STANDARD OPERATING PROCEDURE:

Handling dry ice (solid carbon dioxide)

Note: To be undertaken only by trained personnel in conjunction with a current Safety Data Sheet (SDS) and site-specific risk assessment.

---

1. Introduction

Dry ice is solid carbon dioxide (CO_2). Under normal classroom conditions dry ice changes directly from the solid to carbon dioxide gas, without going through the liquid phase. The phase change of a solid transforming directly into a gas, without passing through the liquid phase, is called sublimation. The properties of dry ice and carbon dioxide form the basis for many interesting classroom demonstrations such as the process of sublimation, cryogenics, fog effects and extinguishing a flame.

2. Context

- These instructions are for the use of experienced science teachers and technicians only.
- The use of dry ice is for demonstration purposes only.

3. Safety Notes

- The sublimation temperature of dry ice is -78.5°C. Contact of dry ice with the skin may result in frostbite or cold burns.
- Dry ice must be used and stored in a well-ventilated area. A concentration of carbon dioxide in air of greater than 1.5% can cause headache, nausea and vomiting and may lead to unconsciousness.
- Dry ice should be stored in an insulated and secure container, which has a loose-fitting lid (e.g. a foam cooler box). Containers should be vented periodically to avoid the build-up of gas. Dry ice must not be stored in a sealed container as the build-up of pressure from sublimation could cause the container to rupture or explode.
- Dry ice may be stored in a running fume cupboard if ventilation is otherwise inadequate.
- Protect eyes, face and skin from contact with dry ice. Safety glasses, thermally insulated gloves, a lab coat and closed shoes should be worn and tongs should be used to pick up pieces of dry ice.
- Carbon dioxide is more dense than air and may accumulate in low, confined spaces with poor ventilation.
- Dry ice is not classified into any hazard class in the GHS. However, the Safe Work Australia *Labelling of Hazardous Chemicals* Code of Practice recommends that containers be labelled with the quantity of dry ice contained and information regarding the asphyxiation hazard and safe handling to avoid cold burns. See the Code of Practice for examples of labels for containers of dry ice.

- Transport in a private vehicle should be avoided; where possible, delivery of dry ice should be arranged with the supplier. If the dry ice is to be transported in a private vehicle, only small amounts (up to 5kg) at a time should be purchased. The dry ice should be collected in an insulated container with a loose-fitting lid and the container securely placed in a compartment of the vehicle, which is segregated from the driver's compartment. Good ventilation to the driver's compartment must be ensured in case of leakage of carbon dioxide gas into the driver's compartment.

4. Regulations, Licences and Permits

Not applicable

5. Equipment

- Insulated storage container, such as a foam cooler box
- Tongs
- PPE: safety glasses, thermally insulated gloves, lab coat or overalls, closed shoes
- Safety screen for use in class demonstrations

6. Operating Procedure

1. Wear PPE and work in a well-ventilated area.
2. Avoid cold burns by wearing gloves and using tongs to pick up pieces of dry ice.

7. Trouble shooting/Emergencies

- First Aid: See latest SDS for more detailed information
    - In case of frostbite or cold burns, flush skin with warm (30°C) water for 15 minutes. Apply a sterile dressing. Seek medical attention. Do not apply hot water or radiant heat.
    - In case of contact with the eye, irrigate eye with tepid water for 15 minutes. Seek medical attention immediately.
    - In case of inhalation, remove patient to well-ventilated area. Apply artificial respiration if not breathing. Seek medical attention.
    - For further advice contact the Poisons Information Centre on 131126.

8. Waste Disposal

- Unused dry ice may be allowed to sublime in a well-ventilated area.

9. Related Material

- SDS
- Risk Assessment.

