Radon Testing Lab

Pre-Lab Assignment

Read the lab description and answer the following questions based on the material contained in the reading assignment

1. Why is radon unique amongst all other naturally occurring radioactive elements?

2. Which cancers is radon thought to be an important cause of?

3. Why are alpha particles inside the body more likely to cause damage than those outside the body?

4. What is meant by ‘ionization’ and how could alpha particles cause it?

5. What are free radicals, and why are they so reactive?

6. What is the stack-effect?

7. A home was tested for radon over a period of 30 days using the technique described in this laboratory. Counting the tracks in 10 different fields of view gave 12, 9, 7, 8, 9, 7, 15, 9, 8, and 16. The diameter of the field of view was 0.2 cm. What was the activity of radon in Bq m^{-3}?

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Theory

Radon-222 is a naturally occurring radioactive gas with a half-life of 3.8 days. Radon comes from the radioactive decay of uranium-238 ($t_{1/2}$ = 4.47 x 10^9 yr); uranium is found in nearly all soils (20-30 ppb average abundance). Radon enters the home through cracks or other holes in the foundation via the ‘stack-effect’.

In this activity you will be constructing and using a radon detector to monitor the occurrence of radon in your home. Columbia Resin-39 (CR-39) is a high-clarity polymer often used in eyeglasses. As it decays, each radon atom emits a high energy alpha particle which penetrates the CR-39 (the plastic detector) forming a track, the plastic is insensitive to both beta and gamma radiation. After chemical etching the track is seen clearly under a microscope. The number of tracks in a given area can be used to estimate the radon level at the sampled location.

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Experiment: Testing for Radon

Objective

Determine the integrated radon concentration over a 30-day period inside a building.

Apparatus

CR-39 polymer with polyethylene film covering both sides, sticky-tac, polystyrene cup, cling film, rubber bands, sample holder (paper clip and split ring), 6M NaOH (240 g diluted to 1 L), test tubes, microscope with 10x objective (100x total magnification), previously exposed and etched sample for comparison.

Method

Preparation: Handle the CR-39 as little as possible and only by the edges. Use pieces approximately 10 mm x 20 mm. Remove the foil wrapping and cut the CR-39 into the required sized pieces. This is done by scoring with a scalpel or similar sharp edge and then holding the marked surface along the edge of a table and tapping it sharply. Remove the plastic layer covering the CR-39 just before placing it in the container.

Identification: Give each piece of CR-39 an identification mark, so that you will recognize it later, by scratching each piece in one corner with something sharp.

Positioning: Attach the CR-39 to the inside bottom of a polystyrene cup, using sticky-tac, as shown in Fig. 1. Make sure that you touch the CR-39 as little as possible. Cover the open end with Cling film and fix firmly with a rubber band. Place the cups on the floor or on a shelf in the sampling points that you have selected.

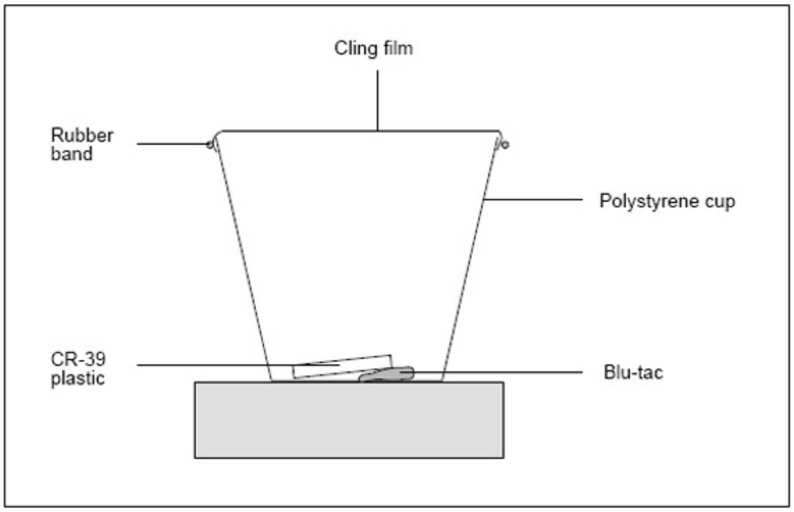


Fig. 1: Radon detection apparatus.

