Dry Ice!

Brief description

This is a WOW lesson your students will never forget! The demonstrations provided are safe, fun, amazing, thought provoking and loud. Use them to discuss the states of matter, evaporation, condensation, temperature and heat. Allow sufficient time to complete all the demonstrations and don't be surprised if you're asked to repeat them over and over again.

Duration:	40 – 70 minutes
Year Level:	Lower to upper primary
Location:	Classroom
Topics:	Three states of matter (solid, liquid, gas), melting, freezing, evaporation, condensation, sublimation, temperature, heat
Preparation:	15 minutes (once dry ice is acquired)
Extensions:	SCIENCE – Research how living things rely on carbon dioxide, study the greenhouse effect, research carbon dating

Overview

Whole class	Introduction	(10 – 15 min)
Small groups*	Observe dry ice	(10 – 15 min)
Whole class	Teacher demonstrations and discussion	(20 – 40 min)

** you may prefer to perform all the demonstrations in a whole class session*

Materials and equipment

Notes for purchasing dry ice:

- Purchase your dry ice the afternoon before, or if possible on the morning of the day you plan to use it
- Store dry ice in an esky and wrap the esky in several towels to slow the evaporation rate
- About $10 to $15 worth of dry ice is sufficient to perform all of the demonstrations described in this lesson plan (provided it is stored appropriately to avoid evaporation losses – check with your dry ice supplier if you are unsure how to store)
- Look under Ice Supplies in the Yellow Pages for ice suppliers who sell dry ice
- Some industrial gas suppliers (listed under Gas–Industrial &/or Medical) may also carry dry ice in your area
- Call in advance to ensure your supplier has dry ice in stock!

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Materials for optional small group activity:

clear plastic drinking cup water

Optional - if you plan to use the Bubble Volcano as a small group activity:

plastic plate detergent

Materials for teacher demonstrations:

Total Qty	Description
1	clear glass
1	set of food colours
3	shallow plastic plates or similar
1	dark plate or black cardboard
1	small aquarium or clear plastic tub (if available)*
1	small bubble blower and bubble solution
1	empty tin with airtight plastic lid**
1	empty soft drink bottle
5	small balloons (20 – 25 cm)
1	roll of twist tie gardening wire
1	funnel (use top of a soft drink bottle if unavailable)
1	jug of water
1	pair of safety gloves (leather gardening gloves are fine)
1	pair of safety glasses (borrow from groundsman if necessary)

*alternatively - use a large coffee plunger flask or soft drink bottle with top removed

** some coffee and baby formula, and most drinking chocolate tins are perfect – your students may be able to bring these to school

Preparation

Materials for teacher to collect:

- Dry Ice (see above for purchasing and storage advice)
- Materials for small group activities and teacher demonstrations
- Practice the demonstrations before performing them in class

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Objectives

The objectives below are a guide only. You should check the outcomes statement for the year level of your class before deciding which of the following objectives are appropriate. Assessment could include testing of comprehension in written and illustrated form and recall of facts presented during the lesson.

Students' prior knowledge

Students are familiar with their group work job responsibilities. No prior knowledge of scientific concepts is assumed for this lesson.

Science concepts

Students will observe that:

- dry ice changes directly from solid to gas – a process called sublimation (ie dry ice sublimes)
- 'normal' ice (ie made from water) changes from solid to liquid – a process called melting – before evaporating into gas
- dry ice sublimes more rapidly when submerged in water
- the bubbles of carbon dioxide formed under water by dry ice are filled with a white cloud – this cloud is made of condensed water
- air filled soap bubbles float on carbon dioxide – this is because carbon dioxide is more dense than air
- the gas formed by dry ice expands as it heats up causing pressure to build up inside a sealed container – the pressure is enough to cause the lid to pop off
- the carbon dioxide gas formed by dry ice expands causing a balloon to inflate until the balloon bursts

Students will learn that:

