Investigation 1.4.1 OBSERVATIONAL STUDY

The Nuts and Bolts of Atomic Mass

SKILLS MENU

- Questioning
- Researching
- Hypothesizing
- Predicting
- Planning
- Controlling Variables
- Performing
- Observing
- Analyzing
- Evaluating
- Communicating

The atomic mass recorded on the periodic table is the weighted average of all the naturally occurring isotopes for that element. One of the challenges when working with atomic models and concepts is that we cannot see individual atoms—let alone measure their mass. To help you to understand the concept of atomic mass, you will use nuts and bolts to build models of the different isotopes of the element boltium (an element very similar to hydrogen!). In this model, the bolts will represent protons and the nuts will represent neutrons (**Figure 1**). You will find the mass and abundance of these different isotopes and you will use this data to determine the atomic mass for boltium.

Figure 1 Nuts and bolts represent neutrons and protons of the element boltium.

Purpose

To gain a better understanding of the concept of atomic mass

Equipment and Materials

- 20 bolts
- 40 nuts
- plastic cup
- electronic balance

Procedure

SKILLS HANDBOOK A2.1, A2.4

1. Create a table in which to record your observations.
2. Obtain a sample of boltium from your teacher. Your sample will contain a mixture of different boltium isotopes: boltium-1, boltium-2, and boltium-3.
3. Place your sample of boltium in a plastic cup. Measure and record the total mass of the sample in the cup.
4. Carefully empty the contents onto a large flat surface.
5. Measure and record the mass of the empty cup.
6. Sort the different isotopes of boltium. Count and record the total number of atoms of each isotope.
7. Measure and record the mass of all of the boltium-1 atoms.
8. Repeat Step 7 for the other two isotopes.

Analyze and Evaluate

(a) From your measurements in Steps 3 and 4, calculate the total mass of your sample of boltium. T/I

(b) Calculate the isotopic abundance for each isotope of boltium. T/I

$$\%\text{ abundance of boltium-1} = \frac{\#\text{ of atoms of boltium-1}}{\text{total }\#\text{ of atoms}} \times 100\%$$

(c) Calculate the mass for your entire sample by multiplying your atomic mass by the total number of atoms. T/I

(d) Compare the measured mass of your sample to the calculated mass of your sample determined in Question (c). Explain your answer. T/I

Apply and Extend

(e) Determine the atomic mass for one atom of boltium using the mass of each isotope and the isotopic abundance for each isotope. T/I

(f) Describe the difference between the isotopes of neon-19, neon-20, and neon-22. K/U

(g) Define the terms isotope, isotopic abundance, and atomic mass. K/U

(h) This activity is intended to provide an analogy or comparison to isotopes and atomic mass. Are nuts and bolts good analogies for isotopes of atoms? Explain the benefits and drawbacks of using this analogy. T/I

Investigation 1.5.1 OBSERVATIONAL STUDY

The Search for Patterns

SKILLS MENU

- Questioning
- Researching
- Hypothesizing
- Predicting
- Planning
- Controlling Variables
- Performing
- Observing
- Analyzing
- Evaluating
- Communicating

As you examine the physical and chemical properties of elements in groups and periods, you will be able to connect these properties to the atomic structure of the elements.

This two-part investigation allows you to explore the patterns in reactivity in the periodic table. In Part A, you will observe what happens when five metals (calcium, magnesium, copper, sodium, and lithium) are placed in water. In Part B, you will test the reaction of four metals (magnesium, iron, zinc, and aluminum) with dilute hydrochloric acid.

Purpose

To observe relationships between the reactivity of elements and their location on the periodic table

Equipment and Materials

SKILLS HANDBOOK A1.2, A1.2

Part A: Reactivity of Metals in Water

- chemical safety goggles
- lab apron
- safety gloves
- 250 mL beaker
- test tube (18 mm × 150 mm)
- test-tube rack
- scoopula
- spark lighter
- Bunsen burner clamped to a retort stand
- test-tube clamp
- red and blue litmus paper or pH paper
- paper towel
- small samples of
  - calcium, Ca(s)
  - magnesium, Mg(s)
  - copper, Cu(s)
- wooden splint
- small samples of
  - sodium, Na(s) (to be handled by your teacher only)
  - lithium, Li(s) (to be handled by your teacher only)

This investigation involves the use of open flames. Tie back long hair and secure loose clothing.

