Acutely Toxic Gases (ATGs)

H280 H330 H331 H332 H333

Areas with blue text indicate that information must be provided or modified by researcher prior to the SOP approval.

This SOP is not a substitute for hands-on training.

Print a copy and insert into your laboratory SOP binder.

Department:	Chemistry
Date SOP was written:	Monday, October 24, 2016
Date SOP was approved by PI/lab supervisor:	
Principal Investigator:	Name: R. Sarpong Signature: _____
Internal Lab Safety Coordinator or Lab Manager:	Name: Melissa Hardy/Justin Jurczyk Lab Phone: 406-696-1225/412-728-1952 Office Phone: 510-642-6312
Emergency Contact:	Name: Melissa Hardy/Justin Jurczyk Lab Phone: 406-696-1225/412-728-1952
Location(s) covered by this SOP:	Latimer Hall 831,832,834,836,837,838,839,842,844,847,849

1. Purpose

This SOP covers the precautions and safe handling procedures for the use of Acutely Toxic Gases (ATGs).

For a list of ATGs covered by this SOP and their use(s), see the "List of Chemicals". Procedures described in Section 12 apply to all materials covered in this SOP.

If you have questions concerning the applicability of any recommendation or requirement listed in this procedure, contact the Principal Investigator/Laboratory Supervisor or the campus Chemical Hygiene Officer at ucbcho@berkeley.edu.

2. Acutely Toxic Gases Information

Before working with any Acutely Toxic Gases (ATGs), review the UC-Berkeley EH&S publication ***Toxic Gas Program on the EH&S website***. If you have questions about Toxic Gas Program requirements, contact EH&S at 642-3073.

3. Potential Hazards/Toxicity

Toxic gases are gases that may cause significant acute health effects at low concentrations. Health effects may include severe skin or eye irritation, pulmonary edema, neurotoxicity, or other potentially fatal conditions.

The Globally Harmonized System of Classification and Labeling of Chemicals (GHS) designates ATGs by one or more of the following H codes:

H280 Contains gas under pressure; may explode if heated
H330 Fatal if inhaled
H331 Toxic if inhaled
H332 Harmful if inhaled
H333 May be harmful if inhaled

ATGs may also have other hazardous properties in addition to acute toxicity (e.g. corrositivity, pyrophoricity). Safe use requires assessing all potential hazards.

It is the Principal Investigator's responsibility to ensure activity-specific laboratory procedures and/or processes are taken into account when using this Chemical Class SOP.

Please, review the SDS of any chemical before use (see Section 11 – SDS Location).

4. Engineering Controls

Use the engineering controls listed below unless other lab-specific information is included in the Protocol/Procedure section.

- Work with ATGs must be conducted in a fume hood unless other controls are designated in the lab-specific Protocol/Procedure section. Sash height must be kept low to avoid escaping fumes and provide a physical barrier.
- Indoor storage of all gas cylinders in this program must be in a mechanically ventilated, lockable area. Examples of mechanical ventilated areas include exhausted gas cabinets, fume hoods, and special fire code compliant gas storage rooms.
- All cylinders and gas cabinets must be clearly labeled with content and hazard information.
- All regulators, valves, piping, tubing and fittings must be chemically compatible with the gases being used. Regulators must be compatible with the size and type of gas cylinder being used and rated for full cylinder pressure. Consult your gas supplier for approved regulators, valves, piping, tubing, and fittings.
- Cylinders must be stored upright, with tank valves securely closed and valve protection cap in place, and firmly secured to prevent falling or being knocked over.
- Some ATGs have poor warning properties. If a particular ATG falls into this category and work with this gas will be done routinely or larger quantities will be employed, install a continuous electronic warning sensor with alarm if available. Insure that the fume hood is operating properly and keep the sash as low as possible at all times. A ventilation monitor is required on the hood.

5. Personal Protective Equipment

At a minimum, the following PPE must be worn at all times.

Eye and Face Protection

A. ANSI Z87.1-compliant safety glasses with side shields, or chemical splash goggles.
   - Ordinary prescription glasses will NOT provide adequate protection unless they also meet ANSI standard and have compliant side shields.

B. If the potential for explosion/splashing exists, and adequate coverage is not provided by the hood sash, a face shield must be worn.

