INVESTIGATION 3

WHAT IS RADON?

INTRODUCTION

Radon is a naturally occurring radioactive gas. It is formed by the radioactive breakdown of radium, and is found in soils just about everywhere. You cannot see it, taste it, or smell it. It is continuously formed in rocks and soils and escapes into the atmosphere. In some cases, it makes its way into homes, builds up to high concentrations in indoor air, and can become a health hazard.

Although there are several different isotopes of radon, the one that is of greatest concern as a potential human health threat is called radon-222. Radon-222 is formed naturally during a chain of radioactive disintegration reactions (decay series). The decay series begins when uranium-238 decays. Uranium is widely distributed in rocks and soils throughout the earth's crust. It has a half-life of 4.5 billion years, which means a very slow breakdown. The decay series is shown schematically in Figure 1. There are eight different elements and 15 different isotopes in the series, beginning with uranium-238 and ending with lead-206. New elements formed by radioactive disintegration reactions are called decay products. Thus, radium-226 is one of the decay products of uranium-238. Polonium-218 and lead-214 are decay products of radon-222. The final isotope, lead-206, is stable (non-radioactive) and its formation ends the series. All of the elements in this series are solids, except radon.

Radioactivity - the spontaneous emission of energy by certain (radioactive) atoms, resulting in a change from one element to another or one isotope to another. The energy can be in the form of alpha or beta particles and gamma rays.

Because radon is a gas, it moves freely in air spaces between rocks and in soils. It becomes a human health concern when it leaks from the underlying soil into homes and other buildings. If it builds up to high concentrations in indoor air, radon and its decay products can be inhaled and cause lung cancer. The isotopes in the series that are most damaging to biological tissues are the polonium decay products of radon, primarily when they undergo radioactive disintegration inside the lungs. The three most important geological factors that influence radon movement into homes are: 1) radium (and often uranium) concentrations in the rocks and soils under the home, 2) fractures in the rock materials, allowing upward movement of radon gas, and 3) soil permeability. **In this exercise you will examine the characteristics of the principal uranium decay products and their relationship to the radon health issue.**

Isotopes - Two or more forms of the same element which have the same number of protons, but a different number of neutrons in their nuclei.

OBJECTIVES

To identify what radon is, how it is formed, and why it is a human health concern.

PROCEDURE

1. Examine the data presented in Table 1, showing some characteristics of selected isotopes in the uranium-238 decay series, and the text box on page 30, describing the various kinds of radiation emitted. Evaluate the characteristics of radon and its relationship to other isotopes in the series, especially those characteristics that cause it to be a potential health concern.