Calcium, sodium, and lithium are highly reactive and may burn in water. Do not touch any of these metals with your hands. Only your teacher should handle sodium and lithium.

Part B: Reactivity of Metals in Hydrochloric Acid

- chemical safety goggles
- lab apron
- safety gloves
- 20 mL graduated cylinder
- 4 test tubes (18 mm × 150 mm)
- test-tube rack
- scoopula
- small samples of
  - magnesium, Mg(s)
  - iron, Fe(s)
  - zinc, Zn(s)
  - aluminum, Al(s)
- dilute hydrochloric acid (0.5 mol/L)
- spark lighter
- Bunsen burner clamped to a retort stand
- paper towel
- wooden splint
- masking tape or test-tube stopper

Hydrochloric acid is an irritant. Wash any spills on skin or clothing immediately with plenty of cold water. Report any spills to your teacher.

This investigation involves the use of open flames. Tie back long hair and secure loose clothing.

Procedure

SKILLS HANDBOOK A2.1, A2.4

1. Read the entire procedure before conducting the lab. Prepare a list of safety concerns. Discuss how these concerns should be addressed in the lab.
2. Prepare appropriate data tables in which to record your observations. Write titles for all data tables.
3. Write a procedure, based on **Figure 1** (on the next page), to collect any gas produced when a metal reacts with water. Include any necessary safety precautions. Ask your teacher to approve your procedure.

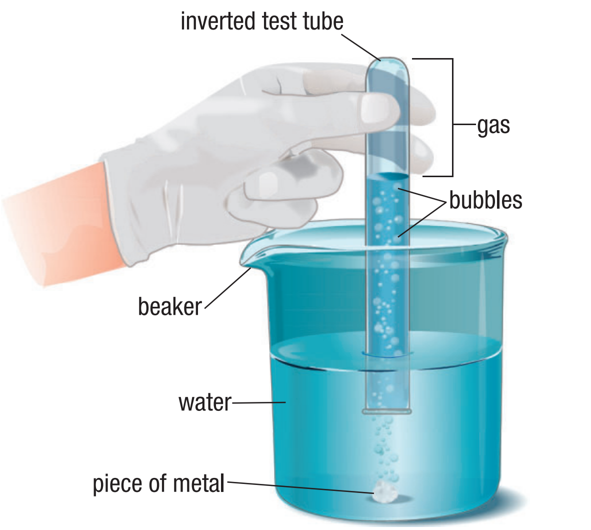

Figure 1 Collecting gas produced by the reaction of a metal in water

Part A: Reactivity of Metals in Water

4. Put on your safety goggles, lab apron, and safety gloves.
5. Half-fill a clean 250 mL beaker with tap water.
6. Test the water with either litmus paper or pH paper. Record your results.
7. Using a folded, square piece of paper towel, obtain a piece of calcium from your teacher. Observe and record its physical properties.
8. Stand at arm's length from the beaker. Using the scoopula, carefully place the calcium in the water. Record your observations.
9. When the reaction is complete, test the resulting solution with either litmus paper or pH paper. Record your results.
10. Dispose of the waste materials according to your teacher's instructions. If possible, recycle your materials.
11. Repeat this procedure using samples of magnesium and copper. Record all your results.
12. Select a metal that produced a gas when reacting with water. Use your approved procedure from Step 3 to collect a test-tubeful of the gas.
13. Set the test tube, mouth down, in the test-tube rack.
14. Use the spark lighter to light your Bunsen burner. Light a wooden splint from the flame. Turn off the burner.
15. Using a test-tube clamp, lift the test tube and stand it, with its opening at the top, in the test-tube rack.
16. Insert the burning splint inside the mouth of the test tube. Record your observations.
17. Extinguish the splint with water from the tap. Dispose of any waste according to your teacher's instructions.
18. Watch your teacher perform the same tests on sodium and lithium. Observe and record the results.

