

Station 1 Dry Ice Experiments / Producing CO₂ in a reaction

1. WHAT IS DRY ICE

Put a flat chunk of dry ice on the counter and see how easy it "floats" on top of the counter when you give it a small push. Also see how finely ground dry ice moves around on the counter.

Does a puddle of liquid form? No, Why not? Solid \rightarrow Gas (Sublimation)

Put a quarter on the edge of the dry ice. What do you observe or hear?

What is dry ice? It is solid, frozen CO₂

We breathe in O₂ breathe out CO₂. Are we going to run out of O₂ on earth?

No! Trees and plants take in CO₂, produce O₂.

Why does it hurt to touch the dry ice? Have students touch it but only very briefly.

At room temperature and pressure CO₂ wants to be a gas. In solid CO₂, the molecules hold onto to each other. It requires heat to pull molecules apart. It takes the heat from your hand when you touch it or from the air molecules surrounding it.

2. CAN WE BLOW UP A BALLOON WITH SOLID CARBON DIOXIDE?

Students will see how the dry ice goes from a solid to a gas by putting a chunk of dry ice into a balloon. Stretch a balloon wide-open using both hands – put your fingers deep into the balloon to stretch it open as wide as you can. Using a pair of tongs, have a student place a small piece or a couple small pieces of dry ice in the balloon. Tie the balloon shut and watch it inflate as the dry ice sublimates (solid \rightarrow gas). Students can keep the balloon.

What is the white frost on the outside of the balloon? Some students think dry ice goes through the balloon. Discuss water vapor in the air and how it condenses on the balloon because it is cold. Feel how cold it is.

3. MAKING FOG

Fill a plastic tub with hot water from sink. Pour **two cups** of ground up dry ice into the hot water, all at once. What do you observe?

What is the fog? Why does it flow over the edge of the container and down to the ground?

FOG: The fog is not CO₂ (g). When you breathe out CO₂ (g), it is clear. The water vapor above the hot water condenses (when CO₂ (s) \rightarrow CO₂ (g) it absorbs heat, making it very cold so water condenses (like fog or clouds).

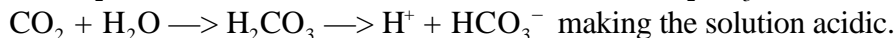
Why does the fog drop to the floor? It is heavier than the air. Talk about fire extinguishers: CO₂ (l) forms CO₂ (g), drops down onto the fire, keeps O₂ (g) away from fire, so it extinguishes the fire. Light a birthday candle and have the students put it in the fog. They will see that the CO₂ (g) blows out the flame immediately.

Fill a 250-mL beaker about half-way with water. Put a small chunk of dry ice in the water. Students can see bubbling as the CO₂ (s) \rightarrow CO₂ (g).

4. WHAT IS THE DIFFERENCE BETWEEN ICE AND “DRY ICE”?

Have students place 40 mL of water in two 150 mL beakers. Place the beakers on a stir plate. Students put universal indicator in each beaker – stir the solution with a stirring rod. To one beaker add some ice; to the other beaker add a chunk of dry ice. What do you see?

The CO₂ dissolves in water to produce carbonic acid, H₂CO₃:



Students will see a color change for the dry ice / water reaction and not for the regular ice dissolving in water. Let other students try this. Explain what universal indicator is.

Produce carbon dioxide gas in a reaction

1. WHAT ARE THE BUBBLES IN SOFT DRINKS?

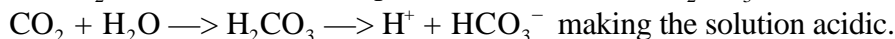
Talk about CO₂ (g) in sodas. High temperature or high pressure (shaking soda) releases CO₂ (g). Gases like carbon dioxide and oxygen dissolve in water – this is good because aquatic plants, fish and all living species in water need carbon dioxide and oxygen to survive.

TESTING 7UP – IS SODA ACIDIC?

