



Mini-Labs (13)

# Mini-Labs

1. Magic Raisins
2. Mysterious  
Balloons
3. Candle Power
4. Super-cooled  
Liquid
5. Singing Tongs
6. Film Canister
7. Movie Fog
8. Jet Power
9. Sauce Pan
10. Magnetic Bubbles
11. Aquarium Magic
12. Hockey Puck
13. Carbon dioxide  
balloons

# 1-Q. Magic Raisins

- Why do the raisins sink in Sprite in the first place?
- Why do they rise up to the top?
- Why do they sink again?
- What does the  $\text{CO}_2$  have to do with what is happening?



**YouTube Video:** Click on the picture to watch raisins in Sprite.

# 1-A. Magic Raisins

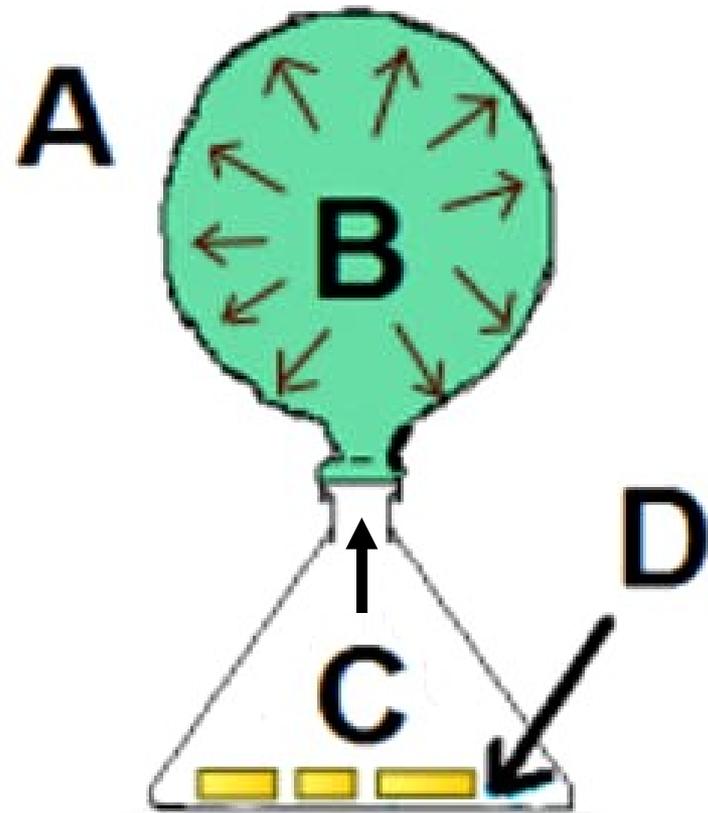
1. The raisins sink at first because they are more dense than the Sprite.
2. The raisins lift off from the bottom because creases and grooves in the raisin allow carbon dioxide bubbles to attach to the raisin, causing its total density to be LESS than the Sprite – so, the raisin floats.
3. At the surface, the bubbles of carbon dioxide pop, causing the raisin to then be more dense than the Sprite. So, the now heavier raisin again sinks to the bottom.



**YouTube Video:** Click on the picture to watch raisins in Sprite.

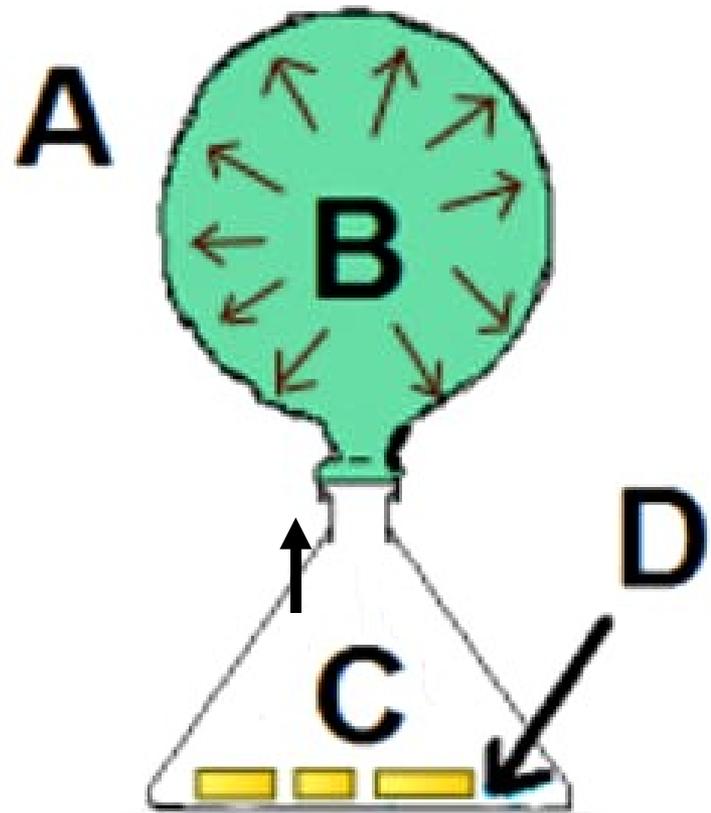
# 2-Q. Mysterious Balloons

- Why does the balloon inflate?
- What do the letters A-D represent?
- When you take the balloon off the flask, does it behave the same as a normal balloon?