- dry ice is frozen carbon dioxide (CO_2)
- normal ice is frozen water (H_2O) – solid water melts (freezes) at 0^0C
- carbon dioxide is a gas at room temperature – solid carbon dioxide becomes gas (sublimes) at -78^0C
- dry ice is too cold to touch with bare hands – it will cause freeze burns to skin
- air contains nitrogen, oxygen and carbon dioxide

Positive attitudes

Students will:

- work cooperatively in small groups
- ensure each member has an opportunity to see and understand the activities
- handle equipment and materials carefully and responsibly
- use materials sparingly and dispose of waste responsibly

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Procedure

Dry ice demonstrations are very likely to create an atmosphere of excitement and lively discussion which can be misinterpreted as disruptive behaviour. It is worthwhile allowing a few moments between demonstrations for your students to revel in the enjoyment of this lesson! Decide in advance whether you wish to allow students to observe dry ice in small groups.

Introduction (Whole class / 10 – 15 min):

- Show the class some pellets of dry ice, discuss its appearance and ask whether anyone has heard of or seen it before
- Discuss the properties of dry ice – its temperature (-78^{0}C) and its composition (CO_2) and compare these to water
- Ask students to predict what will happen if you dropped a few pellets into a glass of water – perform the demonstration (Demo 1) and discuss
- Distribute and discuss worksheets (if averaging has not yet been covered, discuss how the average of the tests will be calculated)
- Allocate group work jobs and badges (if using group work model)
- Prepare the room for experiments and test flights

Optional small group activities (10 – 15 min):

- All group members understand that only the teacher, or a person wearing gloves may handle the dry ice pellets
- All group members should have the opportunity to see the dry ice up close
- Once a group is ready, place a few pellets of dry ice on their plate – once they have had enough time to look at it, use the tongs to transfer the pellets into the plastic cup
- Once the pellets have completely sublimed, add a few drops of detergent to the groups water – when mixed, add a few more pellets of dry ice and observe the results

Teacher demonstrations (Whole class / 20 – 40 min)

- Perform some or all of the remaining dry ice demonstrations and discuss each one
- Discuss the hazards of dry ice and the safety precautions you have taken to avoid accidents for each demonstration

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Teacher notes

Simple safety precautions

Dry ice is relatively safe and the safety precautions are easy to implement. It is very important however, to consider the individual circumstances of your students and classroom environment when assessing the hazards and risks in your planning. You should discuss any concerns with your principal and/or science coordinator, or a high school science teacher. Your dry ice supplier will also be able to discuss the hazards of dry ice and the simple safety precautions you can take.

It is highly recommended that you practice the demonstrations before performing them for your class so that you know what to expect and how to handle spills and accidents.

During the demonstrations, have the students sitting on the floor at least two metres from the desk on which you are working. Wear safety gloves and glasses during all of the demonstrations.

The main hazards and according safety precautions for using dry ice are:

HAZARD 1: Extremely low temperature (–78^{0}C) can cause freeze burns
SAFETY PRECAUTION: Wear gloves when handling dry ice or use tongs or spoon
NOTE: When performing demonstrations, wear gloves even when you are using tongs

HAZARD 2: Expansion of carbon dioxide gas produced can generate high pressures in sealed airtight containers
SAFETY PRECAUTION: Store dry ice in non-airtight containers. Never store in airtight containers with screw caps.
NOTE: Storing dry ice in a standard esky with the lid on is safe as the carbon dioxide can leak out through small gaps between the lid and esky

HAZARD 3: Carbon dioxide gas produced is an asphyxiant in high concentrations
SAFETY PRECAUTION: Use in large, well ventilated areas. This hazard is negligible in the small quantities required for the demonstrations provided.

Evaporation and sublimation

Dry ice is so called because it does not melt into liquid carbon dioxide before turning into gas. The process of a liquid changing state into gas is called evaporation. When a solid changes directly into gas, the process is called sublimation (the solid sublimes). Carbon dioxide be liquefied under higher than atmospheric pressures, but the concentration of the gas in air prevents the liquid from forming naturally on Earth.