References:

Safe Work Australia. 2011. 'Model Code of Practice Labelling of Hazardous Chemicals' http://www.safeworkaustralia.gov.au/sites/swa/about/publications/pages/labelling-hazardous-chemicals-cop (Accessed April 2014)

Air Liquide Australia Limited, Material Safety Data Sheet AL066: Carbon dioxide, solid (CO_2), Dry Ice, Revised edition number 7, MSDS date 8 November 2012. http://docs.airliquide.com.au/msdsau/AL066.pdf

Risk Management Technologies, Perth, WA, BOC Limited (Australia) Safety Data Sheet #033: Solid Carbon dioxide, Revision 2, SDS date 8 January 2014 http://msds.chemalert.com/?id=21&file=0008513_001_001.pdf

Information on the properties and uses of dry ice: http://science.howstuffworks.com/innovation/science-questions/question264.htm

Date	Version Number	Notes
April 2014	Version 1.0	
Jan 2016	Version 2.0	Activities added

Activities with dry ice (solid carbon dioxide)

These activities are for the use of experienced science teachers and technicians as demonstrations only, and involve the processes of sublimation, cryogenics, fog effects and extinguishing a flame. Activities involving a sealed system such as the balloon and the popping film canister should not be carried out. All run the risk of exploding and showering students with dry ice and other shrapnel. None of the activities should be brought close to the face or ears.

Some activities that involve the ***sublimation*** process are:

Awesome bubbles

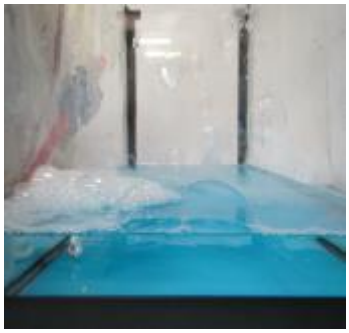
You will need:

- gloves/tongs
- glass measuring cylinder
- liquid detergent
- food colouring optional
- dry ice

Method

1. Fill a 250 mL glass measuring cylinder with 150 mL warm water.
2. Add a squirt of dishwashing liquid to the water followed by a few drops of food colouring.
3. Place 2–3 pieces of dry ice into the soapy water and watch as the bubbles climb out of the cylinder with a burst of ‘smoke.
4. For an eerie glow, add a glow stick into the water along with the dry ice.

Floating bubbles



You will need:

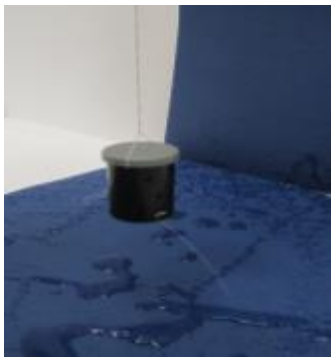
- gloves/tongs
- aquarium
- bubbles solution and wand
- dry ice

Method:

1. Fill the bottom of a fish aquarium (60 L) with 4 litres of warm water.
2. Add 2–3 pieces of dry ice.
3. Blow a few bubbles into the aquarium, using a bubble wand and bubbles solution.

Bubbles will appear to float in mid-air on a cushion of invisible carbon dioxide gas.

Hero's engine or film canister engine



You will need:

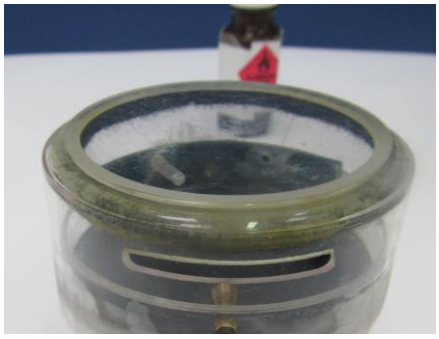
- gloves/tongs
- film canister
- tape
- cotton string
- paper towel, dry ice
- scissors

Method:

1. Pierce two holes on the opposite sides of a film canister near the bottom
2. Tie a loop in a piece of string and tape to the inside of the cap of the canister. You should be able to suspend the canister from the string.
3. Add 1 piece of dry ice and 5 mL of warm water to the canister and hold it in the air over some paper towels or absorbent pads.
4. Lift the canister by the thread and watch the sprinkler effect.

Cloud chamber

1. The diffusion cloud chamber can be used to observe Alpha or Beta particles in the presence of dry ice.
2. If a commercial cloud chamber is not available, a simple one can easily be made in the lab.
3. Firstly, cover the base of a 200–250 g glass jar and one third of the sides with black felt.
4. Cut out a piece of cardboard larger than the top of the dish.
5. Soak the felt in isopropyl alcohol until it is saturated and drain off any excess alcohol.
6. Place the cardboard on the glass container and rub the top with your hand.
7. Place the container on some dry ice.
8. Shine a flashlight through the side of the container and observe the vapour trails.



