

- **Cryogenic** liquids are defined as having a boiling point that is below  $-73\text{ }^{\circ}\text{C}$ . These liquids and their vapors are usually unreactive, colorless and odorless. They're usually used in laboratories to produce extremely low temperatures (below  $-153^{\circ}\text{C}$ ), such as liquid nitrogen (b.p.:  $-196\text{ }^{\circ}\text{C}$ ). Although dry ice or carbon dioxide is solid and therefore is not considered as a cryogenic liquid, it is immediately sublimated (at  $-78^{\circ}\text{C}$ ) to carbon dioxide gas. Dry ice is prevalently used to shuttle samples, grind materials and perform experimental procedures with. Therefore, dry ice, as well as liquid nitrogen, pose a potential laboratory risk.
- When working with cryogenics one should always protect one's hands in order not to touch frozen surfaces and avoid a frost bite. Cryogenic gloves are recommended. Never touch liquid nitrogen or dry ice with your bare hands. Use gloves which can be easily removed. Do not wear nitrile gloves when handling cryogenic liquids as they will freeze unto your skin immediately upon contact.
  - Never touch materials, metals especially, which have been exposed to cryogenic liquids. Handle them with forceps, tweezers or tongs, preferably waiting until they have reached room temperature before handling them. Dry ice, for example, should only be handled using forceps. Never use a heat gun or other methods to thaw liquids or metals that have been cooled down using cryogenic liquids. Large temperature differences might lead to cracking or metal fatigue.
  - In case a glass vessel should be cooled down, dip the vessel slowly and gradually inside the cooling bath. Never insert a warm or a hot container into a cryogenic liquid alas spontaneous boiling and splashing of the cooling liquid will occur.
  - Eyes must also be protected when working with cryogenics to avoid splashing. Cryogenic liquids boil rapidly when exposed to materials at room temperature.
  - Dewars are the only vessels to be used for storing and transferring cryogenic liquids. Make sure they are properly clamped. Do not place Dewars on the floor. Dewars are vacuum sealed and can implode when damaged.
  - In case a large volume of a cryogenic liquid should be dispensed from a low-pressure liquid nitrogen tank – use a wide-necked bottle and a cryogenic apron and a full-face shield to prevent splashes.
  - Always work in well-ventilated areas or in the fume hood to avoid asphyxiation (nitrogen gas expands by a factor of 696). Asphyxiation can only occur when the oxygen content in the laboratory drops below 19.5%. Small and medium spills do not pose significant asphyxiation hazards. In case of a large spill evacuate the premises. When possible close the valve of the liquid nitrogen container and open windows and doors to properly ventilate area. Only return when the oxygen content in the air has risen above 19.5%.
  - Dry ice dissipates into the laboratory atmosphere, reaching a non-favorable concentration, therefore dry ice, which is not in use, should be stored outside the lab in a well-ventilated area.

- Vacuum traps, which have been cooled down by liquid nitrogen, should never be exposed to the atmosphere, even for short time intervals, as the latter can cause liquid oxygen to condense in the trap.
- In case liquid nitrogen is the coolant of the vacuum trap, make sure the pump is open and the Schlenk line is under active vacuum prior to commencing cooling. When using a Schlenk line – always make sure that the set-up does not leak and that it can hold a good static vacuum.
- When freezing a solution in a Schlenk-flask or performing freeze-pump-thaw cycles, never leave the flask open to the inert atmosphere. always evacuate the flask to assure no gasses have been condensed into it prior to closing the flask.
- If argon must be used as the inert atmosphere gas in a Schlenk line, always fill the vacuum trap with dry-ice/iso-propanol prior to cooling them with liquid nitrogen.
- When working with a Dewar inside a vacuum trap, be alert for any hints of residual blue liquids (oxygen) inside the vacuum trap. If a blue liquid is observed, then liquid nitrogen / argon / oxygen have condensed into the trap, posing a highly dangerous situation. In this case return Dewar to its original position. Make sure the vacuum traps are cooled all the while using liquid nitrogen. Then, isolate Dewar from the (inert) atmosphere or from the leak to avoid additional condensation of gasses into the trap. Keep the vacuum pump ON. When working inside a fume hood - close the sash of the hood` when working outside the hood, put a blast screen around the Dewar containing the vacuum trap.