Please record the following information:

Date detector was put in place________	Time detector was put in place_______
Location of detector ________________	Floor level of detector ______________
Date detector was removed __________	Time detector was removed _________

After about four weeks collect the pieces of CR-39, cover them with metal foil, and secure them in a plastic bag.

Etching the Disk: After 4 weeks of exposure, remove the disk and peel off the polyethylene film from the back. Slip the ring of an “etch clamp” over the top of the disk and fasten onto a paper clip that has been bent so there is a hook at each end. Hold the disk inside a test tube, and add enough 6 M NaOH solution to cover the disk in the tube.

CAUTION: Hot 6 M NaOH is extremely corrosive. Wear goggles at all times. Rubber gloves are recommended.

Heat the test tube in a water bath at 98 °C. After 1 hour, remove the disk and rinse thoroughly with lots of water.

Counting Alpha Tracks: Determine the area (in cm^2) of the field of view of your microscope at low power (100-200x) by looking through the microscope at a ruler, a graticule or by using 4 mm squares made from graph paper. Modern microscopes may be fitted with a camera and calibrated using a calibration slide.

Practice looking at alpha particle tracks on a previously exposed and etched disk. Your disks will have fewer tracks. Note the various shapes of the tracks, which depend on how the alpha particles entered the solid (the circular-shaped tracks are due to alpha particles that entered straight in, tear-drop shaped are due to particles that entered at an angle).

CAUTION: If your microscope is dirty it may require cleaning. Check using a new blank slide.

Place your disk on a microscope slide and count the number of tracks in 10 different fields of view.

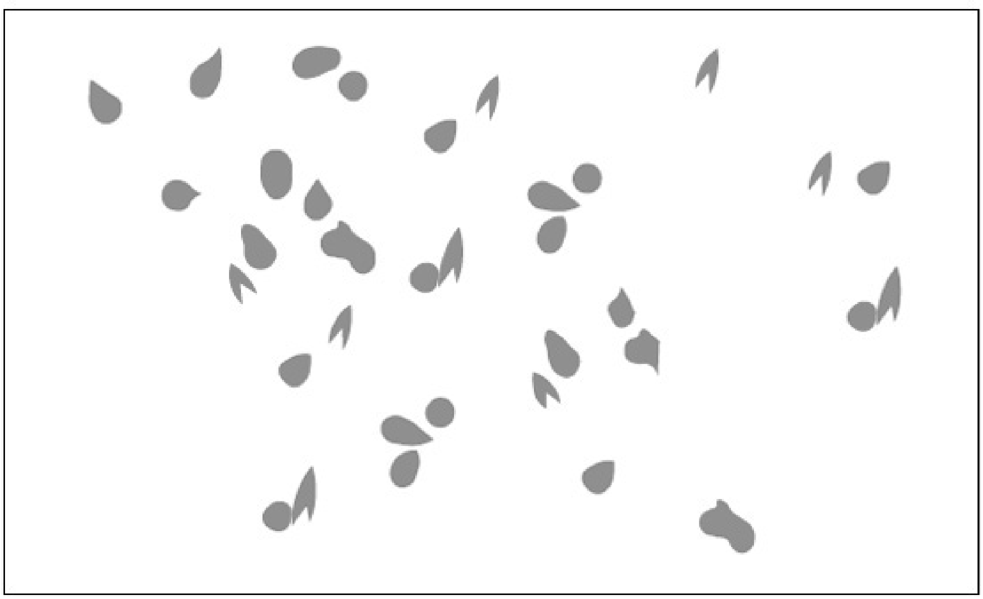


Fig. 2: Alpha tracks visible in etched CR-39 (x400).

Calculation:

Experiments have shown that tracks due to background alpha radiation are negligible. Determine the average number of tracks in a field of view for your disk, and then determine the average number of tracks per square centimeter per day.

Control disks that were sent to a radon facility in which the radon level was known to be 13700 Bq m^{-3} were found to exhibit 2585 +/- 242 tracks cm^{-2} d^{-1}. Given this relationship calculate the radon level in Becquerel's per meter cubed of air for your sample.

The precision of this experiment is not good due to daily and seasonal variations in radon levels. Commercially available alpha-track detectors give results that vary by about 25 % for a 30 day exposure at a 4 pCi L^{-1} (148 Bq m^{-3}) level.

Example Results

Counting the tracks in 10 different fields of view gave 3, 4, 4, 5, 9, 7, 4, 3, 8, and 6 for an average of 5.3 tracks.