Skin and Body Protection

1. Gloves are required when handling hazardous chemicals.
   - Refer to specific chemical SDS for information on glove selection.
   - For additional information on glove selection, go to: http://ehs.berkeley.edu/hs/63-laboratory-safety/94-glove-selection-and-usage.html
2. Lab coats are required when handling hazardous chemicals in the lab. Select the type of lab coat according to the hazards at the specific workplace.
3. Long pants, closed-toe/closed-heel shoes, covered legs, and ankles.

Respiratory Protection

Respiratory protection is normally not required for UC Berkeley laboratory activities. Any lab personnel considering the use of a respirator must contact EH&S for a workplace assessment.

6. First Aid Procedures and Medical Emergencies

In the event of an injury, notify your supervisor immediately and EH&S within 8 hours.

Go to the Occupational Health Facility (Tang Health Center, on campus); if after hours, go to the nearest emergency room (Alta Bates, 2450 Ashby Ave in Berkeley); or

Call 911 (from a cell phone: 510-642-3333) if:

- ***it is a life threatening emergency; or***
- ***you are not confident in your ability to fully assess the conditions of the environment and/or the condition of the contaminated/injured person, or you cannot be assured of your own safety; or***
- ***the contaminated/injured person is not breathing or is unconscious.***

Please remember to provide a copy of the appropriate manufacturer SDS (if available) to the emergency responders or physician. At a minimum, be ready to provide the identity/name of any hazardous materials involved.

In case of skin contact

If skin contact occurs, and/or skin or clothing are on fire, immediately drench in the safety shower with copious amounts of water for no less than 15 minutes to remove any remaining contaminants. If possible to do so without further injury, remove any remaining jewelry or clothing.

In case of eye contact

Rinse thoroughly with plenty of water using an eyewash station for at least 15 minutes, occasionally lifting the upper and lower eyelids. Remove contact lenses if possible.

If inhaled

Move into fresh air.

7. Special Handling, Storage, and Disposal Requirements

Lab-specific information on handling and storage may be included in the Protocol/Procedure section.

Precautions for safe handling

- Do not drag, roll, slide or drop cylinders. A suitable hand truck, to which the cylinder is secured, must be used for cylinder movement.
- When transporting gases outside the lab, the protective cap must be in place and must cover the valve.
- Never attempt to lift a cylinder by its cap.
- Secure cylinders at all times while in use and during transport.
- Once cylinder has been connected to process, open valve slowly and carefully. If experiencing difficulty opening cylinder valve, discontinue use and contact supplier. Do not attempt to force freeing "frozen" or corroded valves.
- Regulators and valves must be kept free of moisture. Systems must be purged with dry inert gas (e.g. helium, nitrogen, argon, etc.) before the product is introduced and when system is out of service.

Conditions for safe storage

- It is essential that all ATGs be stored separately from all chemicals with which they may react. Ensure segregation of incompatible chemicals per guidance within EH&S guidelines. Also, follow any substance-specific storage guidance provided in Safety Data Sheet (SDS) documentation.
- All compressed gas cylinders must be stored upright with valve cover caps in place. Damage to a valve can cause the cylinder to become a dangerous projectile. Cylinders must be properly secured with two non-combustible restraints to prevent them from falling at all times.

Disposal

- All empty gas cylinders must be labeled as empty; however, empty cylinders may still contain some toxic gas, so must remain in exhausted enclosures or fire code compliant gas storage rooms. Depleted gas cylinders must be returnable to the vendor according to their guidelines.

8. Chemical Release

Chemical Release Dial 911

- Accidental Release – Help contaminated or injured persons. If conditions and time permit, close any open valve. Evacuate the release area. Avoid breathing vapors. Eliminate sources of ignition. Keep others from entering this area (e.g., use caution tape, barriers, etc.). *Notify supervisor and EH&S immediately.*
- Contact with body or clothes – Remove clothing and rinse body thoroughly in emergency shower for at least 15 minutes. Seek medical attention. *Notify supervisor and EH&S immediately.*
- Contact with Eyes – Immediately rinse eyeballs and inner surface of eyelid with water for 15 minutes using an eyewash station by forcibly holding the eye open. Seek medical attention. *Notify supervisor and EH&S immediately.*

9. Cleaning and Decontamination

Lab-specific information on decontamination may be included in the Protocol/Procedure section.

