Cloud Chambers

Nuclear Chemistry

Introduction

Condensation trails in a cloud chamber provide evidence of the passage of charged radioactive particles.

Concepts

- Radioactivity
- Radioactive decay

Materials

Cloud chamber
Blotting paper viewer
Radioactive source (lantern mantle)
Ethyl alcohol, denatured
Beral-type pipet or medicine dropper
Strong light source (projector or flashlight)
Dry ice, flat, 6″ × 6″

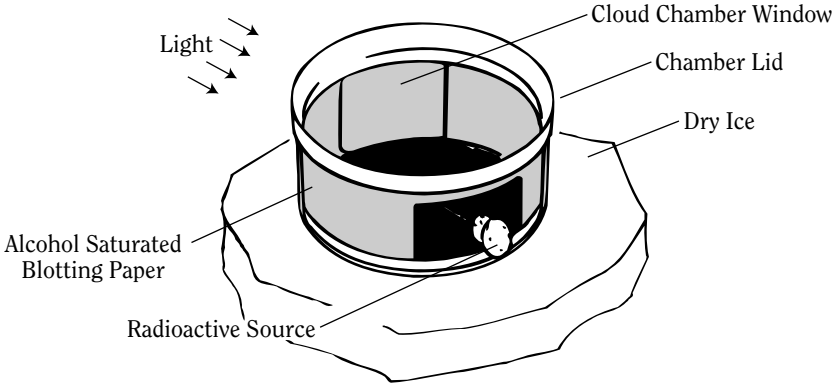
Safety Precautions

This activity requires the use of hazardous components and/or has the potential for hazardous reactions. The radiation level produced by the radioactive source is ***very*** *low (less than 0.1 μCi). Therefore, no special safety precautions need to be taken. However, it is still recommended that you wash your hands after handling the mantles and avoid inhaling mantle dust. Dry ice should be handled only with insulated gloves. Ethyl alcohol is toxic by ingestion and poses a fire hazard. Wear chemical splash goggles while performing the demonstration. Please review current Safety Data Sheets for additional safety, handling, and disposal information.*

Procedure

1. Using the Beral-type pipet or medicine dropper, soak the blotting paper inside the chamber with the ethyl alcohol. Add enough ethyl alcohol so that there is a thin layer on the bottom of the chamber.
2. Place the lid on the chamber.
3. Place the cloud chamber on a flat piece of dry ice.
4. Partially insert the radioactive source (the lantern mantle) into the hole in the side of the cloud chamber. This can be done by pushing the white side of the lantern mantle through the hole with your hands.
5. Allow the cloud chamber to sit on the dry ice for approximately 5 minutes so that it will cool. (The cloud chamber will not completely cloud up but there will be a misty layer on the bottom.)
6. Focus light from a flashlight through the cloud chamber window.
7. Observe cloud "trails" against the black bottom of the cloud chamber. (Trails are thin and look like small wisps of smoke shooting out randomly from the lantern mantle.)

The Cloud Chamber



Disposal

The dry ice can be allowed to evaporate in a well-ventilated area. The blotting paper can be allowed to dry, and the entire cloud chamber kit can be reused. The lantern mantles can be used indefinitely and can be stored in a plastic bag.

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Discussion

The radioactive source in the lantern mantle is thorium nitrate, $Th(NO_3)_4$. The thorium in the compound is thorium-232, a radioactive element which has a half-life of 1.4×10^{10} years and is an alpha-particle emitter. Alpha (α) particles are nuclear particles which are essentially helium nuclei, consisting of two neutrons and two protons. Therefore, they have a mass of 4 and a charge of +2, and are written as ${}^{4}_{2}\text{He}$. Alpha particles are one of the three basic types of ionizing radiation resulting from nuclear decay. The others are beta (β) and gamma (γ) radiation. Beta particles have almost no mass and either a positive or negative charge. If the β-particle has a negative charge, it is identical to an electron and it is written as ${}^{0}_{-1}\beta$. If the β-particle has a positive charge, it is known as a positron, and it is similar to an electron except that it has a positive charge. A positron is written as ${}^{0}_{1}\beta$. Gamma radiation, or gamma rays, are high-energy photons having no mass and no charge, and they are written as ${}^{0}_{0}\gamma$.

The reaction for the alpha decay of Th–232 is:

$$ {}^{232}_{90}\text{Th} \rightarrow {}^{228}_{88}\text{Ra} + {}^{4}_{2}\text{He} $$

Actually, the lantern mantles do not produce only α-particles. As thorium undergoes radioactive decay, "daughter elements" such as Ra–228 are produced. Ra–228 also undergoes radioactive decay, with a half-life of 5.8 years, and produces a β-particle. The reaction for the beta decay of Ra–228 is:

$$ {}^{228}_{88}\text{Ra} \rightarrow {}^{228}_{89}\text{Ac} + {}^{0}_{-1}\beta $$

The cloud chamber, also known as a fog chamber, shows the path of the radioactive particles. The particles cause ethyl alcohol vapor present in the chamber to condense. It is these liquid ethyl alcohol droplets formed in the path of the particle that are visible.

Reference

Heiserman, D. L. *Exploring Chemical Elements and Their Compounds;* TAB Books: New York, 1992; pp 288–290.

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Cloud Chambers* activity, presented by Steve Long, is available in *Nuclear Chemistry*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Cloud Chambers* are available from Flinn Scientific, Inc.

Additional materials to perform this activity are available from Flinn Scientific.

Catalog No.	Description
AP4389	Flashlight
E0012	Ethyl Alcohol, 500 mL
AP2253	Pipets, Beral-type, Pkg/20

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.