2. Complete the analysis and answer the questions that follow.

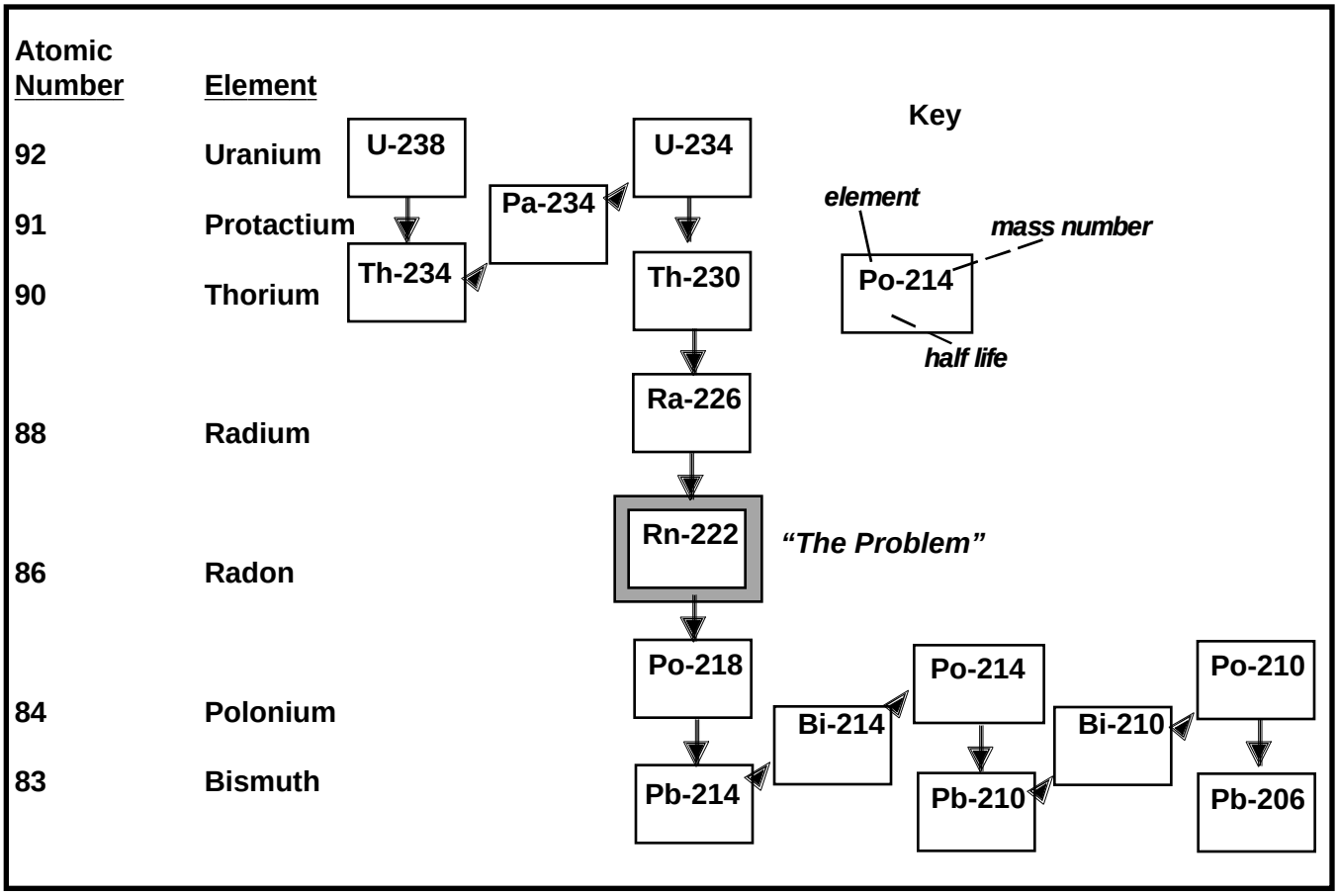

Figure 1. Radioactive decay series that proceeds from uranium-238 to lead-206. Radon-222 is the only gas formed during this series, thus allowing it to move out of the rocks and soils where uranium is found and into a home.

Kinds of Radiation

Radioactive isotopes can give off three kinds of radiation: alpha, beta, and gamma. Each kind of radiation ***can*** damage your health under certain conditions. But the kinds of radiation are very different; they differ in how far they travel, how much energy they possess, and how much damage they are likely to do.

Type of Radiation	Relative Relative Size	Amount of Energy	Penetrating Ability
Alpha particle	large particle	great	poor - will not penetrate human skin
Beta particle	small particle	small	moderate - can penetrate human skin
Gamma ray	very small energy ray	small	good - can pass right through your body

DATA

Table 1. The following table provides information on some of the isotopes that occur in the uranium-238 decay series.

Isotope	Physical State	Principal Radioactive Emission	Half-life	Decays to Form
uranium-238	solid	alpha	4.5 billion years	thorium-234
radium-226	solid	alpha, gamma	1600 years	radon-222
radon-222	gas	alpha	3.8 days	polonium-218
polonium-218	solid	alpha	3 minutes	lead-214
lead-214	solid	beta, gamma	27 minutes	bismuth-214
bismuth-214	solid	beta, gamma	19.7 minutes	polonium-214
polonium-214	solid	alpha	164 microseconds	lead-210

ANALYSIS

3. Would radon be a greater, or lesser, health threat if its half-life was 1 second instead of 3.8 days? Why? What if its half-life was 50 years?

Hint: Half-life tells us how long the isotope will last before it decays into something else.

4. Does the fact that radon is the only gas in the uranium-238 decay series increase or decrease its importance as a potential health threat? Why and how?

5. When radon is formed within the soil, it may or may not reach the air spaces within the soil, thereby allowing the radon gas to escape from the soil. A very important factor influencing whether or not this will occur concerns*where* in the soil the radon is formed. Only radon atoms formed very close to the outer surface of the soil particles are likely to reach the soil air spaces. What happens to the atoms of radon gas that form in the middle of a large soil particle?

The National Uranium Resource Evaluation (NURE) Project was conducted in the 1970s by the U.S. Department of Energy. An important goal of NURE was to discover areas with uranium concentrations sufficiently high for uranium extraction (mining). Part of the program involved airborne radiometric reconnaissance. Airborne radiation detection devices were used to identify areas for follow-up ground studies. The process involved radium measurements, which sometimes, but not always, correlated well with high radon levels. Although the program was not designed for the study of radon, it did provide some useful data for the evaluation of areas where homes might be expected to contain high radon concentrations.

6. Review the information presented in the inset box regarding the NURE Program. Did the airborne reconnaissance component of NURE involve measurement of alpha, beta, or gamma radiation? How do you know?

CONCLUSIONS

7. List 4 properties, or characteristics, of radon that cause it to be an important health concern. Explain why each property is important in influencing radon human health effects.

8. Radon has been known to reach the ground surface from one hundred feet or more below the ground. How might this occur, given the physical state and half-life of radon?