Have students place 40 mL of water in one 150 mL beaker. Place the beaker on a stir plate. Students put universal indicator in each beaker – stir the solution with a stirring rod. Fill the remainder of the beaker with 7up. What do you see?

7up has carbonic acid just like dry ice in water!

The CO₂ dissolves in water to produce carbonic acid, H₂CO₃:



So does this mean that the dry ice in water is safe to drink?

Station 2 Methane Bubbles

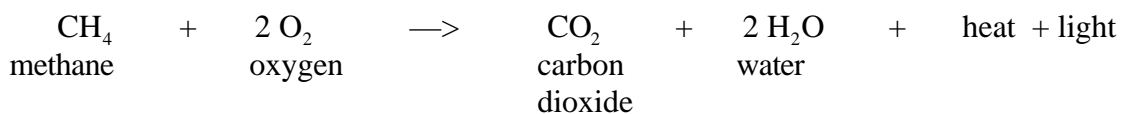
1. Blow some bubbles by blowing into a wand and watch the bubbles float down to the ground.
2. Methane gas is commonly used as fuel for heating homes and for cooking. The molecular formula for methane is CH₄ and has a relative mass of 16. Will methane gas bubbles rise or fall? Blow some methane bubbles to see what happens. Clean funnel with water if bubbles pop too easily.
3. What else can we do with methane bubbles?

We can light them!!!

Use a torch with a candle to light the methane bubbles. Use a big candle to light the small candle (using the big candle is easier than matches to re-light the candle).

4. What do you see? What happens as the gas burns? Do you see how the gas rises and spreads out as it rises? The flame is showing you where the gas is. What color is the flame?
5. Can you feel the heat given off as the methane burns. The methane burns in air. What gas in air does methane need to burn?

Methane needs oxygen to burn.



NOTE: If the bubbles break too easily, turn off the gas and rinse and dry the funnel.

Burning a dollar bill ????

Solution: 50 mL of isopropyl alcohol, 50 mL DI water, 1-2 g NaCl This makes 50% isopropyl alcohol. The 70% isopropyl alcohol available in drugstores must be diluted.

1. Soak a \$ 1 in 50% isopropyl alcohol. Remove \$1 using tongs (grab \$1 in center, hold it in horizontal position). Light the \$1 using a Bunsen burner: put the \$1 bill into the flame for only a second than take it out of the flame to see it burn over the sink.

NOTE: If \$1 itself catches fire, wave the bill back and forth to blow it out.

2. Alcohol burns and the dollar bill is fine. Why?
3. What is the \$1 made of?
Paper. Where does paper come from? Trees. Strong bonds hold paper together.
4. Alcohol molecules don't hold onto each other so strongly (note the high vapor pressures at room temperature and pressure, you can smell it). Alcohol burns at a much lower temperature than the paper so the paper does not catch fire.

Burning the alcohol produces CO_2 and H_2O just like when we burn up sugar or carbohydrates - to burn anything containing C, H and O you need O_2 and the combustion reaction produces CO_2 and H_2O . So we breathe in O_2 , burn up food and breathe out CO_2 .

5. Why is it better to use 50% than 70% isopropyl alcohol? The 50% alcohol contains more water. Water does not burn and keeps the \$1 from burning while the alcohol burns.
6. What is the purpose of adding the NaCl? Sodium atoms heated in a flame emit yellow light so the flame is more visible if you add some salt to the 50% isopropyl alcohol solution.

EXTRA TIME: IS A DOLLAR BILL MADE OF A SPECIAL PAPER? DOES THIS EXPERIMENT WORK WITH A PAPER TOWEL?

Fold up a paper towel, using tongs to hold the paper towel, soak it in 50% isopropyl alcohol. Remove the paper towel, light it using a Bunsen burner by putting it into the flame for only a second than take it out of the flame to see it burn over the sink.

Is there a difference between burning the \$1 bill soaked in alcohol and the burning paper towel soaked in alcohol? The paper towel burns much longer – why?

