# Lab 13. Density and the Periodic Table: What Are the Densities of Germanium and Flerovium?

## Introduction

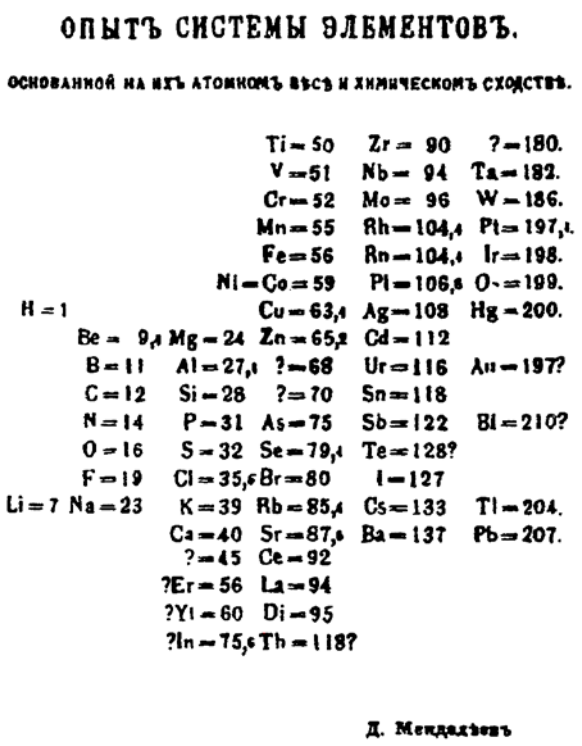
At the time Dmitri Mendeleev proposed his periodic table for the classification of the elements in 1869, only 63 elements were known. Mendeleev arranged these 63 elements into a table of rows and columns in order of increasing atomic mass and by repeating physical properties. He also suggested that there were some missing elements that still needed to be discovered.

In Mendeleev's periodic table (see Figure L13.1), carbon and silicon were placed in the same period. Carbon appeared in the 2nd group and silicon appeared in the 3rd group. Mendeleev then proposed that there should be another element in this period. He named the missing element eka-silicium and predicted its physical properties. The German chemist Clemens Winkler discovered a new element in 1886 and called it germanium. In one of his reports of the discovery, he stated,

> It was definitely premature when I expressed such an assumption in my first notice concerning germanium; at least there was no basis for its proof. Nor would I have ventured at first to assume argyrodite to be a sulpho salt with a quadrivalent acid radical, because there were no analogies at all for such an assumption. Thus the present case shows very clearly how treacherous it can be to build upon analogies; the quadrivalency of germanium has by now become an incontrovertible fact, and there can be no longer any doubt that the new element is no other than the eka-silicium prognosticated fifteen years ago by Mendeleev. (Winkler 1886)

## FIGURE L13.1

**Mendeleev's 1869 periodic table**



ОПЫТЪ СИСТЕМЫ ЭЛЕМЕНТОВЪ.

ОСНОВАННОЙ НА ИХЪ АТОМНОМЪ ВѢСѢ И ХИМИЧЕСКОМЪ СХОДСТВѢ.

| | | | | |
|---|---|---|---|---|
| | | Ti = 50 | Zr = 90 | ? = 180. |
| | | V = 51 | Nb = 94 | Ta = 182. |
| | | Cr = 52 | Mo = 96 | W = 186. |
| | | Mn = 55 | Rh = 104,4 | Pt = 197,1. |
| | | Fe = 56 | Ru = 104,4 | Ir = 198. |
| | | Ni = Co = 59 | Pl = 106,6 | O = 199. |
| H = 1 | | | Cu = 63,4 | Ag = 108 | Hg = 200. |
| | Be = 9,4 | Mg = 24 | Zn = 65,2 | Cd = 112 | |
| | B = 11 | Al = 27,4 | ? = 68 | Ur = 116 | Au = 197? |
| | C = 12 | Si = 28 | ? = 70 | Sn = 118 | |
| | N = 14 | P = 31 | As = 75 | Sb = 122 | Bi = 210? |
| | O = 16 | S = 32 | Se = 79,4 | Te = 128? | |
| | F = 19 | Cl = 35,6 | Br = 80 | I = 127 | |
| Li = 7 | Na = 23 | K = 39 | Rb = 85,4 | Cs = 133 | Tl = 204. |
| | | Ca = 40 | Sr = 87,6 | Ba = 137 | Pb = 207. |
| | | ? = 45 | Ce = 92 | | |
| | | ?Er = 56 | La = 94 | | |
| | | ?Yt = 60 | Di = 95 | | |
| | | ?In = 75,6 | Th = 118? | | |

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As this example from this history of chemistry illustrates, Mendeleev's periodic table gave chemists a powerful tool for predicting the properties of the elements. The periodic table, however, has been reorganized and rearranged over time. Carbon, silicon, and germanium are now placed in group 14 with tin and lead. Group 14 also contains another element called flerovium (atomic number 114). Flerovium is an extremely radioactive element that can only be created in the laboratory. In fact, scientists have only been able to create about 80 atoms of flerovium since it was first produced at the Flerov Laboratory of Nuclear Reactions in 1998. In this investigation, you will use the periodic table to determine the densities of two elements found in group 14.

## Your Task

Determine the densities of carbon, lead, silicon, and tin by measuring the mass and volume of a sample of each of these elements. Then use this information to predict the densities of the other two elements in group 14 (germanium and flerovium).

