**Cloud Chamber**

**Materials**
- Cloud chamber
- 91% isopropanol
- 3 tall Styrofoam trays
- Radioactive lantern mantle
- 1 short styrofoam tray
- Uraninite (pitchblende) ore
- 4 heat sinks
- Scissors
- Aluminum sheet (optional)
- X-acto knife
- Flashlight
- Liquid Nitrogen

**Background**

The Wilson cloud chamber is one of the simplest radiation detectors. It was first invented in 1911 in Scotland by physicist Charles Wilson, who won the Nobel Prize in Physics in 1927 for this work. Wilson’s cloud chamber used rapid expansion of air to produce the conditions necessary for cloud formation in a small chamber saturated with water vapor. In this lab, you will be using a similar device, called a diffusion cloud chamber, which produces the needed conditions by using a cold material (usually dry ice, liquid nitrogen, or a Peltier cooler) to cool the supersaturated air.

The diffusion cloud chamber works as shown in Figure 1. Liquid nitrogen cools steel heat sinks which are in thermal contact with the bottom of a plastic chamber. A thermal gradient is therefore set up across the chamber, since the top of the chamber, at least at first, is relatively warm at room temperature. If the air inside the chamber is allowed to become saturated with isopropanol then several distinct regions will form, depending on the temperature of the region. At the top of the chamber the isopropanol will still be in vapor form and will be invisible. At the bottom of the chamber, isopropanol droplets will form making a cloud and even isopropanol rain. Between the two regions, however, there may be a supersaturated region. In this region the isopropanol is still in vapor phase, but anything that can act as a seed will immediately cause droplets to form. This is the basis of jet contrails and cloud seeding.

It is possible, if the top of the chamber is too cold, for the chamber to fill with fog and for no supersaturated region to exist. Similarly, if the bottom is not cold enough, there may not be a supersaturated region. In these cases the chamber will not work – in fact, cloud chambers rarely work continuously for long periods of time.

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because of the need for just the right gradient. Usually they will work for a while, then either get too cold (especially when cooled by liquid nitrogen) or too warm.

**Setup**
The cloud chamber you will be using is shown in Figure 2. The heat sinks are placed with their tines downward into a Styrofoam tray into which a small amount of liquid nitrogen is poured. The chamber is inserted into a Styrofoam shield that makes the liquid nitrogen last longer and helps keep water vapor from condensing in the air around the chamber. Inside the chamber there is a felt ring with is soaked with isopropyl alcohol, causing the air in the chamber to become saturated. Tracks leaving the radioactive source can be seen in the supersaturated region of the air inside the chamber if the chamber is illuminated from the side by a flashlight.

![](image1.png)

**Figure 2.** Cloud chamber used in this experiment. The heat sinks (left photograph) are placed into the nested Styrofoam trays so that the times stick down into the liquid nitrogen. The chamber (right photograph) sits on top of the heat sinks, and contains a radioactive mantle as a source of radiation. The chamber is inserted into a hole cut into a Styrofoam shield.

**Procedure**

1. Get three nested tall Styrofoam trays, and place into them four heat sinks.
2. Trace the bottom of a chamber onto a short Styrofoam tray and cut out a hole for the chamber to fit into.
3. Trim the edges of the short tray so that it fits down inside the tall Styrofoam tray at the level of just above the top of the heat sinks. The idea is that when the chamber is inserted, the Styrofoam shield should be right at the bottom of the chamber when the chamber is sitting on the heat sink.
4. Put several drops of isopropanol on the felt liner ring inside the chamber. If it’s soaked, that’s too much.
5. Put a piece of lantern mantel in the center of the chamber and put the lid on.
6. Let it sit for several minutes for the air inside to become saturated with isopropanol vapor.
7. Pour about ½ inch of liquid nitrogen into the container while you are waiting. BE CAREFUL! It will give you a burn if it gets on your skin. Wear goggles.
8. Place the chamber in the Styrofoam shield, and pace the assembly on top of the heat sinks.
9. Turn out the lights. Illuminate the chamber from the side with the flashlight. You may need to lift the Styrofoam shield slightly to get the light to shine under it.
10. After a while you should see tracks.

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Troubleshooting
If you have trouble seeing the tracks, here are some things to try:
1. Wait longer. Especially if you don’t see any clouds. If you still don’t see any, it may mean the bottom of your chamber isn’t cold enough. Make sure it’s touching the heat sink. You may want to press down on the chamber, or place a piece of alumini on top of the heat sink and put your chamber on top of the aluminum.
2. If the top cover fogs up, remove the chamber, let it warm up, and try again.
3. If your chamber is completely full of clouds, try putting your hand on top to warm up the top. Do this with something between to keep fingerprints off the lid. If that doesn’t work, remove the chamber and let it warm up, then try again.
4. If you are having trouble getting the side light right, make a paper tube around the flashlight to direct the light. Or even a tube with a small hole.

Results
1. Can you see long, light beta particle tracks and shorter, darker alpha particle tracks? See Figure 3.
2. Try using the Uraninite ore. Does it look the same?
3. What happens when you place a magnet in the chamber? Can you get the magnetic field to deflect the particle trajectory?

Figure 3. Tracks in a cloud chamber. Light tracks from beta particles (left) and darker tracks from alpha particles (right). See C. L. Stong, Scientific American 195, 156 (1956).

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