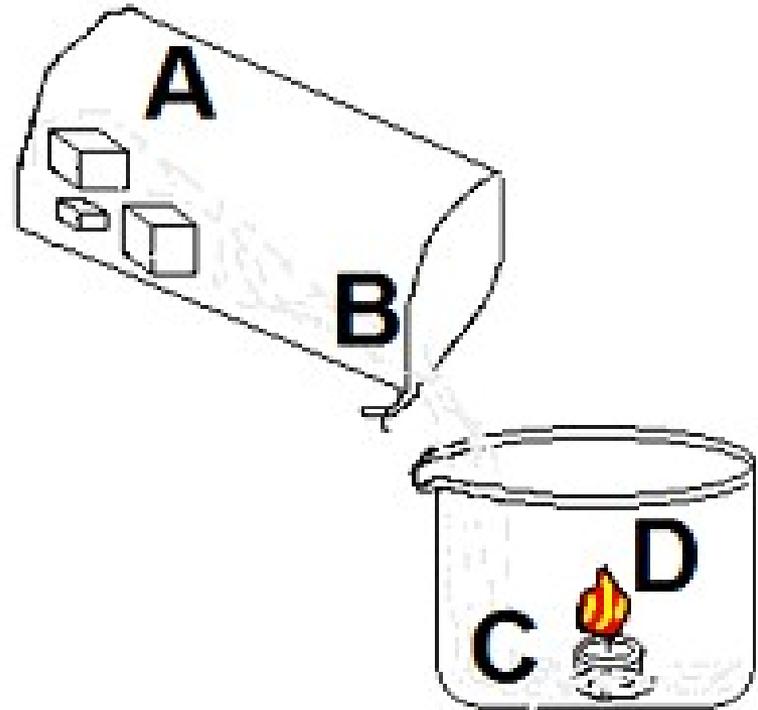
# 2-A. Mysterious Balloons

1. The balloon inflates because more and more carbon dioxide is sublimating from the dry ice pellet. It has to go somewhere, so it first fills up the flask and then begins inflating the balloon since it needs more room (volume).
2. A = outside air of normal pressure; B = expanding carbon dioxide with increased pressure; C = dry ice sublimating and producing carbon dioxide gas; D = dry ice pellet
3. When you take the balloon off the flask, it seems **HEAVIER** than a normal balloon.



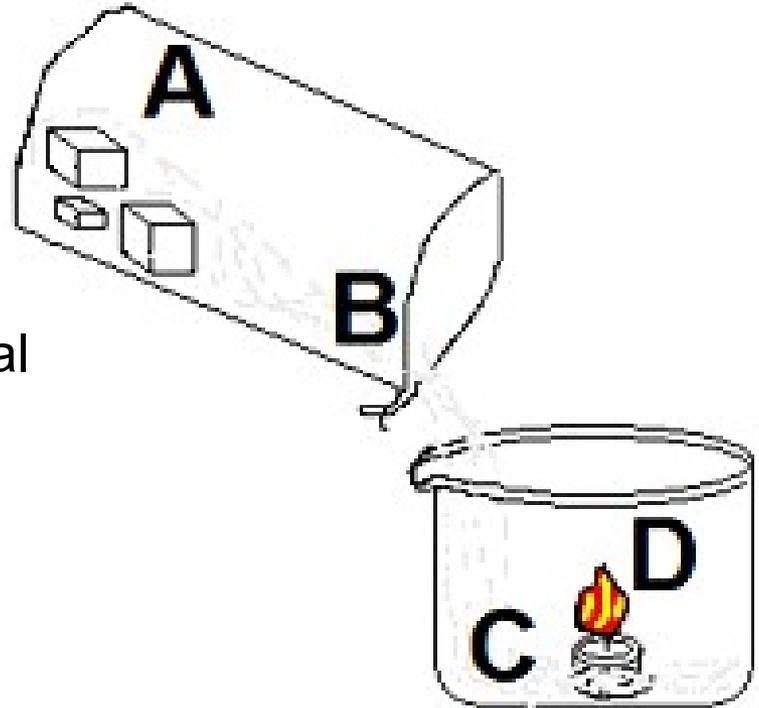
# 3-Q. Candle Power

- Why can you pour the gas?
- Why does the gas extinguish the flame?
- What do the letters A-D represent?
- What 4 properties of carbon dioxide does this illustrate?



# 3-A. Candle Power

1. You can POUR the gas because it is heavier (more dense) than air.
2. Carbon Dioxide will extinguish (put out) the flame because it is not flammable itself. It won't burn.
3. A = dry ice pellets; B = carbon dioxide gas; C = carbon dioxide gas; D = normal mix of gases before carbon dioxide is added.
4. Properties of Carbon Dioxide: denser than air, non-flammable, colorless, odorless



# 4-Q: Super-cooled Liquid



- When dry ice is added to denatured alcohol why do flowers freeze?
- At what temperature will denatured alcohol freeze?

# 4-A: Super-cooled Liquid



- Denatured alcohol freezes at  $-173^{\circ}\text{F}$
- Dry ice is  $-109^{\circ}\text{F}$
- Denatured alcohol looks just like water, but it is NOT!
- By putting dry ice into denatured alcohol we super-cooled the water down to  $-100^{\circ}\text{F}$ . This allowed us to freeze water VERY quickly. We were also able to freeze a flower. The petals just broke off or broke into pieces because the flower was so brittle after being frozen.

Water balloon, frozen into a cup shape.