If you were to spill water on the counter what would you use to wipe it up a dollar bill or a paper towel? Why? The paper towel absorbs more water. A paper towel burns longer because it absorbs more alcohol than the dollar bill.

EYE WASH STATION

If you have time show students how the eye-wash works – they like it.

Station 3 Liquid nitrogen experiment

1. FREEZE FLOWERS, TENNIS BALLS, RUBBER HOSE

What happens to flowers when immersed in liquid nitrogen? Have students do this.
What do you hear? What does it sound like? Is the liquid nitrogen boiling?

Put some liquid nitrogen in a teakettle – hear it whistling – is the liquid nitrogen boiling?

How about a tennis ball? Rubber hose? What are the changes in properties?
Mention space shuttle application.

What is liquid nitrogen? How cold is it?

Temperature at which water boils?	100 °C
Temperature at which water freezes?	0 °C
Temperature of liquid nitrogen?	- 197 °C => very cold!

What is the fog above the liquid nitrogen? Condensed water vapor.

2. SHRINK A BALLOON SHAPED LIKE A DOG, THEN MAKE IT COME BACK TO LIFE

Show them a balloon filled with air: How does the balloon stay blown up? Atoms and molecules move, collide with the walls of the balloon, and cause pressure inside the balloon.

What happens when we put a balloon filled with air in the hot sun? Why?

Atoms and molecules speed up, increasing the number of collisions with the walls, increasing pressure.

What happens when we put a balloon filled with air in liquid nitrogen? Why? Put balloon in liquid nitrogen. Have students do this also.

Shrinks => molecules slow down

How does a microwave heat food?

Water molecules absorb radiation, excites rotational modes, water collides with other molecules in food, increases their motion (energy) => food is hot.

Temperature is proportional to average kinetic energy.

3. WHO WANTS TO CONDENSE THEIR BREATH? MAKE IT INTO A LIQUID AND SOLID

Blow up a balloon with air (5-6 inches in diameter, not bigger!) and put it on a test tube.
What is in the air that you blew into the balloon?

N₂, O₂, CO₂, H₂O and whatever else is in the air you breathe out.

What is in between the gas molecules in air?

Nothing - it is just empty space.

How much space is between the molecules in a gas? Do an experiment to show this.

Immerse the test tube with the balloon on top in liquid nitrogen.

What will happen?

As the gas cools, the molecules slow down. The volume of the balloon decreases and eventually completely deflates.

Remove the test tube from the liquid nitrogen.

What is inside the test tube? liquid and solid

What liquids? $N_2(l)$, $O_2(l)$,

What solids? $CO_2(s)$, $H_2O(s)$

How much space is between the liquid and solid molecules?

Not much - they are in direct contact with each other.

How does the volume of liquid and solid in the test tube compare with the volume of gas in the balloon?

The volume of liquid/solid inside the test tube is much smaller than the volume of gas in the balloon. Thus, there is lots of space between the molecules in the gas.

4. CAN WE BLOW UP A BALLOON USING LIQUID NITROGEN?

At room temperature and pressure nitrogen is a gas. Put ~ 200-300 mL of liquid nitrogen in a plastic water bottle using a funnel. Put a balloon over the top and secure balloon. What is happening?

In one bottle, put in ~200-300 mL water. Put a balloon on top. What is happening?

In another bottle put some chunks of dry ice. Put a balloon on top. What is happening?

water → stays in the liquid phase → balloon does not inflate

liquid nitrogen → nitrogen gas → blows up balloon fast

dry ice (solid) → carbon dioxide gas → blows up balloon slowly

How can we speed this up?