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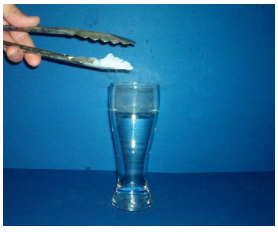
Demonstrations & Activities

The order in which the demonstrations are presented below is a suggestion only and can be changed to suit your planning. Demonstrations 1 and 3 can be safely performed in small groups

Demo 1: Dry Ice in water *(&/or Small Group Activity 1)*

This demonstration is a great attention grabber and a spectacular way to begin the lesson. While it is safe to carefully drink some of the water while the dry ice is present, it is recommended that you do not do so in order to demonstrate appropriate safety precautions. It is also recommended that you wear appropriate gloves (eg leather gardening gloves) even when handling dry ice with tongs.



1. Add dry ice to a glass of water

   SMALL GROUP NOTE: When using this demonstration as a small group activity, you should add the dry ice once the group has filled their plastic cups with water

2. The dry ice will sublime rapidly and produce fog filled bubbles

   Each bubble is filled with very cold carbon dioxide and a small amount of water vapour (evaporated water) which condenses inside the bubble forming a white cloud (fog). The fog is cold and therefore descends (as opposed to hot water vapour produced by boiling water which rises).

Demo 2: Dry Ice in coloured water

1. Add coloured water and dry ice to a glass, flask or beaker of coloured water for a "spooky chemistry lab" special effect

   You could ask students to predict what colour fog they expect to see prior to adding the dry ice and discuss their observations (they commonly predict that it will be the colour of the water).

2. The fog produced is white and does not take on the colour of the water. This is because the fog is produced by water which has evaporated into the bubbles produced by the dry ice.

3. Use several colours in separate beakers and/or flasks to create a colourful bubbling laboratory

   This is the way most Hollywood set dressers create the appearance of a chemistry laboratory – your students will recognise the effect from many films and television programs!

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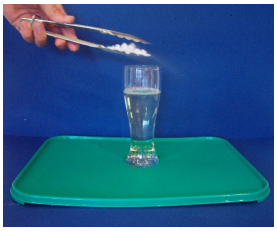
Demo 3: Bubble Volcano! *(&/or Small Group Activity 2)*



1. Do this demonstration on a shallow plate or similar to contain the spill over. Add a good squirt of detergent to a glass of water mix thoroughly. Add several pellets of dry ice to produce the Bubble Volcano.

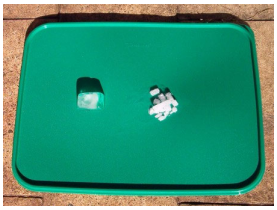
2. The dry ice will sublime rapidly, producing large fog filled soap bubbles which spill over the edge of the glass.

3. The rate of bubbling will eventually subside until all the dry ice has sublimed.

   Discuss observations with your class – remind them how amazing these bubbles are. Their walls are thinner than a human hair and each one has a cloud trapped inside!

Demo 4: Why it's called "dry" ice

The time taken for the dry ice to completely sublime will depend on the temperature (ie faster on hot days). If possible, do this demonstration in a sunny position on a dark plate, or even a piece of black cardboard to speed up the process.



1. Place an ice cube and a few pellets of dry ice side by side on a shallow plate (or similar)

2. The ice cube will melt to form a small puddle of water while the dry ice simply "disappears" without forming a puddle demonstrating that carbon dioxide does not have a liquid phase under normal atmospheric conditions*

   The process of changing directly from the solid state to the gas state is called *sublimation* – dry ice *sublimes*

3. The dry ice will completely sublime long before the ice has melted, let alone completely evaporated

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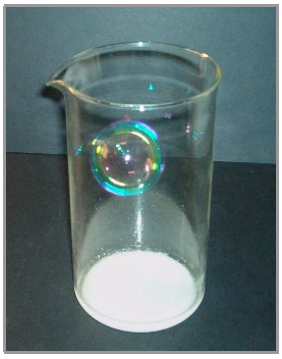
Demo 5: *Amazing floating bubbles*

This demonstration can be performed in a small aquarium, clear plastic tub, tall clear flask or a 2 litre soft drink bottle with the top removed. You will need some bubble solution (water and detergent) and a bubble blower (easily made from a piece of plastic coated gardening wire).