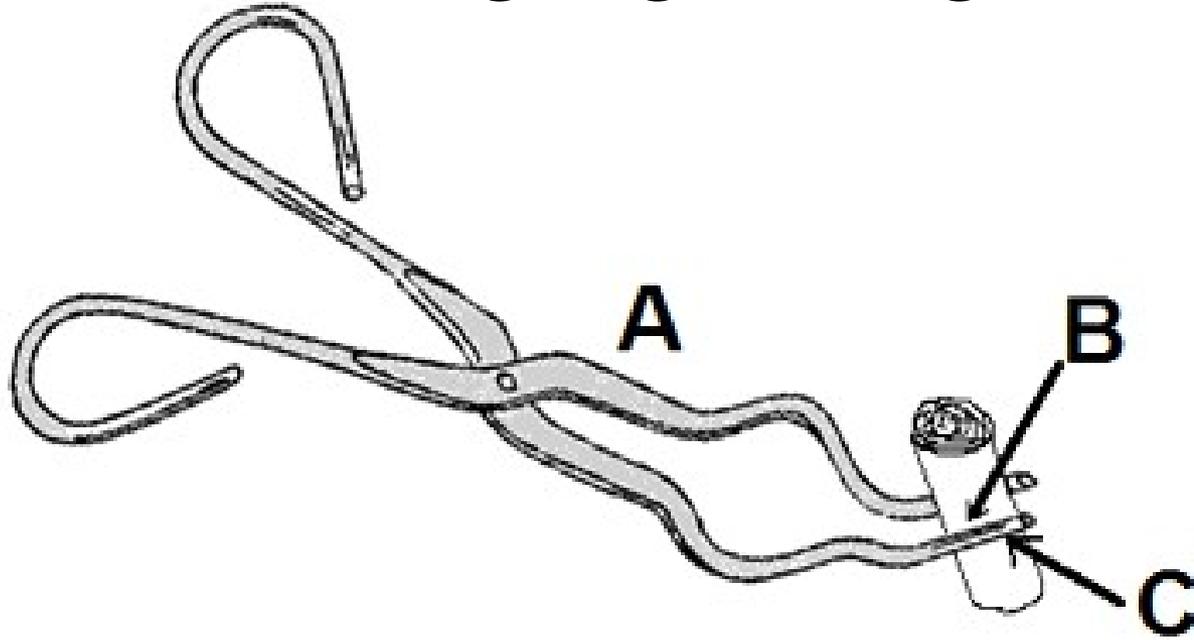


Water balloon, frozen into an egg shape.



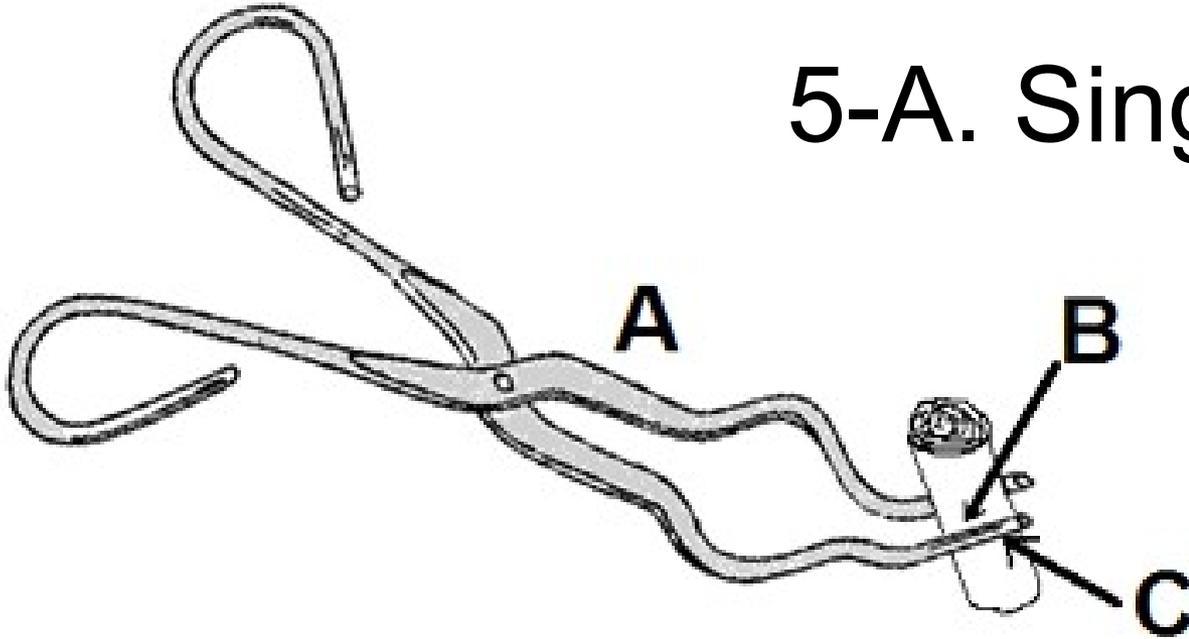
Water balloon frozen solid.

# 5-Q. Singing Tongs



- What is happening directly underneath the metal tong arms that makes the tongs sing?
- What do the letters A – C represent?