All lines or ducts carrying purged or exhausted emissions of gases must be connected to a mechanical exhaust system that discharges to a safe location (i.e., presents no potential for re-entrainment into any building supply air intake or occupied area). Construction of the exhaust ducts must be chemically resistant to degradation by the gas in use. Significant emissions of corrosive or toxic gases require an emission control device (*e.g.*, scrubber, flare device, adsorbent) before the purged gas can be vented into the exhaust duct system. Refer to ***Toxic Gas Program.***

10. Hazardous Waste Disposal

Label Waste

- All empty gas cylinders shall be labeled as empty

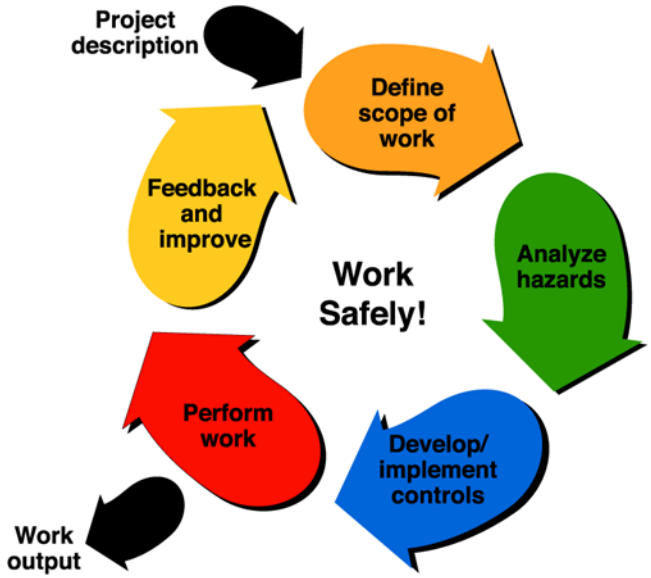
Dispose of Waste

- Depleted gas cylinders should be returnable to the vendor according to their guidelines.
- Contact EH&S at 642-3073 if you need assistance.

11. Safety Data Sheet (SDS) Location

SDS can be accessed online at http://ucsds.com

-Take Ownership of Your Safety-



Before starting any work, ask yourself:

1- What will I be doing?
2- Do I know what the hazards are?
3- Do I have everything I need to do the job safely?
4- Am I doing the job safely?
5- What can we do better?

12. Protocol/Procedure – Acutely Toxic Gases (ATGs)

Section 12 must be customized to your specific needs. Delete any procedure that does not apply to your laboratory.

Procedure/Use	Scale	Engineering Controls/Equipment	PPE (eye, face, gloves, clothing)	Procedure Steps and Precautions
1. Use as a reagent.	**Up to 2 L of condensed acutely toxic gas or less is permitted.** Remember to obtain PI approval if higher scale is necessary.	All reactions using these materials must be performed in a properly operating fume hood with the sash as low as possible. Or in an inert atmosphere glovebox.	**Eye protection**: Wear ANSI Approved tight-fitting safety goggles or safety glasses with side shields. **Face protection**: Face shields are to be used when there is no protection from the hood sash. **Hand protection**: Confirm the compatibility of the gloves you use with the specific ATG. General guidance (unless otherwise specified in the specific SDS): at a minimum, 8 mil minimum nitrile gloves must be used to prevent incidental contact. For gas release or for potential contact with larger quantities, use double nitrile or heavier gauge nitrile or neoprene gloves. Gloves must be inspected prior to use. Remove gloves immediately upon contamination. Wash and dry hands after use. **Clothing**: Wear lab coat; full length pants or equivalent; and close-toed, close-heeled shoes.	Avoid inhalation of these materials. Be sure that the delivery pressure of the ATG is compatible with the reaction apparatus. Use a compatible gas regulator. Insure that the gas being passed through the reactor is properly vented into the fume hood and that any vented gases do not constitute a health threat to coworkers or nearby populations. Extreme care should be taken not to over pressurize glass reactors.
Notes	Any deviation from this SOP requires approval from PI.			