1. Cover a shallow plate with a layer of dry ice (if the plate is relatively small compared to the aquarium or tub, use two or more plates)

   After a few minutes, blow bubbles so that they descend into the aquarium – they will float on the invisible layer of carbon dioxide gas produced by the dry ice



2. Alternatively, use a large coffee plunger flask or 2 litre soft drink bottle with top removed – you can move the flask gently to catch bubbles

Carbon dioxide is more dense than, and descends in normal air. Because the air filled bubbles are less dense, they float on the invisible layer of carbon dioxide in the aquarium. Helium filled balloons float in air for exactly the same reason, except that helium is less dense than air. Any substance (or object) will float when immersed in a fluid (ie gas or liquid) if the substance (or object) is less dense than the fluid.

If you are lucky, some bubbles will land in the dry ice without popping and freeze. You may also notice that the bubbles initially bounce up and down on the invisible carbon dioxide layer.

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Demo 6: Popping lids

This demonstration will be met with much excitement and cheering. The time taken for the lid to pop off depends on several variables which are worth discussing with your students.

1. Add a small amount of water to the empty tin, so that the level is approximately 3 or 4 cm deep

2. Add a scoop of dry ice pellets

3. Press the plastic lid on firmly and gently, ensuring an airtight seal is formed

4. After a few seconds (sometimes up to 15 or 30), the lid will pop off the container

   The lid pops off because the dry ice sublimes, producing cold carbon dioxide gas. The gas produced continues to heat up inside the tin until it reaches the same temperature as its surroundings (ie room temperature). Gases expand as they heat up, however the container cannot stretch, so instead, the pressure increases until the lid can no longer contain it.

   The time taken for the lid to pop off depends on:

   - the initial temperature of the water and tin
   - room temperature
   - tightness of the lid

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Demo 7: Popping Balloon

This demonstration is a great way to end the lesson ... with a BANG! While it is very safe, you should practice this demonstration before the lesson if possible so that you are familiar with the process and result. It is also important to wear ear plugs (which you can make from paper tissue if necessary) in case the balloon pops earlier than expected. The sound level produced does not present a hazard at a distance of one metre (ie it is no more hazardous than popping a balloon with a pin).

1. Use a funnel to add several scoops of dry ice pellets so the bottle is approximately quarter full

   Hint: cut the top off another soft drink bottle to make a funnel with exactly the same spout size as your bottle

2. Add water until the bottle is approximately half full

   Hint: use a normal funnel and lift it a little to prevent spitting caused by the rapidly expanding CO_2 gas

3. Stretch a balloon over the neck of the bottle

   Important: ensure the neck is stretched right down over the threaded part of the bottle to prevent leakage and to allow for the next step

4. The balloon will begin to inflate rapidly, but you will have ample time to complete the next step, provided you have the twist tie handy!

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5. Secure the balloon onto the bottle with a twist tie – you can do this with gloves on by following the hint below

   Hint: have the twist tie secured loosely to the bottle and hanging below the thread of the bottle before you begin – you can then stretch the balloon over the thread, raise the twist tie, and twist to secure it while wearing gloves. Practice this without adding dry ice first!

6. Wait for the balloon to pop!

   It can take up to two minutes for the balloon to pop – if the balloon fails to pop, you can either release the balloon and start again, or pop it with a pencil – remember to wear earplugs if you attempt to remove the balloon, just in case it pops

7. Once the balloon has popped, inspect the contents of the bottle – an interesting layer of ice often forms around the dry ice

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