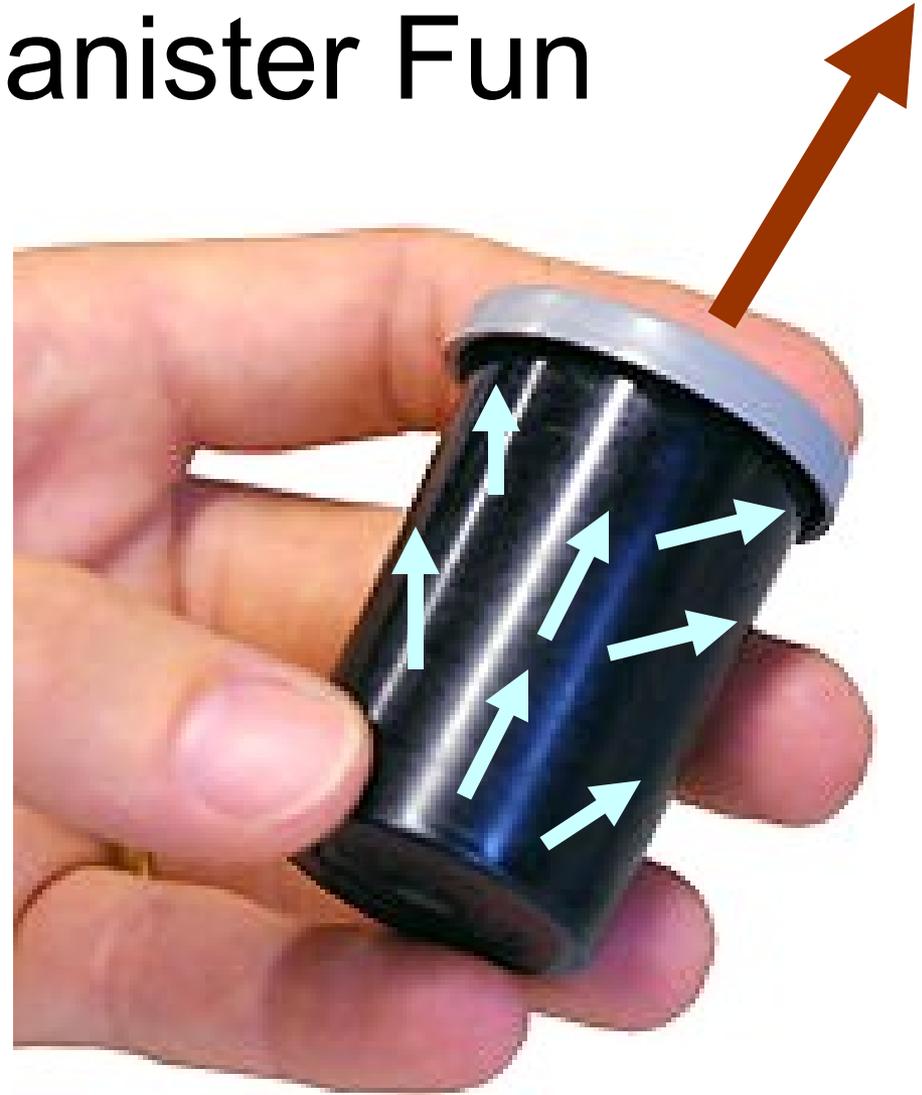
# 5-A. Singing Tongs



1. Dip the tongs in hot water, shake off the excess water, and press the tongs against the dry ice. The warm tongs will cause the dry ice to sublime (turn into a gas without becoming a liquid) where the pellet is being held. The sublimating gas directly underneath the tongs will lift the tongs off the ice, but the pressure of you holding the tong handles will push the tongs back against the dry ice. This repeats so quickly that the tongs vibrate, causing a singing sound to be generated that will vary with the pressure that you exert on the handles.
2. A = room temperature; B =  $-109^{\circ}\text{F}$  dry ice & area where greatest sublimation occurs; C = Getting much colder

# 6-Q. Film Canister Fun

- Why does the dry ice pellet blow the top off the film canister?
- Which gas law does this illustrate?
- What two words summarize what is happening?

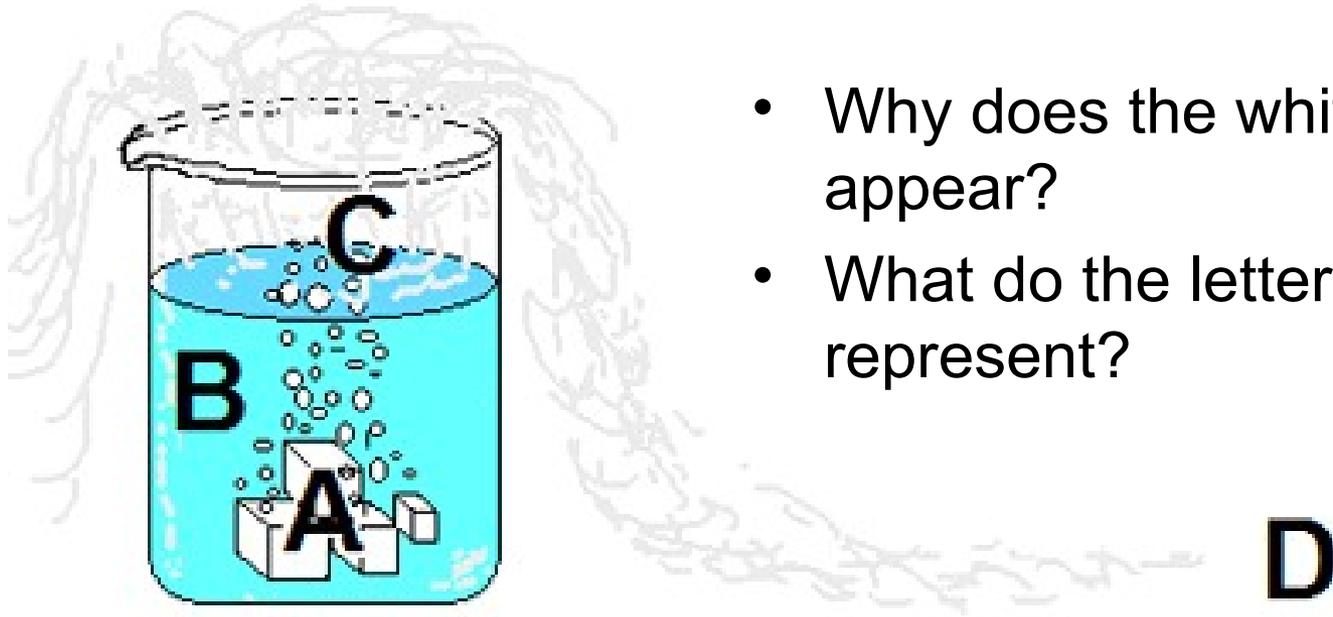


# 6-A. Film Canister Fun

1. As the dry ice pellets inside the canister sublimate, more and more carbon dioxide gas builds up inside the canister. This increase in **PRESSURE** eventually causes the top to blow off.
2. This is a variation on Gay-Lussac's Law where an increase in pressure will cause an increase in volume. If the top remained on the canister, the entire container would explode.
3. Two words to summarize what is happening with this mini-lab:  
**SUBLIMATION** and **PRESSURE**.



