot of people present. A hard floor without carpet is a particular hazard. You should know ahead of time who can tend to spills immediately after they occur, and who at your institution will complete the job.

If a situation arises, stay calm. People will look to the organizer to follow proper safety protocols so that the rest of the event continues smoothly.

Always wear goggles and gloves when cleaning up spills! It is essential to model and practice safety while spills are being cleaned up so that secondary accidents do not occur.

Communicate to visitors that a spill has occurred. Make sure that you stay in control. It's good to have someone who can stand next to the area and talk to visitors while a spill is being cleaned up.

NOTE: The "Cleaning Oil with Chemistry" activity is messy. The vegetable oil used in this longer activity is slippery and does not mix with water. If you have extra unused polypropylene particulate, it can be used to dab up a spill on the floor or on a table. A substance such as a dilute solution of Murphy's Oil Soap in water or dilute rubbing alcohol can help to deal with the slipperiness.

Disposal and waste considerations

Waste containers are provided for storing liquid waste while certain activities are ongoing. These activities include "The Nature of Dye" and "What's In the Water." Waste containers should always be labeled clearly.

You may periodically need to transfer waste into other containers or pour them down the drain—when safety standards allow this—as they accumulate during your event. Make sure to check with someone from your institution about which sinks should be used, and if there are any specific policies about liquid or solid waste disposal. After your event, the liquid wastes from all of the activities except for "Cleaning Oil With Chemistry" can be poured down the drain with excess water. *Vegetable oil should never be poured down the drain!* The "Cleaning Oil with Chemistry" activity creates large quantities of solid and liquid waste. The liquid oil should be combined with the polypropylene material and disposed of in solid waste. Sinks used for food preparation or food service hand-washing should not be used for chemical waste disposal! Toilets also generally should not be used for chemical waste disposal.

Tablecloths used to protect the activity table can go into solid waste along with the solid waste materials used in the kit activities. Be careful not to spill any substances that remain on the tablecloths.

CHEMISTRY MATERIALS AND SUPPLIES

The *Let's Do Chemistry* physical kit includes enough materials to do each of the activities approximately 100 times. If you plan to use the activities with more than 100 participants, you will need to purchase additional materials and consumables. The activity guides provide specific information about the materials included in each of the activities. We suggest sourcing materials as similar as possible to those found in the original kits.

Ordering and storing replacement materials and supplies

Buying chemicals in bulk. It's not always the best practice to order as much material as possible. Issues include shelf life, degradation during storage, and changes in the safety classification of substances. There are examples of museum educators ordering materials years ago when they were considered environmentally benign, only to have these substances later classified as hazardous, requiring costly disposal. While the *Let's Do Chemistry* activities use materials that are not problematic, it's still a good idea to restrict the amount you're keeping on hand at any time. Chemical storage spaces can become troublesome when abandoned reagents accumulate or if the same substance is ordered many times without coordination, requiring the storage of duplicate containers.

Considerations include:

- How much of the chemical are you really going to use?
- Where will it be stored? Who will oversee the storage?
- Will the substance be used again right away? How much time will elapse before it's used again?
- Who else needs to know about it?

Principles of green chemistry

In addition to potential human health impacts, chemical safety encompasses potential impacts on the environment, including but not limited to issues of toxicity and lifecycle. The American Chemical Society and other professional institutions in the field are encouraging chemists to use the most environmentally friendly options wherever possible. This practice is called "green chemistry," and it deals with issues such as reducing the total quantity of materials used, reducing hazardous wastes, and finding new ways to produce the same product.

As educators, we can apply green chemistry principles while considering issues including:

- How much of a chemical is really required to show a given phenomenon?
- Is a particular demonstration really necessary given the risks?
- What kinds of wastes are created by doing a given activity?

Information on green chemistry practices, including lessons for many educational hands-on activities, can be found in the section below.