Procedure/Use	Scale	Engineering Controls/Equipment	PPE (eye, face, gloves, clothing)	Procedure Steps and Precautions
2. Connecting gas regulator to an ammonia cylinder.	N/A	Anhydrous ammonia may only be used in a fume hood with a face velocity not less than 100 fpm. Specific uses of ammonia must be approved by EHS following an on-site inspection. The gas cylinder of ammonia if small enough should be placed in a fume hood. If the cylinder is too large for a normal hood consider using a walk-in hood or toxic gas cabinet, with the cylinder anchored with two non-combustible restraints.	**Eye protection**: PERSONS WITH POTENTIAL EXPOSURE TO AMMONIA SHOULD NOT WEAR CONTACT LENSES Tight-fitting safety goggles or safety glasses with side shields. **Face Protection**: Face shields are to be used when there is no protection from the hood sash. **Hand protection**: Confirm the compatibility of the gloves you use with the specific ATG. General guidance (unless otherwise specified in the specific SDS): at a minimum, 8 mil minimum nitrile gloves must be used to prevent incidental contact. For gas release or for potential contact with larger quantities, use double nitrile or heavier gauge nitrile or neoprene gloves. Gloves must be inspected prior to use. Remove gloves immediately upon contamination. Wash and dry hands after use. **Clothing**: Wear (flame resistant) lab coat; full length pants or equivalent; and close-toed and close-heeled shoes.	1. Properly restrain ammonia gas cylinder within gas cabinet or fume hood at all times. 2. Remove gas cap, confirm tank valve is closed, and remove bolt from regulator inlet. 3. Tightly insert appropriate regulator. 4. Open gas cylinder valve once all the appropriate tubing is connected. Set delivery pressure to the desired pressure.
Notes	Any deviation from this SOP requires approval from PI.			

Procedure/Use	Scale	Engineering Controls/Equipment	PPE (eye, face, gloves, clothing)	Procedure Steps and Precautions
3. Dispensing anhydrous ammonia into reaction flask.	Up to 2 L liquid ammonia per reaction. Remember to obtain PI approval if higher scale is necessary.	Anhydrous ammonia may only be used in a fume hood with a face velocity not less than 100 fpm. Specific uses of ammonia must be approved by EHS following an on-site inspection. The gas cylinder of ammonia if small enough should be placed in a fume hood. If the cylinder is too large for a normal hood consider using a walk-in hood or toxic gas cabinet, with the cylinder anchored with two non-combustible restraints.	**Eye protection**: PERSONS WITH POTENTIAL EXPOSURE TO AMMONIA SHOULD NOT WEAR CONTACT LENSES Tight-fitting safety goggles or safety glasses with side shields. **Face Protection**: Face shields are to be used when there is no protection from the hood sash. **Hand protection**: Confirm the compatibility of the gloves you use with the specific ATG. General guidance (unless otherwise specified in the specific SDS): at a minimum, 8 mil minimum nitrile gloves must be used to prevent incidental contact. For gas release or for potential contact with larger quantities, use double nitrile or heavier gauge nitrile or neoprene gloves. Gloves must be inspected prior to use. Remove gloves immediately upon contamination. Wash and dry hands after use. **Clothing**: Wear (flame resistant) lab coat; full length pants or equivalent; and close-toed and close-heeled shoes.	To add ammonia to a reaction flask: 1. Flame dry the flask and fit it with a septum. 2. Pierce the septum with a needle that has been attached to a balloon apparatus, used to provide space for venting ammonia gas. 3. Take this reaction apparatus to the fume hood where the ammonia is kept. Cool the flask down to < -40 °C (- 78 °C is an easier working temperature to keep the ammonia condensed). 4. Affix a long needle to the end of the tubing from the ammonia tank. 5. Pierce the needle into the septum and slowly open the valve on the ammonia tank. This will begin the transfer of ammonia to the reaction flask; ammonia will condense into the reaction flask. 6. Upon completion, close the regulator valve and the cylinder's valve, and remove the needle from the reaction flask. Vent the regulator before removing it. Re-attach the cylinder's cap and allow the components to vent in the fume hood for at least 10 minutes 7. Take the cooled reaction flask back to your hood to add the substrate 8. Ensure that a low temperature < -40 °C is maintained throughout the procedure.
Notes	Any deviation from this SOP requires approval from PI.			