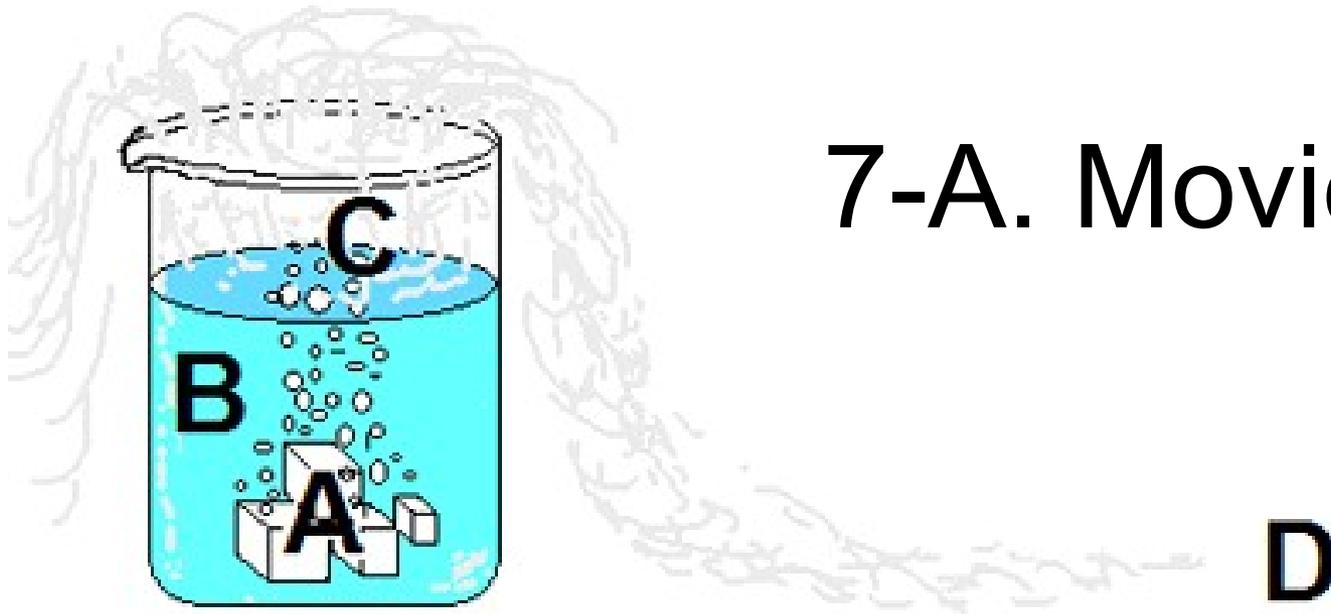
# 7-Q. Movie Fog



- Why does the white fog appear?
- What do the letters A-D represent?

- Why does the white fog disappear across the table top?
- Why does the white fog appear more at the beginning than at the end?

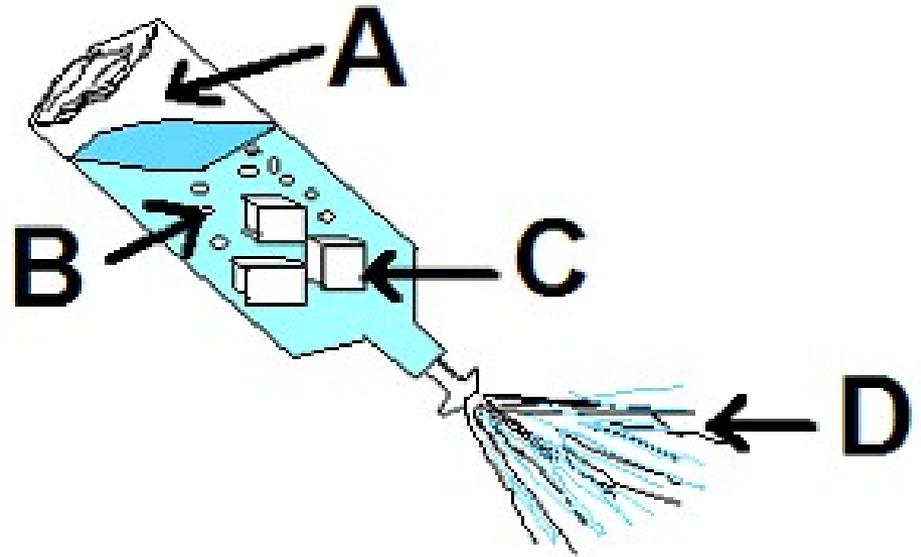
# 7-A. Movie Fog



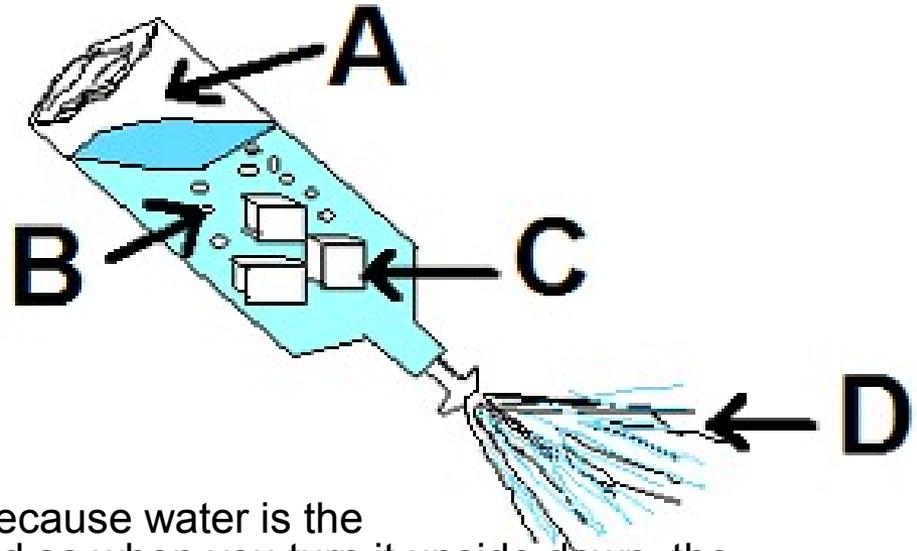
1. The white fog appears because COLD carbon dioxide bubbles up from the dry ice and hits the surface. There, the cold gas causes warm water vapor in the air above the surface to change state and condense into visible droplets of water (fog).
2. A = dry ice pellets; B = sublimating carbon dioxide; C = water vapor condensing into visible droplets of fog; D = fog begins to warm up and evaporates back into invisible water vapor
3. The fog disappears eventually because it warms up and evaporates back into invisible water vapor. In other words, it changes state from a visible liquid of tiny particles (fog) to a gas (invisible).
4. The fog appears more at the beginning (when the water is hot) than at the end (when the water is cold) because with warm water there is more water vapor available. As the temperature of the water and air above it inside the beaker goes down, less and less water vapor above the water's surface is able to change state into a liquid, so less and less "fog" is produced as the temperature drops.

