



# CLOUD CHAMBER

## PROOF OF ALPHA AND BETA DECAY

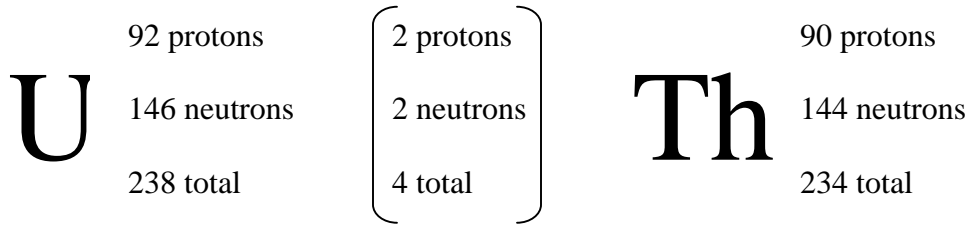
MONROE

<b>Time Frame:</b>	<b>Standards:</b>
30 minutes to construct cloud chamber 30 minutes to conclude experiment	Idaho Standard 8-9 PS 2.4.2
<b>Objectives:</b>	
Students will make simple cloud chambers, and be able to independently track the decay of radioactive elements. Students will understand the differences between the three basic decay paths, and their products.	
<b>Background Information:</b>	
<p>Radioactive decay is anytime there is a change in the nucleus of an atom that causes the element to become something else. There would be, of course, some small exceptions to this, but none that we need to worry about now.</p> <p>There are three basic kinds of decay. There is Alpha, which is a particle consisting of a helium nucleus, Beta, which is a fast moving electron, and Gamma, which is high energy, electromagnetic radiation~ a photon with lots of “punch”.</p> <p>Alpha radiation consists of a helium nucleus. It contains two protons and two neutrons, but no electrons. It has a 2+ electrical charge and is an ion.</p> <p>Beta radiation consists of a fast moving electron with a negative charge. It has <u>almost</u> no mass because an electron has only about 1/ 2,000<sup>th</sup> of the mass of a proton or neutron.</p> <p>Gamma radiation consists of high energy electromagnetic waves. The wavelength of a gamma wave is about the same distance as the space between the sides of the nucleus of a carbon atom. It is very powerful, massless and is carried by a particle called a photon. Do not get hung up on the concept of a massless particle; save that for another day.</p> <p>Recall that elements are radioactive because of an effect of the weak nuclear force. Also recall that elements are described by the components of their nucleus. Elements are named because of the number of their protons. They are also given a number based on the number of protons and neutrons combined.</p> <p>An example of a radioactive element is Uranium-238. The periodic table shows that all Uranium will have 92 protons in its nucleus. The number “238” indicates that this particular isotope of Uranium has 238 protons AND neutrons in its nucleus. Subtraction tells us there MUST be 146 neutrons only. When an atom of U-238 proceeds with Alpha decay, it will lose two protons and two neutrons, because two protons and two neutrons is an Alpha particle. It becomes Thorium-234.</p>	

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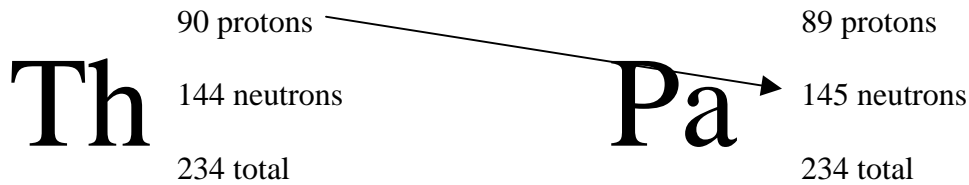
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Alpha Radiation Example



A Uranium atom, that loses an Alpha particle, will become a Thorium atom. None of the protons or neutrons change charge, they just split off of the Uranium atom.

Beta Radiation Example



A Thorium atom may have a proton that will spontaneously turn into a neutron. The total number of particles in the nucleus remains the same. Since there is now one less proton, the atom has fewer (less) positive charges. To make sure that the law of conservation of charge is not violated, an electron (beta particle) is created, and sent on its way.

Gamma Decay Example

Gamma decay does not change the nucleus of an atom; therefore no new elements are created. Gamma rays are an indicator of a high energy event.