Area of view at 10x: A = 3.14159 x $(\text{diameter}/2)^2$ = 3.14159 x$(0.17 /2)^2$ = 0.023 cm^2

Days exposed: 24.19 d

Tracks cm^{-2} d^{-1}: 5.3 tracks / 0.023 cm^2 / 24.19 d = 9.5 tracks cm^{-2} d^{-1}

Activity, A_{Rn}:

$$\frac{13700 \text{ Bq m}^{-3}}{2585 \pm 242 \text{ tracks cm}^{-2} \text{ d}^{-1}} = \frac{A_{Rn} \text{ Bq m}^{-3}}{9.5 \text{ tracks cm}^{-2} \text{ d}^{-1}}$$

A_{Rn} = 50.3 +/- 5.2 Bq m^{-3}

A simplified expression for the activity of Radon is:

$$A_{Rn} = (5.3 \pm 0.5) \times \frac{Z}{n} \text{ Bq m}^{-3}$$

where Z = no. tracks per cm^2 and n = the number of days that the CR-39 was exposed.

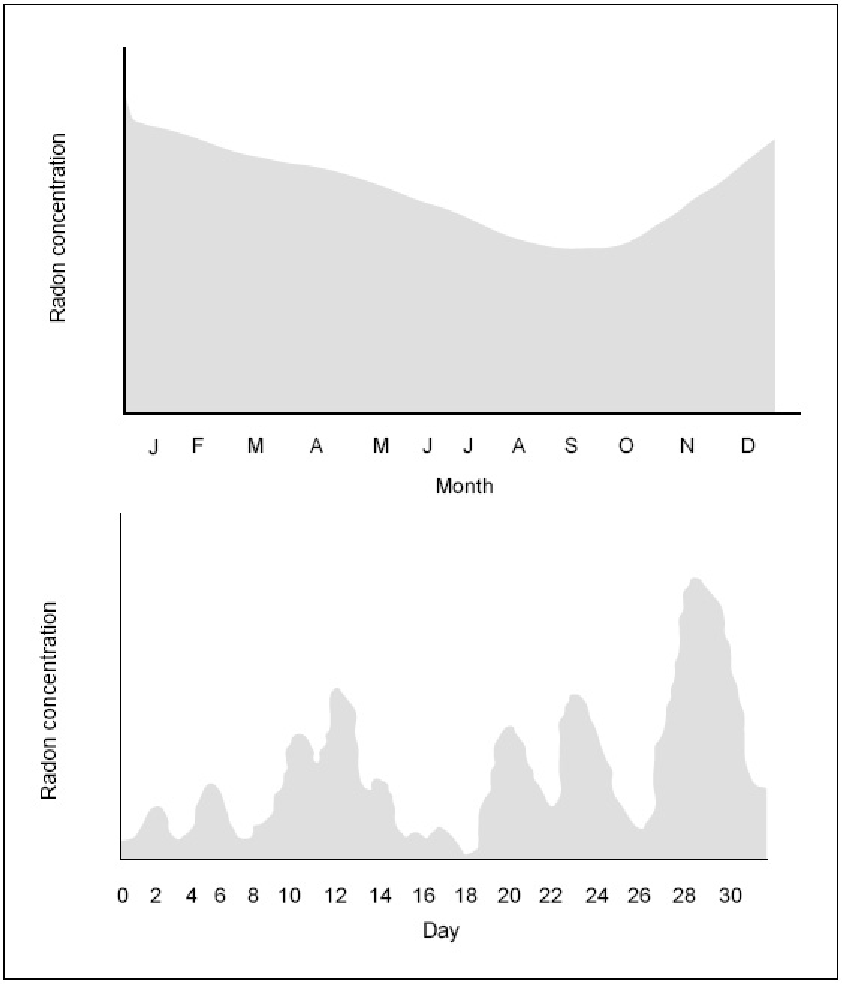
Questions:

1. Why did you record the tracks in five different fields of view?

2. How does your sample compare with the 4 pCi L^{-1} (148 Bq m^{-3}) guideline set by the US Environmental protection Agency?

3. What are some possible sources of error in the experiment?

3. What factors affect the concentration of radon in the home?



a. Explain the shape of the monthly radon distribution graph.
b. Explain the shape of the daily radon distribution graph.
c. Predict what a graph of radon concentration for one day would look like.

Explain your reasoning.