# 8-Q. Jet Power

- Why does a geyser form?
- Why does water shoot out of the bottle when you hold it down?
- When held vertically, why is the geyser stronger at the beginning?
- What do A – D represent?



# 8-A. Jet Power



1. A geyser forms because the continually sublimating dry ice in the bottom of the bottle is producing so much carbon dioxide gas that pressure builds up forcing the fog and carbon dioxide out of the bottle top. The white fog coming out of the top is from water vapor condensing into visible fog.
2. Water shoots out when you hold it down because water is the most dense substance inside the bottle and so when you turn it upside down, the water blocks the nozzle. Meanwhile the carbon dioxide gas is the least dense and so it collect at the top. It has no where to go and the pressure is building up, so it pushes against the water, blowing it out of the nozzle so it can get out too and expand.
3. The geyser is stronger at the beginning because the water is warm at first and there is a lot of production of carbon dioxide and water vapor. As the water cools down, the dry ice sublimates more slowly and there is less water vapor available to condense into fog.
4. A = carbon dioxide building up PRESSURE; B = Sublimating carbon dioxide; C = dry ice pellets; D = expelled water.

# 9-Q. Sauce Pan

- What is the substance on the outside of the pan?
- How and why did it form?



This sauce pan contained multiple dry ice pellets.

# 9-A. Sauce Pan

1. The white substance that forms on the outside of the sauce pan is condensed water vapor.
2. Here is how it works: The dry ice turns the bottom portion of the pan very cold.

When warm water vapor molecules in the air get close to the cold outside of the pan, they change state and turn into liquid water, attaching to the sides of the pan. As the temperature continues to get colder, those liquid molecules then freeze.



# 10-Q. Magnetic Bubbles

- Why are the bubbles white at first and then turn clear?
- Why do the bubbles stick together?



1. The bubbles are white at first because water in the beaker is warm, producing lots of water vapor above the surface. As cold carbon dioxide reaches the surface, it causes the warm water vapor to condense into visible droplets of water (fog). These fog droplets and the carbon dioxide gas are then captured inside the bubbles because of the soap in the water. After the water cools down, there is less water vapor available and so less fog is produced.

2. The bubbles stick together because of the soap. Soap reduces surface tension of the water and makes bubbles more stable. The reduced surface tension also allows the bubbles to stick together more easily.

## 10-A. Magnetic Bubbles

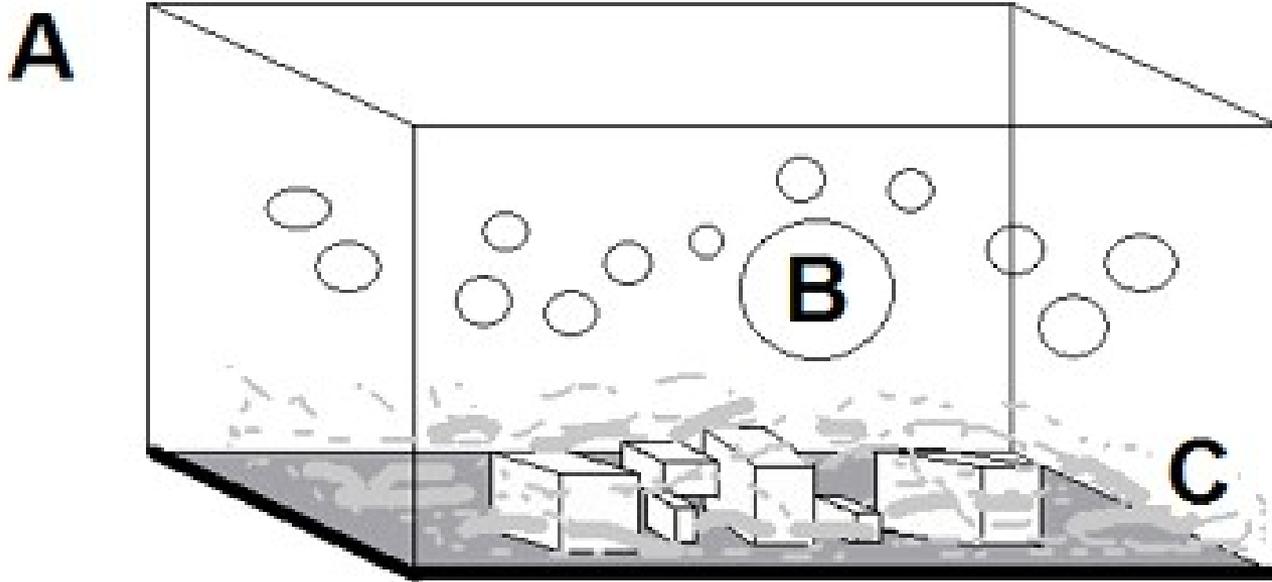


# Soap Helps to Stabilize Bubbles

- A bubble made with pure water alone is not stable.
- A dissolved surfactant such as soap is needed to stabilize a bubble.
- A common misconception is that soap increases the water's surface tension.
- Actually soap does the exact opposite, decreasing it to approximately one third the surface tension of pure water.
- Soap does not strengthen bubbles, it stabilizes them.
- As the soap film stretches, the surface concentration of soap decreases, which causes the surface tension to increase.
- Thus, soap selectively strengthens the weakest parts of the bubble and tends to prevent the bubble from stretching further.