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### Materials:

1. 1 Large plastic Petri dishes. 3” tall unit works well.
2. 1 Can of glossy black paint
3. 1 Coil of Velcro (use the loop side), or strips of felt.
4. 200 mL High grade Ethanol. Methanol will **NOT** work well. Ethanol is alcohol that can be drunk, so 190 proof or higher will work. Prior approval by school administrator is a very good idea. By all and any means one should relabel the alcohol as a chemical and not as a beverage. **Do not leave unattended.**
5. 2 kg Dry Ice. This can be kept for quite a while if it is well insulated. Keeping the dry ice in a Styrofoam minnow bucket, wrapped by a blanket, inside a box will slow the sublimation to an acceptable pace.
6. Windows. The window that you will shine a flashlight through can be made in a couple of ways. One can cut a hole in the Petri dish, and cover it with thin plastic, and this does let light through easily. One can also just cover up the dish before painting, and then remove the tape. Clear plastic will be left underneath. The instructor should try it both ways, and see which works best in that particular situation. The second window reduces glare.
7. Radiation Source. This is critical. The source should give off a lot of Alpha rays (which will provide short but thick trails), or Beta rays (which will give off long and skinny trails). Gamma rays will leave very long and wispy trails. Set the radiation source inside and in the middle of the apparatus.
  - a. Old lantern mantles from camping lanterns. If the package says “No Thorium”, it will not work.
  - b. Chunk of Potassium Chloride. Potassium is slightly radioactive. This is called “No Salt”, and can be found at most grocery stores.
  - c. Sources through scientific catalogs. Carolina Scientific ([www.carolina.com](http://www.carolina.com)) also can supply materials needed. Be cautious, because if the half-life is too short, Po is only 138 days, it will become useless in just a couple of years. Cesium is my radioactive source of choice.



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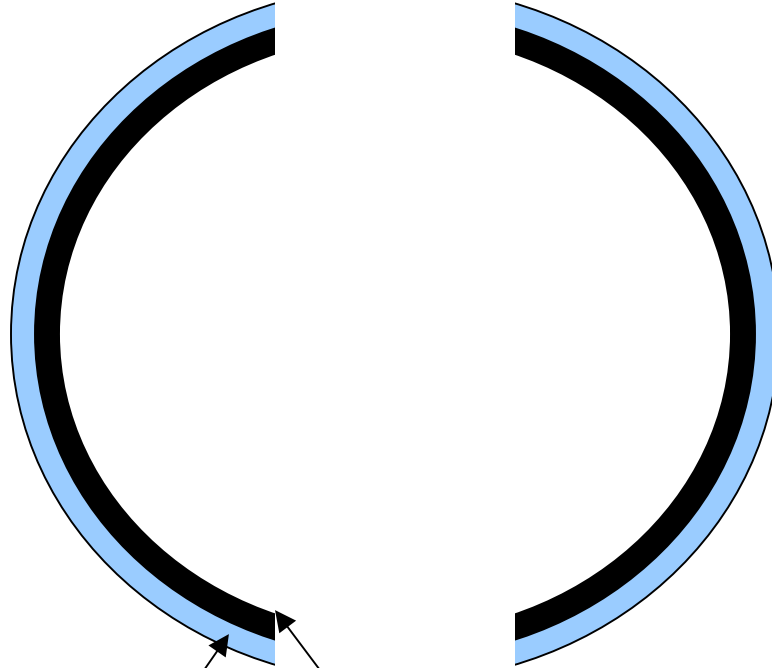
### Construction:

1. Paint the inside of the Petri dish a glossy black. Either leave some of the dish a clear plastic, or cut a window and cover that with something like overhead film.
2. Put the Velcro, or the felt, around the inside of the Petri dish. It should not impede the lid nor cover the window.
3. Place the radiation source in the center of the Petri dish. Some people also like to have a second window and introduce the radiation from the side. That is a personal choice.
4. Rub alcohol onto the Velcro, or felt, so it can evaporate into the dish.
5. Place the clear cover onto the dish. It should not be airtight, because the alcohol must displace the oxygen and nitrogen in our atmosphere.
6. Shine a flashlight through the window. A narrow beam works best.
7. Look down into the Petri dish and you should see small trails forming in the alcohol cloud. The short fat ones are Alpha; the long skinny ones are Beta. Gamma will probably not be present, but if they are present they will be long and wispy. The apparatus must become very cold.