The alcohol absorbed by the felt is at room temperature and is slowly evaporating into the air but as the evaporated alcohol sinks toward the dry ice, it cools down and wants to turn back into a liquid.

At the end of this activity, place the glass container in the fume cupboard with the fan on. This will allow the isopropyl alcohol from the felt to evaporate over time.

Singing spoon

You will need:

- gloves
- spoon
- dry ice

Method

1. Hold a warm spoon on a piece of dry ice and listen to the spoon screaming loudly as the dry ice absorbs the heat from the spoon and sublimates.

The gas pressure pushes the spoon away from the dry ice and ceases sublimation. The spoon then comes back into contact with the dry ice and the cycle starts again.

This whole process is so quick that it results in the vibration of the spoon molecules and thus the singing/screaming sound.

Bubbling and smoking water

This activity involves **sublimation, fog effect** and can also be used to demonstrate the **flame extinguishing** process.

You will need:

- gloves/tongs
- beaker
- dry ice
- warm water

Method

1. Place some dry ice in a beaker of warm water. Immediately, the dry ice will start to sublimate and a cool white cloud is formed which is perfectly safe.
2. When the “smoking” starts to slow down, replace the cold water with some warm water.
3. For fog effect use boiling water, clouds of white fogs are created which consist of condensed water vapour mixed in the invisible carbon dioxide gas.
4. The fog can be used to extinguish a lit match or candle.

Candles experiment

This activity involves **sublimation, fog effect** and can also be used to demonstrate the **flame extinguishing** process.

You will need:

- gloves/tongs
- beaker
- candles
- dry ice
- warm water

Method

1. Place some dry ice in a beaker of warm water and allow the dry ice to sublimate into a white cloud.
2. Secure 3 different lengths of candles into a large beaker or container and light them.
3. Slowly pour the white smoke/fog down the side of the beaker and watch the candles extinguish one-by-one from the bottom to the top.

Making a big ice bubble

This activity involves **sublimation, fog effect** processes.

You will need:

- gloves/tongs
- bowl
- water
- detergent
- dry ice

Method

1. Place 5–10 pieces of dry ice into a bowl, which has a lip around the top.
2. Add 250 mL of warm water to the dry ice.
3. Soak a piece of cloth in some dishwashing detergent and run it around the lip of the bowl before dragging it across the top of the bowl to form a bubble layer over the dry ice.

The carbon dioxide vapour is trapped under the soapy layer and forms a big bubble.

The bubble will grow bigger until the pressure becomes too much and it will explode, spilling fog over the edge of the bowl.

Dry ice bubbles

This activity involves **sublimation, fog effect** processes.

You will need:

- gloves/tongs
- 1L or 2L Büchner flask (or vacuum pressure flask)
- rubber stopper
- Morning Fresh Original® detergent
- glycerine
- rubber tubing
- dry ice
- plastic funnel or plastic cup with a hole in the end to allow the tubing to fit through

Method

1. Prepare a bubble solution by mixing 70 mL of water, 30 mL of detergent (Morning Fresh Original®) and 10 mL of glycerine. Stir the mixture slowly and thoroughly. Allow the bubble mix to sit for at least 1–2 hours.
2. Firmly attach the rubber tubing to the side arm of a 1L or 2L Büchner flask or vacuum pressure flask.

3. Connect the other end of the rubber tubing to a funnel, or slide it into a hole in a small cup.
4. Place 100–200 mL of warm water into the flask.
5. Place 2–3 pieces of dry ice into the flask.
6. Dip the free end of the rubber tubing into the bubble solution to wet the end of the tube.
7. Remove the tubing from the bubble solution with one hand and then place the rubber stopper into the neck of the flask with the other hand. The aim is to blow a bubble filled with fog due to the production of carbon dioxide gas and the build-up of pressure.

8. When the bubble reaches the desired size, gently shake it off of the tubing.

The bubbles formed are quite long-lived. Students enjoy taking part in this activity.