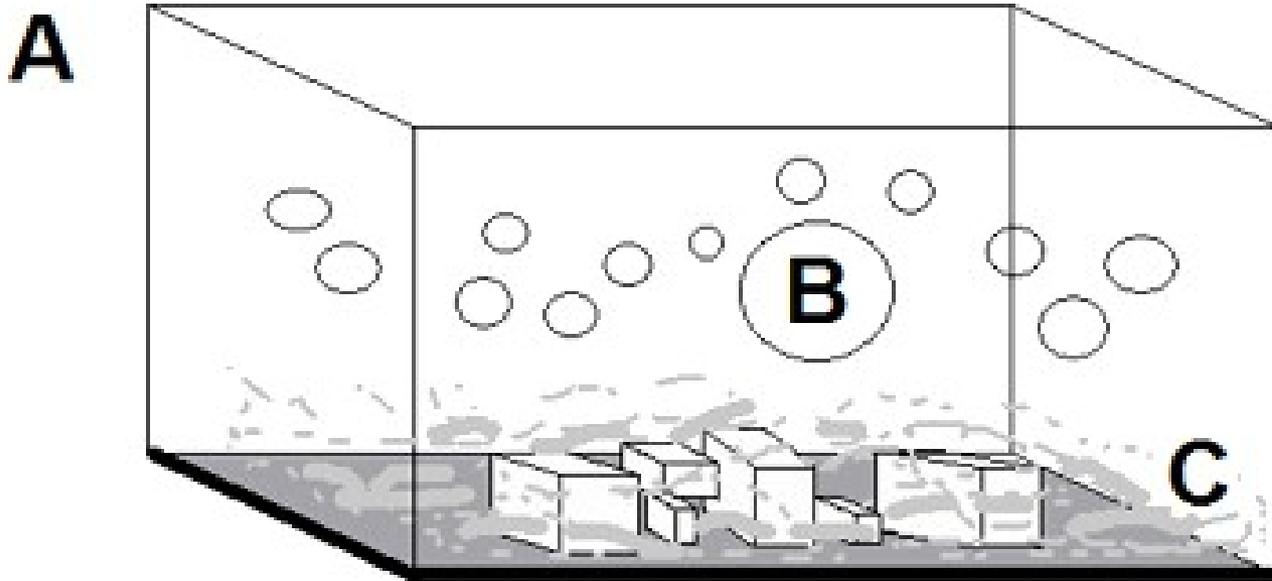


# 11-Q. Aquarium Magic



- Explain this density sandwich using A, B, and C as the layers of the sandwich.
- Explain the frozen bubbles on the bottom.

# 11-A. Aquarium Magic



- A = least dense (air)
- B = medium density (bubbles -- more dense than air & less dense than carbon dioxide)
- C = most dense (carbon dioxide gas -- more dense than the bubbles and more dense than air... so, carbon dioxide is on the bottom of the density sandwich)

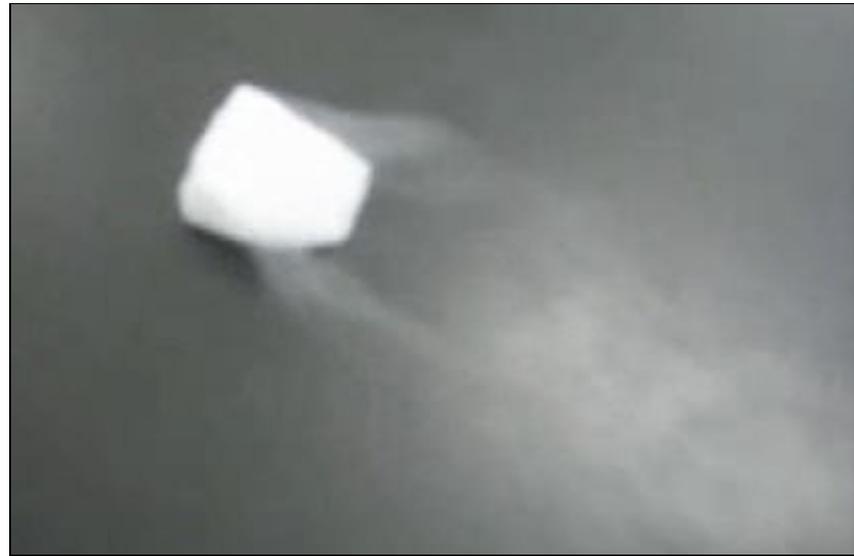
# How to Freeze a Bubble...

## Freezing

- Soap bubbles blown into air that is below a **temperature** of  $-15\text{ }^{\circ}\text{C}$  ( $5\text{ }^{\circ}\text{F}$ ) will freeze when they **touch a surface**. The air inside will gradually **diffuse** out, causing the bubble to crumple under its own weight.
- At temperatures below about  $-25\text{ }^{\circ}\text{C}$  ( $-13\text{ }^{\circ}\text{F}$ ), bubbles will freeze in the air and may shatter when hitting the ground. When a bubble is blown with warm air, the bubble will freeze to an almost perfect sphere at first, but when the warm air cools, and a reduction in volume occurs, there will be a partial collapse of the bubble. A bubble, created successfully at this low temperature, will always be rather small; it will freeze quickly and will shatter if increased further.

# 12-Q. Hockey Puck

- Why does dry ice slide across the table so easily?
- Does the shape of the dry ice matter?

