Density Is A Periodic Property Lab Answers

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Flinn ChemTopic™ Labs: The Periodic Table

Density is a Periodic Property

Discovering an Element

Introduction

"With the periodic and atomic relations now shown to exist between all atoms and the properties of their elements, we see the possibility not only of noting the absence of some of them but even of determining...properties of them as yet unknown elements."

Dmitri Mendeleev proposed the periodic law for the classification of elements in 1869–1871. After observing trends in the properties of elements when they were arranged in order of increasing atomic mass, Mendeleev made a startling prediction. He predicted the existence and properties of at least three undiscovered elements. Mendeleev saw what other scientists before him had missed—he saw what wasn't there!

Concepts

- Periodic law
- Density
- Group IV elements
- Period number

Background

At the time Mendeleev proposed the periodic law, the foundation of the modern Periodic Table for the classification of elements, 63 elements were known. Their physical and chemical properties had been studied, and their atomic masses measured. Mendeleev arranged the known elements in a calendar-like table of rows and columns in order of increasing atomic mass and repeating chemical properties. It is at this point, however, that Mendeleev made a giant leap of discovery—he suggested that there were some gaps or missing elements in the list of known elements.

Among the Group IV elements in Mendeleev's classification scheme, carbon appeared in the second row, followed by silicon in the third row. Both tin and lead shared similar chemical properties with carbon and silicon and were also known at this time. Because of their high atomic masses, however, these metals were placed in later rows of Mendeleev's Group IV column of elements. In 1871, Mendeleev proposed that there existed an as-yet-unknown element beneath silicon in the Group IV elements. He named the missing element eka-silicon and predicted its physical properties (atomic mass, melting point, density and specific heat). In 1886, the element germanium was discovered by the German chemist Clemens Winkler. In his report of the discovery, Winkler stated: "There can be no longer any doubt that the new element is no other than the eka-silicon prognosticated fifteen years ago by Mendeleev."

Within 15 years of Mendeleev's prediction of the existence of missing elements, three of the elements had been discovered, their properties in excellent agreement with those predicted by Mendeleev. Is it possible to recreate some of the excitement that followed the prediction and discovery of Mendeleev's missing elements?

Experiment Overview

The purpose of this experiment is to measure mass and volume data for silicon, tin and lead, calculate their densities, and use these results to predict the density of germanium, Mendeleev's "undiscovered" element in the Group IV family of elements. The volume of the elements will be measured by water displacement.

Pre-Lab Questions

1. One of the elements Mendeleev predicted was eka-aluminum, corresponding to a gap in the fourth row or period of the Group IIIA elements, between aluminum and indium. The density of aluminum (period 3) is 2.70, that of indium (period 5) 7.31 and that of thallium (period 6) 11.85 g/cm³. Make a graph of period number on the *x*-axis versus density on the *y*-axis for each of these elements.
2. Use your graph to predict the density of eka-aluminum. What known element in the modern Periodic Table corresponds to eka-aluminum? Look up the density of the modern element in a reference source, and record its actual and predicted density values.
3. How do the actual and predicted density values compare? Use the following equation to calculate the percent error between the predicted and actual values for the density of eka-aluminum.

$$\text{percent error} = \frac{|\text{actual} - \text{predicted}|}{\text{actual}} \times 100\%$$

Materials

Lead shot, Pb, 35–40 g
Silicon lumps, Si, 8–10 g
Tin shot, Sn, 25–30 g
Water
Balance, centigram (0.01 g precision)
Beakers, 50-mL, or small cups, 3
Forceps or tongs
Graduated cylinder, 25-mL
Marking pencil or pen
Paper towels

Density is a periodic property lab answers represent a crucial aspect of understanding the periodic table and the behavior of elements. Density, defined as mass per unit volume, is not only a physical property but also plays a significant role in various scientific applications, including material science, chemistry, and engineering. The periodic trends in density can reveal much about an element's atomic structure, bonding characteristics, and even its reactivity. This article will explore how density serves as a periodic property, the methodology for conducting density lab experiments, and how to interpret the results effectively.

Understanding Density as a Periodic Property

Density varies among different elements and often shows periodic trends when analyzed in the context of the periodic table. The key factors influencing density include:

- **Atomic Mass:** Heavier elements tend to have higher density.
- **Atomic Volume:** The volume occupied by atoms influences how tightly packed they are.
- **Crystal Structure:** The arrangement of atoms in a solid can affect its density.
- **Elemental State:** Gases, liquids, and solids have different densities due to atomic spacing.

As one moves down a group in the periodic table, the atomic mass generally increases, leading to higher density. However, this trend can be complicated by changes in atomic volume and structure.