The guiding question of this investigation is, **What are the densities of germanium and flerovium?**

## Materials

You may use any of the following materials during your investigation:

| Consumables | Equipment |
|---|---|
| • Charcoal<br>• Lead shot<br>• Silicon shot<br>• Tin shot<br>• Distilled water | • 4 beakers (each 250 ml)<br>• Graduated cylinders (25 ml and 50 ml)<br>• Electronic or triple beam balance<br>• Periodic table<br>• Weighing dishes |

## Safety Precautions

Follow all normal lab safety rules. Your teacher will explain relevant and important information about working with the chemicals associated with this investigation. In addition, take the following safety precautions:

- Wear chemical-splash goggles while in the laboratory.
- Handle all glassware with care.
- Wash your hands with soap and water before leaving the laboratory.

## Investigation Proposal Required? ☐ Yes ☐ No

## Getting Started

To answer the guiding question, you will need to think about what type of data you need to collect, how you will collect the data, and how you will analyze the data.

To determine *what type of data you need to collect*, think about the following questions:

- What type of information will you need to collect during your investigation to determine the densities of carbon, lead, silicon, and tin?
- How will you use the densities of carbon, lead, silicon, and tin to predict the densities of the other two elements?

To determine *how you will collect the data*, think about the following questions:

- What equipment will you need?
- How will you reduce measurement error?
- How will you keep track of the data you collect?

To determine *how you will analyze the data*, think about the following questions:

- What types of calculations will you need to make to determine the densities of carbon, lead, silicon, and tin?
- How can you use mathematics to predict the densities of the other two elements based on the densities of carbon, lead, silicon, and tin?
- What type of graph could you create to help make sense of your data?

## Connections to Crosscutting Concepts, the Nature of Science, and the Nature of Scientific Inquiry

As you work through your investigation, be sure to think about

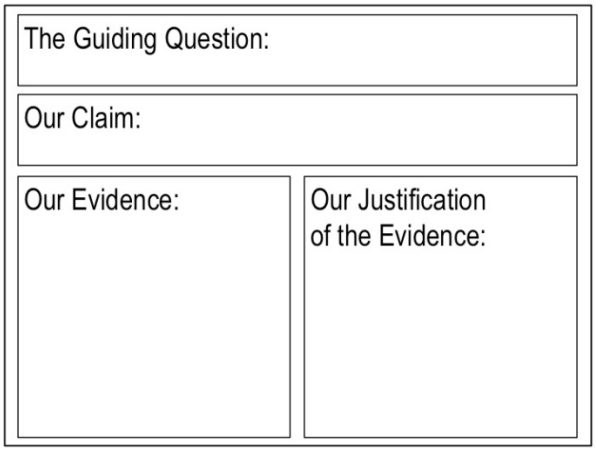
- the importance of identifying patterns;
- issues of scale, proportion, and quantity;
- how scientific knowledge can change over time in light of new evidence; and
- how scientists can use different methods to answer different types of questions.

## Initial Argument

Once your group has finished collecting and analyzing your data, you will need to develop an initial argument. Your argument must include a *claim*, which is your answer to the guiding question. Your argument must also include *evidence* in support of your claim. The evidence is your analysis of the data and your interpretation of what the analysis means. Finally, you must include a *justification* of the evidence in your argument. You will therefore need to use a scientific concept or principle to explain why the evidence that you decided to use is relevant and important. You will create your initial argument on a whiteboard. Your whiteboard must include all the information shown in Figure L13.2.

FIGURE L13.2

**Argument presentation on a whiteboard**




## Argumentation Session

The argumentation session allows all of the groups to share their arguments. One member of each group stays at the lab station to share that group's argument, while the other members of the group go to the other lab stations one at a time to listen to and critique the arguments developed by their classmates. The goal of the argumentation session is not to convince others that your argument is the best one; rather, the goal is to identify errors or instances of faulty reasoning in the initial arguments so these mistakes can be fixed. You will therefore need to evaluate the content of the claim, the quality of the evidence used to support the claim, and the strength of the justification of the evidence included in each argument that you see. To critique an argument, you might need more information than what is included on the whiteboard. You might therefore need to ask the presenter one or more follow-up questions, such as:

- How did your group collect the data? Why did you use that method?
- What did your group do to make sure the data you collected are reliable? What did you do to decrease measurement error?
- What did your group do to analyze the data, and why did you decide to do it that way? Did you check your calculations?
- Is that the only way to interpret the results of your group's analysis? How do you know that your interpretation of the analysis is appropriate?
- Why did your group decide to present your evidence in that manner?
- What other claims did your group discuss before deciding on that one? Why did you abandon those alternative ideas?
- How confident are you that your group's claim is valid? What could you do to increase your confidence?

Once the argumentation session is complete, you will have a chance to meet with your group and revise your original argument. Your group might need to gather more data or design a way to test one or more alternative claims as part of this process. Remember, your goal at this stage of the investigation is to develop the most valid or acceptable answer to the research question!

## Report

Once you have completed your research, you will need to prepare an *investigation report* that consists of three sections that provide answers to the following questions:

1. What question were you trying to answer and why?
2. What did you do during your investigation and why did you conduct your investigation in this way?
3. What is your argument?

Your report should answer these questions in two pages or less. The report must be typed and any diagrams, figures, or tables should be embedded into the document. Be sure to write in a persuasive style; you are trying to convince others that your claim is acceptable or valid!

## Reference

Winkler, C. 1886. About germanium. *Journal für prakische Chemie* 142 (N.F. 34): 177–229. Excerpt available online at *www.chemteam.info/Chem-History/Disc-of-Germanium.ht*ml.