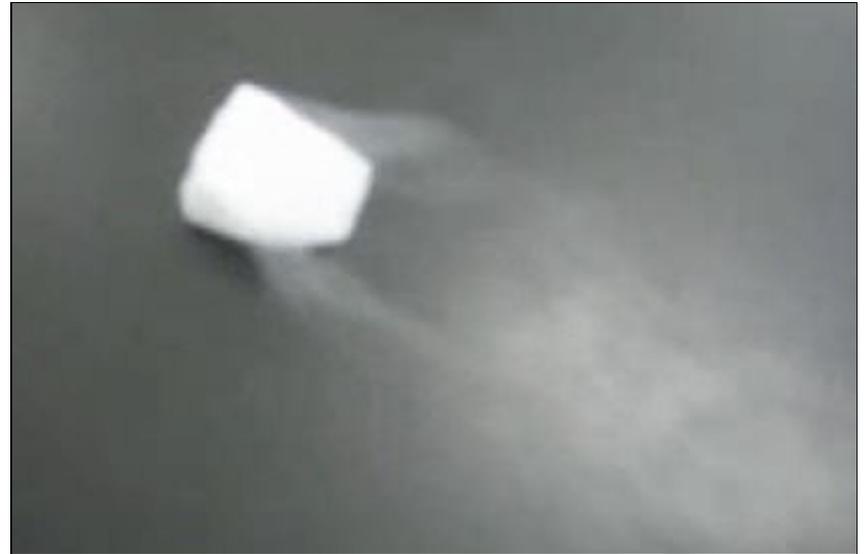


**YouTube Video:** Click on the picture to watch dry ice behave like a hockey puck.

# 12-A. Hockey Puck

1. The dry ice pellet sublimates faster on the bottom where the pellet is touching the warm table top. Carbon dioxide gas pushes **DOWN** against the table, lifting the pellet **UP** and decreasing friction between the pellet and the table. The pellet **RIDES** on a thin layer of carbon dioxide gas across the table top.

2. In order for the “hockey puck to work, the piece of dry ice needs to have a flat side. You can hold the pellet down with an insulated glove and it will sublimates faster against the table, producing a flat side.



**YouTube Video:** Click on the picture to watch dry ice behave like a hockey puck.

# 13-Q. Latex Balloons

- CO<sub>2</sub> balloon vs. regular balloon
- Why did the CO<sub>2</sub> balloons deflate when the regular balloons did not?



# 13-A. Latex Balloons

1. Latex balloons are made out of a natural material that is biodegradable.
2. The skin of a latex balloon is permeable, meaning there are tiny holes in the membrane that will allow a gas inside to escape.
3. Carbon dioxide as a gas increases this permeability, allowing MORE of the gas inside to escape.
4. If you look closely at the skin of a deflated carbon dioxide balloon you will notice that the skin appears ruffled and distorted. This is the effect that carbon dioxide has on the skin. It speeds up the biodegrading of the balloon.



4. Continued...

There are three additional reasons for the degradation of the latex balloon: 1) exposure to ultraviolet light, 2) oxygen in the air, and 3) static electricity.

# Properties of Dry Ice

- What properties of frozen carbon dioxide have you discovered by working through the eleven mini-labs + two puzzlers?
- NOTE: Mini-labs # 3 and # 5 provide the most clues.

# Properties of Dry Ice, aka... frozen carbon dioxide

- It sublimates directly from a solid into a gas, bypassing the liquid phase.
- It's cold ---- > - 109°F
- It's heavier than air – therefore, you can “pour” the gas.
- It's not flammable. It will put out flame.
- It is colorless.
- It is odorless.
- When placed into a closed container, pressure builds up because more and more dry ice is sublimating. As more and more carbon dioxide molecules crowd into the confined space, the container must expand or explode.

# Vocabulary #1

- **density** – a substance's mass divided by the volume it takes up. We experimented with the density of raisins in Sprite and used an aquarium to develop a gas density sandwich.
- **sublimation** – the change of a substance from a solid to a gas or a gas to a solid. Dry Ice “sublimates” from a solid directly into a gas without going through the liquid phase.
- **evaporation** – change from a liquid to a gas.
- **condensation** – change from a gas to a liquid
- **4 properties** of carbon dioxide – non-flammable, colorless, odorless, denser than air

# Vocabulary #2

- **non-flammable** – will not burn. Carbon dioxide is “non-flammable.”
- **pressure** – the amount of force acting on a unit area. As dry ice sublimates, it builds up “pressure” inside a flask and will inflate a balloon.
- **Gay-Lussac’s Law** – An increase in temperature will cause an increase in pressure of a gas
- **Boyle’s Law** – A decrease in volume will cause an increase in pressure of a gas
- **Charles’ Law** – An increase in temperature will cause an increase in volume of a gas
- **geyser** – a fountain of water or fog pushed up by pressure from below. We created a “geyser” by filling a bottle with warm water and placing a pellet of dry ice in the bottom. The dry ice sublimated and carbon dioxide gas built up inside, forcing water vapor and carbon dioxide out of the nozzle.
- **surfactant** – a soap; something that decreases the surface tension of a liquid. We added soap to a warm water-filled beaker and the soap acted as a “surfactant” to decrease surface tension, allowing us to use bubbles to capture condensed water (as fog) and carbon dioxide inside the bubbles.

# Vocabulary #3

- **surface tension** - The molecules on the surface of a liquid are not surrounded by like molecules on all sides, they are *more attracted* to their neighbors on the surface. So, soaps decrease the “surface tension” of water, allowing stable bubbles to be created.
- **denatured alcohol** – a non-drinkable alcohol used in alcohol burners. It’s flammable and freezes at -173°F. We used denatured alcohol to “freeze” water balloons and to “freeze” a flower.
- **biodegradable** – able to be broken down naturally by living organisms. For example, latex balloons are “biodegradable.”
- **permeability** – ability of a membrane to allow certain substances to pass through it without destroying the membrane. For example, the skin of a latex balloon is “permeable” to carbon dioxide – much more so than to regular air. The carbon dioxide actually breaks down the skin of the balloon, allowing more gas to escape.