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### Construction Diagrams:



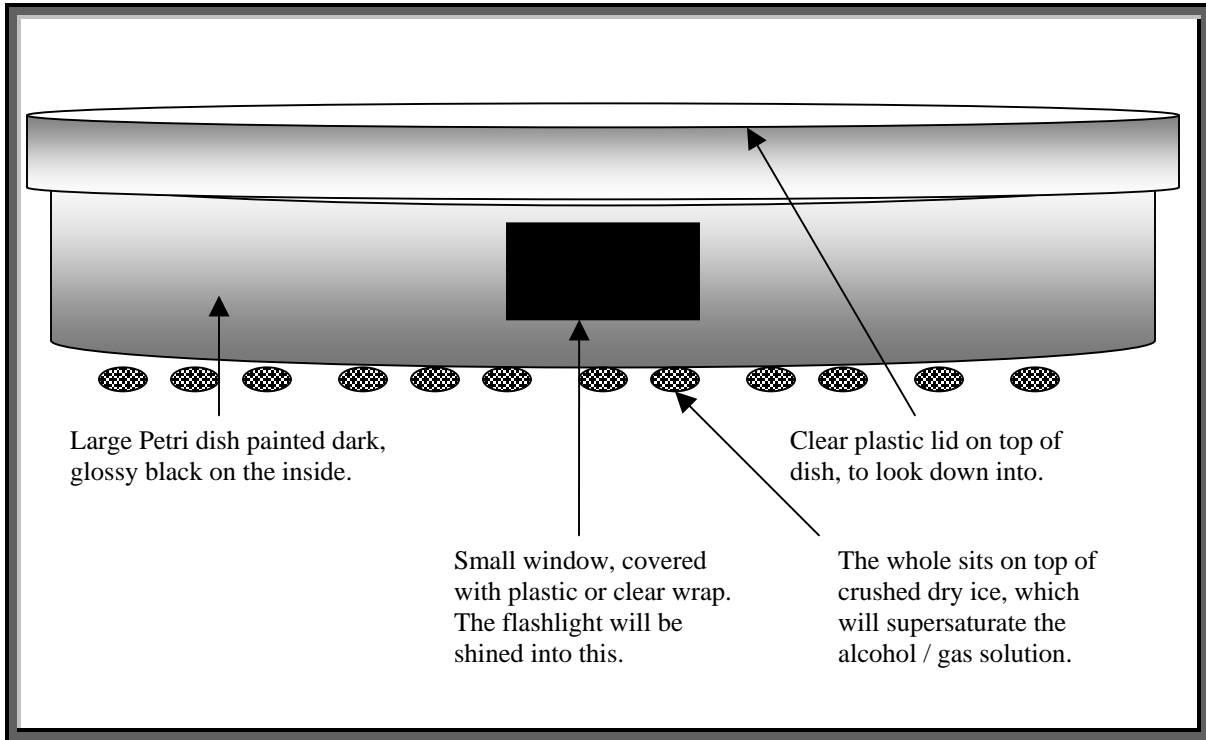
Petri dish with hole cut into the side of it as a window to shine a flashlight into.

Petri dish base lined with Velcro or felt. Rub  $C_2H_5OH$  onto the cloth so it can evaporate into the confined gas

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### How Cloud Chamber Works:

Because there is so much alcohol, the chamber is saturated with alcohol vapor (the gaseous form of alcohol). The dry ice keeps the bottom very cold, while the top is at room temperature. The high temperature at the top means that the alcohol in the felt produces much vapor, which falls downwards.

The low temperature at the bottom means that once the vapor has fallen, it is *supercooled*. That is, it is vapor form, but at a temperature at which vapor normally can't exist. It as if you had made steam at 95 C.

Since the vapor is at a temperature where it normally can't exist, it will very easily condense into liquid form. When an electrically charged cosmic ray comes along, it *ionizes* the vapor--that is, tears away the electrons in some of the gas atoms along its path. This leaves these atoms positively charged (since it removed electrons, which have negative charge). Other, nearby atoms are attracted to this ionized atom. This is enough to start the condensation process. So you see little droplets forming along the path the particle took through the chamber.

This explanation was taken from the following source:

Andrew Foland / Cornell University / Wilson Lab  
<http://www.lns.cornell.edu/~adf4/cloud.html>

### References:

Given in text