

# Ropes and Isotopes

## Isotopes and Atomic Mass

### Introduction

How can you use a rope trick to show how atomic mass is calculated? Watch and be amazed.

### Concepts

- Isotopes
- Atomic mass

### Materials

Rope

### Safety Precautions

*The materials in this lab are considered nonhazardous.*

### Preparation

1. Cut three pieces of rope—six inches, nine inches, and twelve inches

### Procedure

1. Each piece represents a different atomic mass of the element “rope”—isotopes of rope. Each isotope occurs thirty-three percent of the time so the average atomic mass is a simple average of the three isotopes.
2. Place the three pieces of rope into your non-dominant hand with the short piece closest to the wrist, the long piece in the middle, and the medium-sized piece closest to the finger tips (see Figure 1).
3. Show the three rope pieces being held in the palm of your hand as you discuss the fact that on the periodic table of the elements, the atomic mass that is listed is the average mass based upon the abundance of each isotope.
4. As you wrap the rope pieces ensure you do not show your palm to the students. Wrap one end of the short rope on the far side of the long rope.
5. Wrap the free end of the long rope between the short rope and the medium-sized rope.
6. Wrap the free end of the medium-sized rope next to itself (see Figure 2).
7. Carefully grab one end of the medium-sized rope and both ends of the long rope. Use your thumb to hold the two short rope ends and the remaining medium-sized rope end.
8. Pull down both ends of the long rope and one end of the medium-sized rope. Your hand should hide all of the short rope except the two ends extending above your hand. The long rope ends hang down from the loop of the short rope (see Figure 3).
9. Pick up one end of the long rope and replace it into your hand.
10. Repeat with the other end of the long rope and again with the free end of the medium-sized rope.
11. Carefully grab one end of each piece of rope and drop the other ends to show the three different lengths.

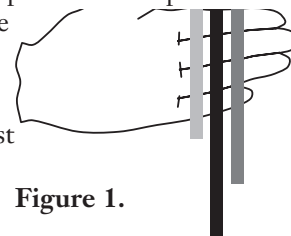


Figure 1.

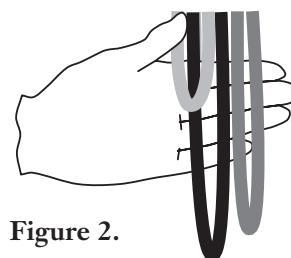


Figure 2.

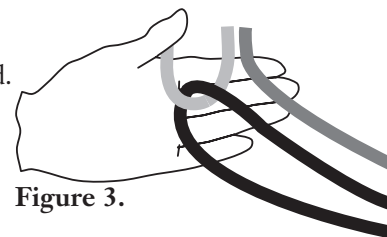


Figure 3.

### Tips

- Practice, practice, practice before performing this demonstration for an audience.
- The lengths of rope provided here are not the only lengths that will work. The important factor is that the length of the long rope while it is hanging from the short rope matches the length of the medium-sized rope.

### Discussion

*Isotopes* are defined as atoms that have the same number of protons but different numbers of neutrons. Since the identity of an element depends only on the number of protons (the atomic number), isotopes have the same chemical properties. Isotopes are thus chemically identical—they form the same compounds, undergo the same reactions, etc. Isotopes are distinguished from one another based on their *mass number*, defined as the sum of the number of protons and neutrons in the nucleus of the atom.

Chlorine, for example, occurs naturally in the form of two isotopes, chlorine-35 and chlorine-37, where 35 and 37 represent the mass numbers of the isotopes. Each isotope of chlorine has a characteristic *percent abundance* in nature. Thus, whether it is analyzed from underground salt deposits or from seawater, the element chlorine always contains 75.8% chlorine-35 atoms and 24.2% chlorine-37 atoms. The atomic mass of an element represents the *weighted average* of the masses of the isotopes in a naturally occurring sample. Equation 1 shows the atomic mass calculation for the element chlorine.

$$\text{Atomic mass (chlorine)} = (0.758)(35.0 \text{ amu}) + (0.242)(37.0 \text{ amu}) = 35.5 \text{ amu} \quad \text{Equation 1}$$

### Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

***Unifying Concepts and Processes: Grades K–12***

Evidence, models, and explanation

***Content Standards: Grades 5–8***

Content Standard B: Physical Science, properties and changes of properties in matter

***Content Standards: Grades 9–12***

Content Standard B: Physical Science, structure and properties of matter

### References

McCormack, A. J. *Magic and Showmanship for Teachers*; Idea Factory, Inc.: Riverview, FL; 1990-06

### Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Ropes and Isotopes* activity, presented by Mike Roadruck, is available in *Isotopes and Atomic Mass* and in *There's Magic in Chemistry*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.