WHERE TO LEARN MORE

Chemical safety goes beyond the activities in this kit. The information in this guide is largely intended to help inform safe practices using the *Let's Do Chemistry* kit, but the general principles and practices are applicable to a wide range of chemical education activities. We hope you will use these chemical safety guidelines, and the resources we've provided below, if you and your colleagues elect to do other chemistry activities at your institution. These resources can help you consider whether an activity you come across elsewhere is safe for you to do at your institution, or whether some alternative might be a better choice to teach chemistry concepts to your audiences. If you would like more information on chemical safety and how to apply this to other activities or topics, we recommend the following resources:

Chemical Safety Resources:

- Recorded NISE Network Online Workshop "Be Prepared: Safety Tips and Reminders for Museums Running Public Events, Including National Chemistry Week and Earth and Space Events" http://nisenet.org/catalog/online-workshop-be-prepared-safety-tips-and-reminders-museums-running-public-events
- American Chemical Society (2016 *Safety Guidelines for Chemical Demonstrations.* Division of Chemical Education (2016) online at http://www.divched.org/content/safety-guidelines-chemical-demonstrations
- American Chemical Society (2017). *Safety in Academic Chemistry Laboratories* https://www.acs.org/content/dam/acsorg/about/governance/committees/chemicalsafety/publications/safety-in-academic-chemistry-laboratories-students.pdf
- Flinn Scientific Training Safety Resources, including links to webinars and trainings https://www.flinnsci.com/resources/safety-reference/.
- National Science Teacher Association online resources, including links to online trainings http://www.nsta.org/safety/
- OSHA Globally Harmonized System Quick Card: https://www.osha.gov/Publications/OSHA3491QuickCardPictogram.pdf

Green Chemistry Resources:

- American Chemical Society https://www.acs.org/content/acs/en/greenchemistry/students-educators/online-educational-resources.html
- Beyond Benign https://www.beyondbenign.org/

Museum Safety and Emergency Preparedness Resources:

The following resources can be helpful when developing and implementing a safety and emergency response preparedness plan.

- **American Alliance of Museums (AAM) Resource Library (login required)**

- Disaster Preparedness & Response Resources https://www.aam-us.org/programs/ethics-standards-and-professional-practices/disaster-preparedness-and-emergency-response-plan/
- Facilities and Risk Management Resources standards and documents (disasters, safety, insurances, etc.) https://www.aam-us.org/programs/resource-library/facilities-and-risk-management-resources/

- **American Children's Museum (ACM) Portal (login required)**
  - Safety & Risk Management sample documents and articles (emergencies, cleaning, accident reports, etc.)
  - If your organization is a member of the Association of Children's Museums (ACM), you can contact membership@childrensmuseums.org to get access to the ACM Online Member Resource Library.

- **International Council of Museums (ICOM)**
  - Guidelines for Disaster Preparedness in Museums http://icom.museum/fileadmin/user_upload/pdf/Guidelines/guidelinesdisasters_eng.pdf
  - Handbook on Emergency Procedures http://icom.museum/uploads/tx_hpoindexbdd/ICMS_Handbook_eng.pdf
  - Emergency Response and Disaster Planning Resources http://icom.museum/fileadmin/user_upload/pdf/Statements/20170929_ICOM_DRMC_List_Resources_EN.pdf

- **Department of Homeland Security (DHS)**
  - Ready.gov—Comprehensive website on preparedness planning for businesses including business continuity planning , IT recovery planning, training , hurricane and earthquake response toolkits, etc. https://www.ready.gov/business

- **FEMA**
  - Online Training related to Schools—Emergency planning and incident reports https://emilms.fema.gov/IS362a/index.htm

- **National Park Service**
  - Museum Handbook, Chapter 10 Emergency Planning https://www.nps.gov/museum/publications/MHI/CHAP10A-B.pdf
  - Primer on Disaster Preparedness Management & Response https://www.nps.gov/museum/publications/primer/primintro.html

- **Council of State Archivists Pocket Response Plan™ PReP ™ Templates**
  Designed to be customized for each institution to help staff note necessary information following a disaster
  https://www.statearchivists.org/programs/emergency-preparedness/emergency-preparedness-resources/pocket-response-plantm-prep-tm-english-template/

- **Getty Museum**
  - Building an Emergency Plan: A Guide for Museums and Other Cultural Institutions
    http://www.getty.edu/conservation/publications_resources/pdf_publications/pdf/emergency_plan.pdf