Part B: Reactivity of Metals in Hydrochloric Acid

19. Put on your safety goggles, lab apron, and safety gloves.
20. Measure out 20.0 mL of dilute hydrochloric acid. Pour 5.0 mL into each of four clean test tubes in your test-tube rack.
21. On folded pieces of paper towel, obtain small quantities of magnesium, iron, zinc, and aluminum from your teacher.
22. Record the physical properties of each of the metals.
23. One at a time, carefully drop each of the metals into a different test tube of hydrochloric acid.
24. Observe over a 20 min period. Occasionally feel the test tubes with your hand to find out if they get warmer as any reaction proceeds. Record your observations.
25. If you observe bubbles, collect a sample of the gas by covering the test tube loosely with a piece of masking tape or a rubber stopper. While the test tube is in the test-tube rack, test the resulting gas by removing the stopper and quickly holding a glowing splint just inside the mouth of the test tube. (Light the splint using the procedure in Step 14.)
26. Recycle or dispose of any waste according to your teacher's instructions.

Analyze and Evaluate

(a) Rank the elements tested in Part A from least reactive to most reactive. T/I C

(b) Sort the elements that you tested into groups. State the apparent order of reactivity as one proceeds down a group. Does reactivity increase or decrease? T/I

(c) Sort the elements that you tested into periods. State the apparent order of reactivity as one proceeds across a period. Does reactivity increase or decrease? T/I

(d) Is the solution that is produced when a metal reacts with water acidic or basic? T/I

(e) Based on your gas test observation in Step 16, what gas is produced? T/I

(f) Rank the elements tested in Part B from least reactive to most reactive. T/I

(g) Does the reactivity increase or decrease as one moves across a period of elements? T/I

(h) Based on your gas test results, what is the gas produced in these reactions (Steps 16 and 25)? T/I

(i) Does the reactivity increase or decrease as one moves down a group of elements? T/I

(j) Evaluate this investigation. Did the design enable you to collect enough evidence to answer the questions? How could it have been improved? Would your suggested improvements raise any safety concerns? T/I

Apply and Extend

(k) Predict what might happen if you were to drop a piece of potassium into a beaker of water. T/I

(l) Connect the trends observed in Parts A and B to atomic radius, ionization energy, and electron affinity. Write a paragraph to explain the trends. T/I C

Investigation 1.7.1 CORRELATIONAL STUDY

SKILLS MENU

• Questioning	• Planning	• Observing
• Researching	• Controlling Variables	• Analyzing
• Hypothesizing	• Performing	• Evaluating
• Predicting		• Communicating

Graphing Periodic Trends

We can identify several periodic trends when we explore the arrangement of elements in the periodic table. In this investigation you will graph provided data for the atomic radius and the first ionization energy of the first 20 elements. You can use graph paper or graphing software to create your graph. You will search for the trends and attempt to explain the relationship among these properties.

Purpose

To discover how two periodic properties, atomic radius, and first ionization energy, vary with the atomic number for the first 20 elements

Variables

What variables are involved in this investigation?

Equipment and Materials

- graph paper or graphing software

Procedure

SKILLS HANDBOOK A2.3

1. Find the data for atomic radii and first ionization energy in Section 1.7, Figures 2 and 5.
2. Select a graphing program or obtain a piece of graph paper.
3. Label the horizontal axis "Atomic number." It should go from 1 to 20, representing the elements H to Ca. Choose an appropriate scale.
4. Label the vertical axis on the right "Atomic radius." Choose an appropriate scale and include the appropriate units.
5. Label the vertical axis on the left "First ionization energy." Choose an appropriate scale and include the appropriate units.
6. Plot the values of atomic radius versus atomic number. Join the points using straight lines.
7. Plot the values of first ionization energy versus atomic number. Join the points using a different colour.
8. Write a title and provide a legend to indicate the two different trend lines.

Analyze and Evaluate

(a) Describe any trends for atomic radius versus atomic number within a period and within a group. T/I

(b) In which group of elements do the atoms have the largest radii as you move across a period? T/I

(c) In which group of elements do the atoms have the smallest radii as you move across a period? T/I

(d) Describe any trends for first ionization energy versus atomic number within a period and within a group. T/I

(e) In which group of elements do the atoms have the greatest first ionization energy as you move across a period? T/I

(f) In which group of elements do the atoms have the smallest first ionization energy as you move across a period? T/I

(g) Compare the trend for atomic radius and the trend for ionization energy. How do these properties relate to one another? T/I

(h) Using your graphed data, predict the atomic radius and the ionization energy for scandium, Sc, and titanium, Ti. Research the accepted values. Compare your predictions to the actual values. How close were your predictions? T/I

Apply and Extend

(i) Predict the relationship between electron affinity and atomic number. Sketch a graph of these two variables. Label the axes properly. T/I C

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