For more information and instructions for how to make your own ‘Boo Bubbles generator’, see http://www.stevespanglerscience.com/lab/experiments/boo-bubbles-dry-ice-science/

Acid properties of dry ice in water

You will need:

- gloves/tongs
- glass measuring cylinder
- water
- universal indicator
- dry ice

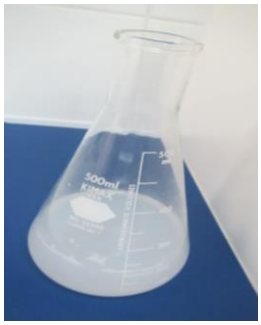
Method

1. Half fill a 100mL glass-measuring cylinder with warm water.
2. Add 20 drops of universal indicator followed by 1 piece of dry ice.

The initial green colour changes to yellow and finally to orange-red as the water becomes more acidic.

Carbon dioxide being an acidic oxide dissolves in water to give carbonic acid.

Making calcium carbonate (acidic properties of carbon dioxide)



You will need:

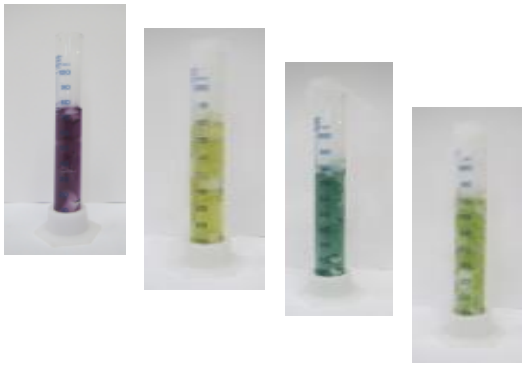
- gloves/tongs
- conical flask
- hotplate
- lime water
- dry ice

Method

1. Pour 200 mL of clear limewater into a 500 mL conical flask followed by 5 pieces of dry ice.

A white precipitate of calcium carbonate is formed which eventually dissolves to give a clear solution. The clear solution can be heated on a hotplate and stirred to once again generate the white precipitate. The resulting mixture can be filtered to obtain the solid calcium carbonate.

Neutralisation reaction



You will need:

- gloves/tongs
- glass measuring cylinder
- water
- universal indicator
- 0.1 M sodium hydroxide
- sodium bicarbonate
- dry ice

Method

1. Half fill a 100 mL glass measuring cylinder with warm water and add 20 drops of universal indicator.
2. Then add 0.1 M sodium hydroxide drop wise to the measuring cylinder until a purple colour is obtained.
3. Shake the measuring cylinder gently to get a uniform purple colour.
4. Add 3 pieces of dry ice to the measuring cylinder. The solution colour will change from purple to blue through to green and finally to a yellowish orange.
5. Once the bubbling stops, gradually add sodium bicarbonate into the measuring cylinder until a green neutral colour is obtained.
6. The resulting solution is then safe to pour down the sink.

Super freeze

This activity involves the **cryogenics** process.

You will need:

- gloves/tongs
- beaker
- methylated spirit
- flower
- dry ice

Method

1. Place 12–15 pieces of dry ice in a 500 mL beaker.
2. Then slowly pour 150mL of methylated spirit over the dry ice. The methylated spirit will turn into a viscous super cooling (cryo) liquid when all the dry ice is used up, fog has cleared and dry ice barely bubbling.

The super cooling liquid can be as cold as -72 ^{0}C. Flowers and green leaves will freeze in just a few minutes.

3. Using tongs, hold the flower in the super cooling liquid for approximately 1–2 minutes. The flower will become brittle and can be snapped apart.
4. At the end of this activity, place the beaker containing the cryo fluid in the fume cupboard with the fan on. This will allow the methylated spirit to evaporate over time.
5. Once the solution has reached room temperature, it can be discarded down the sink whilst running cold water to dilute it further.

Waste disposal

Allow any unused dry ice to sublime in a well-ventilated area.

References

'Awesome dry ice experiments', Steve Spangler Science website http://www.stevespanglerscience.com/lab/experiments/awesome-dry-ice-experiments (Accessed December 2015)

'Dry ice fog and special effects', dryiceInfo.com website, http://www.dryiceinfo.com/fog.htm (Accessed December 2015)

'Experimenting with Dry Ice', Brian Wesley Rich's science website, http://http://www.west.net/~science/co2.htm (Accessed December 2015)

All images courtesy of P Hosany and V Ward.