Liquid nitrogen absorbs heat from the container and the surrounding air molecules outside the container to form the nitrogen gas. Energy is required to pull the N_2 molecules apart. It blows up the balloon, so energy in the form of heat is converted to energy in the form of work.

heat → work

Station 4 Metals, Alloys, Densities

Copper to Silver to Gold

1. The alchemist's dream. Talk about alchemy as you do the experiment.
2. Place polished pennies in hot 3M NaOH and powdered zinc solution (IN THE HOOD). A hot plate is used, keep solution near boiling temperature.
Pennies remain in solution 2 to 3 minutes until pennies appear to be completely silver. Talk about the difference between pre-1982 and post-1982 pennies.

Brand new shiny pennies work great.
3. Remove "silver" pennies from solution using tongs and rinse them in water in the hood (use 600 mL beaker of water to cool pennies).

The pennies are zinc plated and appear silver in color. Small chunks of zinc are usually stuck on the penny. Students take a penny to the sink and in the tub of water they use their hands to remove all the zinc chunks, until the penny is totally clean.

SAFETY: Do **NOT** dry the pennies with paper towels. Small pieces of zinc on a paper towel can ignite and cause a fire in the lab.

4. Students take their penny to a Bunsen burner. They use tongs to pick up one penny at a time (the tongs are positioned on the edges of the penny). Adult supervision is required anytime a Bunsen burner is on.

Heat zinc plated copper pennies in the flame of a Bunsen burner. Turn the penny in the flame as it heats. The zinc and copper atoms form brass. The copper and zinc atoms merged to produce "gold" pennies.

Remove from heat immediately when yellow color appears and submerge the penny and tongs in the beaker of water located next to the Bunsen burner. This will cool the tongs and the penny so no one gets hurt.

Densities of Metals

An added activity will be to compare the mass of equal volumes of mercury and lead. Have students feel the weight of each jar to figure out which one weighs the most. Have them lift the jars only an inch up. **DO NOT let them lift the jars out of the container. Mercury is hazardous and must be kept in the container.** Have students find Mercury (Hg) and Lead (Pb) on the periodic table. Which is heavier according to the periodic table?

Let students figure out why the mercury liquid feels heavier than the lead solid when the periodic table says lead is heavier. Hopefully they will see mercury is a liquid and there is no unoccupied space between the Hg atoms. Lead is heavier. Why does the mercury feel heavier? Have them discuss this and figure it out.

NOTE: The amount of mercury in the vile is approximately 1 mole which is 6.022×10^{23} atoms of Hg!

Station 5 Polar versus Nonpolar Substances (aka Soap station)

