Station 1 Dry Ice Experiments / Producing CO_2 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 —> 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 CO_2
   We breathe in O_2 breathe out CO_2. Are we going to run out of O_2 on earth?
   No. Trees and plants take in CO_2, produce O_2.
   Why does it hurt to touch the dry ice? Have students touch it <u>but only very briefly</u>.
   At room temperature and pressure CO_2 wants to be a gas. In solid CO_2, the molecules hold onto to each other. It requires heat to pull molecules away from each other. The solid takes heat from the air molecules surrounding it. When you touch dry ice for more than a few seconds it hurts. It takes the heat from your hand when you touch 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 sublimes (solid —> gas). One of the students can keep the balloon to be used for the liquid nitrogen station.

   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 **one to 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?
   <u>FOG</u>: The fog is not just CO_2 (g). When you breathe out CO_2, it is clear. The water vapor above the hot water condenses. As the CO_2 sublimes, CO_2 (s) —> CO_2 (g), it absorbs heat, making it very cold so water condenses (like fog or clouds).
   <u>Why does the fog drop to the floor?</u> It is heavier then the air. Talk about fire extinguishers which contain CO_2 (l) which forms CO_2 (g), and drops down onto the fire, keeps O_2 (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 CO_2 (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 CO_2 (s) —> CO_2 (g).

4. WHAT IS THE DIFFERENCE BETWEEN ICE AND "DRY ICE"?

Have students place 40 mL of water in three 100 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 CO_2 dissolves in water to produce carbonic acid, H_2CO_3:
$CO_2 + H_2O \longrightarrow H_2CO_3 \longrightarrow H^+ + HCO_3^-$ making the solution acidic.

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.

WHAT ARE THE BUBBLES IN SOFT DRINKS?

Talk about CO_2 (g) in sodas. High temperature or high pressure (shaking soda) releases CO_2 (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?

Add 7up to the third beaker containing 40 mL of water and indicator. What do you see?

7up contains carbonic acid which reacts with water just like dry ice reacts with water!
The CO_2 dissolves in water to produce carbonic acid, H_2CO_3. Carbonated beverages all have CO_2 dissolved in solution.

$CO_2 + H_2O \longrightarrow H_2CO_3 \longrightarrow H^+ + HCO_3^-$ making the solution acidic.

So if we add dry ice to a bowl of juice at Halloween, is it 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 CH_4 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).

SAFETY: Students must hold the torch up above the funnel but not too close to the person making the bubbles and not too close to the funnel. If the funnel accidentally catches fire there is no danger. Simply hold the funnel away from you and away from the students and turn off the gas.

4. Light another bubble and ask students what they 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.

CH_4	+	$2\ O_2$	—>	CO_2	+	$2\ H_2O$	+	heat + light
methane		oxygen		carbon dioxide		water		fire

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

If there are two volunteers, one volunteer cleans up the methane bubble station while the other volunteer does the burning of the alcohol.

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. If you use the 70% alcohol the dollar bill will catch fire.

You have just learned about the combustion of methane gas. There are many things that can burn. Trees burn, paper burns, even liquids burn. Alcohols are liquids that burn. Will a dollar bill burn?

1. Place a Bunsen burner between the jar of 50% isopropyl alcohol and the sink.
2. Light the Bunsen burner.
3. Soak a dollar bill in 50% isopropyl alcohol. Remove it using tongs (grab the dollar bill in center, hold it in horizontal position). Move the dollar bill into the flame of the Bunsen burner. Leave it in the flame for only a second than take it out of the flame and watch it burn over the sink.

   <u>NOTE</u>: If the dollar bill 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 methane or when we burn up sugar or carbohydrates - to burn anything containing C, H and O we 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% then 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.

7. **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.

SAFETY: If there are two volunteers, one volunteer cleans up this station while the other volunteer does the burning of methane bubbles. It is important to keep the counters clean. Too much alcohol on the counter can catch fire. If the counter does accidentally catch fire there is no great danger. The alcohol burns at a low temperature and burns off very quickly. Simply turn off the gas, step back and wait a second for the alcohol to burn off.

Station 3 Liquid nitrogen experiment

1. **FREEZE FLOWERS, a RACQUET BALL, and a RUBBER HOSE**
   What happens to flowers when immersed in liquid nitrogen? Have students do this. What do you hear when the flowers are immersed in the liquid nitrogen? What does it sound like? Is the liquid nitrogen boiling?

   What about a racquet ball? Show how bouncy the racquet ball is and then put it in the liquid nitrogen. Leave it in liquid nitrogen until the end of their time at this station.

   What about a Rubber hose?   Show how stretchy it is. Put part of the hose in liquid nitrogen. What are the changes in properties? Have students stretch the frozen hose. Mention the space shuttle application.

   What is liquid nitrogen? How cold is it?

   Temperature at which water boils?   100 ^{o}C

   Temperature at which water freezes?   0 ^{o}C

   Temperature of liquid nitrogen?   – 197 ^{o}C => very cold!

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

   Put some liquid nitrogen in a tea kettle. Have the students look inside the kettle and see the bubbling liquid. Is the liquid nitrogen boiling? Close the lid and hear the kettle whistle. Don't we need heat to boil liquid nitrogen? Are we providing heat? Where does the liquid nitrogen get the heat? It absorbs heat from the kettle and from the air around the kettle. Even from water molecules in the air. See the water condensing on the kettle? When we take heat from gaseous water molecules, they condense to form droplets of water.