Periodic Trends in Density

Density does not increase uniformly across the periodic table. Some trends include:

1. Group Trends: As you move down a group (e.g., alkali metals), density typically increases because the atomic mass increases faster than the atomic volume.

2. Period Trends: As you move from left to right across a period, density generally increases due to increasing atomic mass, although the increase in atomic volume can counter this trend.

3. Transition Metals: These elements often exhibit higher densities due to their packed crystal structures and the presence of d-orbitals that allow for greater mass.

4. Noble Gases: Notably, noble gases show a decrease in density across periods, attributed to their relatively low atomic masses and gaseous state at room temperature.

Conducting a Density Lab Experiment

To explore the concept of density as a periodic property, a laboratory experiment can be designed. Below, we outline a typical procedure for measuring the density of various elements or compounds.

Materials Needed

- Samples of different elements or compounds (e.g., metals, liquids)
- Balance (for measuring mass)
- Graduated cylinder or measuring cup (for measuring volume)
- Water (for displacement method, if applicable)
- Calculator (for computing density)

Procedure

1. Measure Mass:
- Use a balance to measure the mass of the sample. Record the mass in grams (g).

2. Measure Volume:
- For solids: If the solid is irregularly shaped, use the water displacement method. Fill a graduated cylinder with a known volume of water, then submerge the sample and measure the new water level. The difference gives the volume of the solid.
- For liquids: Measure the volume directly using a graduated cylinder.

3. Calculate Density:
- Use the formula:
$$
\text{Density} = \frac{\text{Mass}}{\text{Volume}}
$$
- Record the density in grams per cubic centimeter (g/cm³) or grams per milliliter (g/mL).

4. Repeat for Multiple Samples:
- Conduct the same measurements for various elements or compounds. Aim to include a range of elements across different periods and groups.

Data Analysis and Interpretation

Once data is collected, the next step is to analyze the results. A sample dataset might look like this:

Element	Atomic Number	Mass (g)	Volume (cm³)	Density (g/cm³)
Lithium	3	6.94	3.56	1.95
Sodium	11	22.99	10.93	2.10
Potassium	19	39.10	16.20	2.41
Iron	26	55.85	7.87	7.11
Gold	79	196.97	10.19	19.32

From the data, you can observe:

- Increasing Density: The density of metals tends to increase as you move down a group (e.g., from Lithium to Potassium).
- Variation Across Periods: Transition metals like Iron and Gold show significantly higher densities compared to alkali metals.

Conclusion

Understanding how density is a periodic property provides valuable insights into the nature of elements. Through laboratory experiments, students and researchers can observe firsthand the trends in density across different groups and periods of the periodic table. The periodic trends in

density reveal information about atomic structure and bonding, helping to explain why certain elements behave the way they do in chemical reactions and physical processes.

By conducting density experiments and analyzing the results, scientists can deepen their understanding of material properties, paving the way for advancements in fields such as chemistry, materials science, and engineering. Whether in academic settings or industrial applications, the knowledge gained from studying density as a periodic property is indispensable.

Frequently Asked Questions

What is density and why is it considered a periodic property?

Density is defined as mass per unit volume of a substance. It is considered a periodic property because it varies in a predictable manner across the periodic table, often influenced by atomic structure and bonding.

How can density be measured in a laboratory setting?

Density can be measured using the formula density = mass/volume. In the lab, mass is measured using a balance and volume can be determined using graduated cylinders or by water displacement.

What are some common units for measuring density?

Common units for density include grams per cubic centimeter (g/cm^3), kilograms per cubic meter (kg/m^3), and grams per milliliter (g/mL).

Why do different elements have different densities?

Different elements have varying densities due to differences in atomic mass and atomic structure. Heavier atoms and closely packed structures typically result in higher densities.

What role does temperature play in density measurements?

Temperature affects the density of substances; as temperature increases, most substances expand, leading to a decrease in density. Accurate density measurements should consider temperature.

Can density be used to identify an unknown substance?

Yes, density is a useful property for identifying unknown substances. By comparing the measured density with known values, one can often determine the substance.

What is the relationship between density and the periodic table?

Density tends to increase down a group in the periodic table due to increasing atomic mass, while it can vary across periods based on atomic structure and bonding.

How does the concept of density apply to gases?

For gases, density is defined similarly (mass/volume), but it is affected more significantly by temperature and pressure, making it less predictable compared to solids and liquids.

What experimental techniques can be used to determine the density of a solid?

Common techniques include using a balance to measure mass and a graduated cylinder for volume, or applying the Archimedes principle for irregularly shaped solids.

What safety precautions should be taken when conducting density experiments in the lab?

Safety precautions include wearing appropriate personal protective equipment (PPE), handling chemicals safely, ensuring proper ventilation, and following all lab protocols.

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