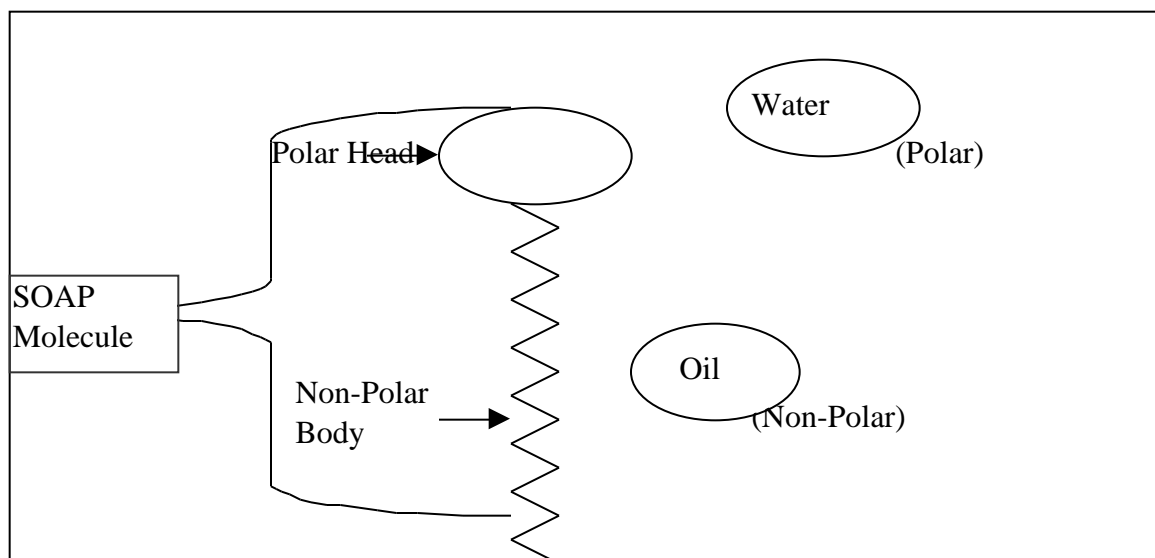
Oil & Water

1. Pour ~35mL of oil into a 250mL beaker and then pour ~100mL water into the same beaker. Ask the students what they see. The water and oil form two separate layers.
2. The concept of density can be brought up here: which is denser - the oil or water? How do we know? The water is in the bottom layer and therefore more dense than oil. You can mention that it is good that oil is less dense than water because it makes it easier to clean up oil spills. How is oil on the surface of lakes or oceans harmful to plants and animals? Ingestion of toxic levels of oil can lead to death. Oil can clog a bird's feather, making it impossible for the bird to fly, and so heavy that the bird may sink. Feathers also lose insulating ability.
3. Have a student stir the beaker and ask the students if the oil and water will mix - they don't. Why? **Introduce the concept of polar and non-polar and explain that non-polar things like to be with non-polar things and polar things like to be with polar things.** Show molecular models. Using a molecular model of H₂O, tell the students that oxygen attracts electrons more strongly than hydrogen. Since electrons have a negative charge and they spend more time near oxygen, the water molecule has a negative end and a positive which is why it is called polar. Using butane, show students that in oils, the hydrocarbon tail is non-polar because hydrogen and carbon have a similar attraction for electrons.
4. Draw a table on the board similar to the one below:

	Water	Oil	Food coloring	Mystery Substance
Polar or Non-Polar?				

Tell the students that water is polar and fill that part of the table in. Ask the students: if we know water is polar, what is oil? Oil did not mix with the water and is non-polar. Fill in the chart.

1. Have a student add food coloring and choose the color: where does the color go? It mixes with water, so this means that it is polar. Add to chart.
2. Add the "mystery substance" and stir – what happens? Both the oil and water mixed with the mystery substance. Is the mystery substance polar or non-polar? What might the substance be? Have students smell the substance and try to guess. The mystery substance is soap and soap is both polar and non-polar. Add to chart.
3. Show molecular model of a soap molecule - explain that soap has a polar head and a non-polar body. The water attaches to the head and the oil attaches to the body.



Food Color Explosion

1. Put a plastic plate on a stool and have students stand around it. Pour just enough milk onto the plate to cover the bottom.
2. Tell the students that the milk is whole milk with lots of fat. Is the fat polar or non-polar? Is fat more like oil or water? It is non-polar. What will happen when food coloring is added to the milk? Food coloring is polar so it won't mix with the globules of fats.
3. Have students each carefully add drops of the four different colors of food coloring onto the plate – **don't squirt a lot at once**. Cover most of the surface of the milk with food coloring. **Make sure students do not touch their pipette to the milk or move the plate**. When finished, add a couple drops of dishwashing liquid and watch what happens! Why do the food colors swirl in the milk when mixed with soap?
4. As soon as dishwashing soap is added, the food coloring drops and the milk rapidly mix together. The soap is made of molecules that have two ends: a fat-friendly end and a water-friendly end. One end of soap attracts the fat in milk (the non-polar end), and the other end attracts the water in food coloring (the polar end). The food coloring mixes with the milk because the dishwashing liquid acts as a bridge between the two.
5. **Now we know soap works because its molecule has a split personality! Its tail loves fat, but its head is wild for water. Soap is non-polar and polar!**
6. Discard the food coloring & milk and oil & water into the sink.

Application: How does washing our clothes in soapy water take grease out of our clothing? Can we wash grease out of our clothing with just water and no soap? Why not?