2. **SHRINK A BALLOON SHAPED LIKE A DOG & 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, 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. This causes the water molecules to rotate more. The rotating water molecules collide with other molecules in food, this increases the motion of molecules in food (it increases the energy), which makes the food hot. Temperature is directly proportional to average kinetic energy. When the temperature of a given substance is high, the kinetic energy of the atoms and molecules of which the substance is made is also high.

3. WHO WANTS TO CONDENSE THEIR BREATH? MAKE IT INTO LIQUID/ 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?
N_2, O_2, CO_2, H_2O 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. **This takes a little while so do the next activity and come back to this later.**

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 WITH 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 another 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
dry ice (solid) —> carbon dioxide gas —> blows up balloon slowly (ask students how we can speed this up?)

How does liquid nitrogen form nitrogen gas to blow up the balloon??

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

Go back and finish the third activity – what happened to your breath inside the balloon?

5. **Break the racquet ball.** Use tongs to take the very cold racquet ball out of the liquid nitrogen. Hold the racquet ball at about your eye level and drop it. It shatters. Students can each take a piece of the ball to keep. **CAUTION**: the pieces of the ball are very cold.
SAFETY: Drop the frozen racquet ball – throwing it with too much force can cause pieces to fly up and hurt someone.

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 very shiny pennies in hot 3M NaOH and powdered zinc solution (IN THE HOOD). A hot plate is used, keep solution near boiling temperature. Brand new shiny pennies work great.

   Pennies remain in solution 3 to 5 minutes until pennies appear to be completely silver. Talk about the difference between pre-1982 and post-1982 pennies and how we make silver and gold pennies as follows.

   Pre-1982 pennies contain a much greater percentage of copper. Post-1982 pennies are mostly zinc. Show the broken penny which is mostly zinc inside. Show them a copper, "silver" and "gold" penny. Talk about how the zinc atoms on top of the copper atoms make the pennies look silver. How do we make the "gold" pennies? We heat the pennies in the flame of a Bunsen burner. As we heat the silver penny the atoms move. The zinc atoms move in between the copper atoms. Help students visualize this be putting one of your hands on top of your other hand the show that if heat makes your fingers move it allows fingers from one hand to move in between the fingers of your other hand. Copper and zinc atoms make brass and looks like gold. Ask if anyone plays a saxophone or a trumpet? These are made of brass.

3. Remove "silver" pennies from solution using tongs and rinse them in water (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 the zinc plated copper pennies in the flame of a Bunsen burner. Turn the penny in the flame as it heats. The zinc atoms move in between the copper atoms to form brass. The copper and zinc atoms merged to produce "gold" pennies.

   Remove from heat <u>immediately</u> 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 then the lead solid when the periodic table says lead is heavier. Hopefully they will see mercury is a liquid and there us 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 mercury!

EYE WASH STATION

If you have time show students how the eye-wash works – they like it. Give them paper towels to dry themselves off.

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 H_2O, tell the students that oxygen attracts electrons more strongly then 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:

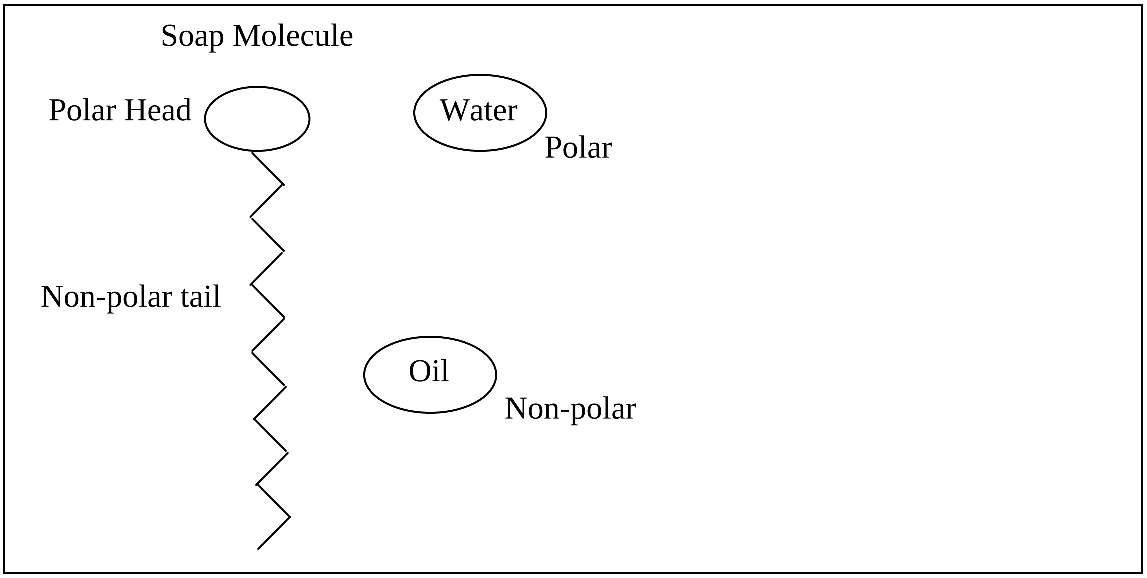
	Water	Oil	Food coloring	Mystery Substance
Polar or Non-Polar?				

   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.

a. 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.

b. 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.

c. 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?