Procedure/Use	Scale	Engineering Controls/Equipment	PPE (eye, face, gloves, clothing)	Procedure Steps and Precautions
4. H_2S is used in the lab as a reagent in chemical reactions.	**Up to 1 L liquid H_2S per reaction is permitted.** Remember to obtain PI approval if higher scale is necessary.	H_2S is a corrosive gas and will corrode carbon steel to the point of becoming brittle and weak. Avoid using carbon steel in the H_2S feed line. Additionally, be aware of the formation of rust on the metal surface as it could indicate the formation of iron sulfide scale, a pyrophoric material. The gas regulator must fit properly to the cylinder. All work using H_2S must be performed in a well-ventilated fume hood. Lower sash as much as possible to prevent escape of fumes. Eliminate ignition sources such as open flames, hot surfaces, steam baths, static electricity, and operation of mechanical and electrical equipment that is not intrinsically safe.	**Eye protection**: Wear ANSI Approved tight-fitting safety goggles or safety glasses with side shields. **Face Protection**: Wear a face shield when connecting H_2S gas lines or when the hood sash does not provide adequate protection. **Hand protection**: Confirm the compatibility of the gloves you use with the specific ATG. General guidance (unless otherwise specified in the specific SDS): at a minimum, 8 mil minimum nitrile gloves must be used to prevent incidental contact. For gas release or for potential contact with larger quantities, use double nitrile or heavier gauge nitrile or neoprene gloves. Gloves must be inspected prior to use. Remove gloves immediately upon contamination. Wash and dry hands after use. **Clothing**: Wear (flame resistant) lab coat; full length pants or equivalent; and close-toed and close-heeled shoes.	If the regulator has been used for other chemicals ensure it purged well with air/N_2 before use with H_2S. 1. Attach appropriate gas regulator to the cylinder. 2. Ensure all seals in H_2S line are properly sealed. Ensure the cylinder is upright and properly secured. 3. Connect sample chamber to H_2S line. The tubing from the regulator may be attached to a Schlenk line (**but not bubbled through Hg bubbler**), or to needle into a reaction mixture. 4. The outlet line must be bubbled through a chlorine bleach solution before the gas is vented to the fume hood. (The bleach solution will oxidize the H_2S to a sulfate or sulfonic acid). This method also works well for materials that do not have a free S-H group, such as organic sulfides, which are oxidized to sulfones.) 5. Open regulator valve and adjust flow valve to desired rates. Use only low flow rates and the minimum amount of gas required. Check for bubbling in the quenching flask 6. After the experiment, shut the primary cylinder valve on the H_2S cylinder. 7. Close regulator flow valve. 8. Upon completion, the regulator is removed from the cylinder and air/N_2 is passed through the regulator and tubing to remove any residual H_2S.

				Neutralize wastes which are then safe to dispose of in regular waste. Properly dispose and clearly label all waste that can be contaminated with the chemical. Leave contaminated equipment in the hood to ventilate and remove H_2S before removing waste or reaction vessel.
Notes	Any deviation from this SOP requires approval from PI.			

13 - Documentation of Training (signature of all users is required)

- Prior to conducting any work with ATGs, designated personnel must provide training to his/her laboratory personnel specific to the hazards involved in working with this substance, work area decontamination, and emergency procedures.
- The Principal Investigator must provide his/her laboratory personnel with a copy of this SOP and a copy of the relevant SDSs provided by the manufacturer.

I have read and understand the content of this SOP:

Name	Signature	Identifier	Date

Appendix – List of Acutely Toxic Gases (non-exhaustive list)

Chemical Name/Formula	CAS#	Chemical Name/Formula	CAS#
Ammonia NH_3	7664-41-7	Arsenic pentafluoride AsF_5	7784-36-3
Arsine AsH_3	7784-42-1	Boron trichloride BCl_3	10294-34-5
Boron trifluoride BF_3	7637-07-2	Carbon monoxide CO	630-08-0
Cyanogen C_2N_2	460-19-5	Cyanogen chloride NCCl	506-77-4
Chlorine Cl_2	7782-50-5	Diazomethane H_2CN_2	334-88-3
Diborane B_2H_6	19287-45-7	Fluorine F_2	7782-41-4
Germane GeH_4	7782-65-2	Hexaethyltetraphosphate $C_{12}H_{30}O_{13}P_4$	757-58-4
Hydrogen bromide HBr	10035-10-6	Hydrogen Chloride HCl	7647-01-0
Hydrogen fluoride HF	7664-39-3	Hydrogen sulfide H_2S	7783-06-4
Hydrogen selenide H_2Se	7783-07-5	Methyl mercaptan CH_3SH	74-93-1
Nitric oxide NO	10102-43-9	Nitrogen dioxide NO_2	10102-44-0
Nitrogen tetroxide N_2O_4	10544-72-6	Oxygen difluoride OF_2	7783-41-7
Phosgene $COCl_2$	75-44-5	Phosphine PH_3	75-45-5
Phosphorous pentafluoride PF_5	7641-19-0	Selenium hexafluoride SeF_6	7783-79-1
Stibine SbH_3	7803-52-3	Sulfur tetrafluoride SF_4	7783-60-0
Trimethylsilyldiazomethane $(CH_3)_3SiCHN_2$	18107-18-1		

List of Chemicals

Chemical(s)	Chemical(s)	Chemical(s)
ammonia	hydrogen chloride	carbon monoxide
boron trichloride		