

# Mendeleev's Periodic Table

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## CONCEPT

## 1

# Mendeleev's Periodic Table

## Lesson Objectives

The student will:

- identify the person credited for organizing the periodic table.
- state the basis for the organization of Mendeleev's periodic table.

## Vocabulary

- periodic table

## Introduction

During the 1800s, when most of the elements were being discovered, many chemists tried to classify the elements according to their similarities. In 1829, Johann Dobringer noted chemical similarities in several groups of three elements and placed these elements into what he called triads. His groupings included the triads of 1) chlorine, bromine, and iodine; 2) sulfur, selenium, and tellurium; 3) calcium, strontium, and barium; and 4) lithium, sodium, and potassium.

In 1864, John Newlands saw a connection between the chemical properties of elements and their atomic masses. He stated that if the known elements, beginning with lithium, are arranged in order of increasing mass, the eighth element will have properties similar to the first element, the ninth similar to the second, the tenth similar to the third, and so on. Newlands called his relationship the law of octaves, comparing the elements to the notes in a musical scale. Newlands tried to force all the known elements to fit into his octaves, but many of the heavier elements, when discovered, did not fit into his patterns.

## Mendeleev's Table Based on Chemical Behavior

The **periodic table** is a tabular arrangement of the chemical elements according to atomic number. In 1869, Dmitri Mendeleev, unaware of Newlands's work, also developed a table of the elements that showed a relationship between the chemical properties of elements and their atomic masses. His table would be similar to the one we use today. Mendeleev avoided Newlands's mistake of trying to force elements into groups where their chemistry did not match. Instead, he left empty spaces in his table for where no known element fit the properties and atomic mass for that space. He assumed that elements discovered in the future would fit in those spots. Mendeleev even predicted some of the chemical and physical properties the undiscovered elements would have.

Mendeleev's table listed the elements in order of increasing atomic mass and grouped elements with similar chemical behavior together. For example, lithium is a shiny metal that is soft enough to be cut with a spoon. It reacts readily with oxygen and violently with water. When lithium reacts with water, it produces hydrogen gas and lithium

hydroxide. As we examine the next few elements in order of increasing mass, we will come to the element sodium. Sodium is also a shiny metal soft enough to be cut with a spoon. It reacts readily with oxygen and violently with water. When sodium reacts with water, it produces hydrogen gas and sodium hydroxide. You should note that the description of the chemical behavior of sodium is very similar to the chemical description of lithium. Whenever Mendeleev found an element whose chemistry was very similar to a previous element, he placed it below that similar element.

3 <b>Li</b> 1.941 Lithium	4 <b>Be</b> 9.0122 Beryllium	5 <b>B</b> 10.811 Boron	6 <b>C</b> 12.011 Carbon	7 <b>N</b> 14.007 Nitrogen	8 <b>O</b> 15.999 Oxygen	9 <b>F</b> 18.998 Fluorine	10 <b>Ne</b> 20.180 Neon	11 <b>Na</b> 22.990 Sodium
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As each succeeding element was considered, Mendeleev continued to place an element underneath other elements with similar chemistry. For this reason, Mendeleev placed magnesium below beryllium, aluminum under boron, and so on.

3 <b>Li</b> 1.941 Lithium	4 <b>Be</b> 9.0122 Beryllium	5 <b>B</b> 10.811 Boron	6 <b>C</b> 12.011 Carbon	7 <b>N</b> 14.007 Nitrogen	8 <b>O</b> 15.999 Oxygen	9 <b>F</b> 18.998 Fluorine	10 <b>Ne</b> 20.180 Neon
11 <b>Na</b> 22.990 Sodium	12 <b>Mg</b> 24.305 Magnesium	13 <b>Al</b> 26.982 Aluminium	14 <b>Si</b> 28.086 Silicon	15 <b>P</b> 30.974 Phosphorus	16 <b>S</b> 32.065 Sulfur	17 <b>Cl</b> 35.453 Chlorine	18 <b>Ar</b> 39.948 Argon
19 <b>K</b> 39.098 Potassium							

When Mendeleev came to potassium, he found that it had very similar chemistry to the chemistry of lithium and sodium, so he placed potassium under sodium. You may notice that the atomic masses are no longer in increasing order with respect to potassium and argon. Although argon has a greater mass than potassium, the chemistry of argon was identical to that of neon, and the chemistry of potassium was almost identical to that of sodium. As a result, Mendeleev did not try to put argon beneath sodium. Instead, he allowed the chemical behavior determine where each element should be placed. As you go through the periodic table, you will find several elements whose atomic masses are not in increasing order.

Mendeleev's procedure was to place the elements in the column with matching chemical behavior regardless of atomic mass, so if no element with appropriate chemistry was known, the space would be left empty. For example, germanium had not been discovered when Mendeleev constructed his table. After gallium, the next known element in Mendeleev's time was arsenic. Arsenic did not match the chemical characteristics of carbon and silicon. Instead, arsenic matched the chemical characteristics of nitrogen and phosphorus. Mendeleev placed arsenic in the column which matched arsenic's chemistry and assumed that there was an undiscovered element that would fit chemically with the carbon column. As a result, Mendeleev left the space blank, as you can see in the table below. At a later date, when germanium was discovered, germanium was found to fit the space and was placed in the empty spot.

3 <b>Li</b> 1.941 Lithium	4 <b>Be</b> 9.0122 Beryllium							5 <b>B</b> 10.811 Boron	6 <b>C</b> 12.011 Carbon	7 <b>N</b> 14.007 Nitrogen	8 <b>O</b> 15.999 Oxygen	9 <b>F</b> 18.998 Fluorine	10 <b>Ne</b> 20.180 Neon				
11 <b>Na</b> 22.990 Sodium	12 <b>Mg</b> 24.305 Magnesium							13 <b>Al</b> 26.982 Aluminium	14 <b>Si</b> 28.086 Silicon	15 <b>P</b> 30.974 Phosphorus	16 <b>S</b> 32.065 Sulfur	17 <b>Cl</b> 35.453 Chlorine	18 <b>Ar</b> 39.948 Argon				
19 <b>K</b> 39.098 Potassium	20 <b>Ca</b> 40.078 Calcium	21 <b>Sc</b> 44.956 Scandium	22 <b>Ti</b> 47.867 Titanium	23 <b>V</b> 50.942 Vanadium	24 <b>Cr</b> 51.996 Chromium	25 <b>Mn</b> 54.938 Manganese	26 <b>Fe</b> 55.845 Iron	27 <b>Co</b> 58.933 Cobalt	28 <b>Ni</b> 58.693 Nickel	29 <b>Cu</b> 63.546 Copper	30 <b>Zn</b> 65.38 Zinc	31 <b>Ga</b> 69.723 Gallium	32 <b>Ge</b> 72.64 Germanium	33 <b>As</b> 74.922 Arsenic	34 <b>Se</b> 78.96 Selenium	35 <b>Br</b> 79.904 Bromine	36 <b>Kr</b> 83.80 Krypton

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## Lesson Summary

- The periodic table in its present form was organized by Dmitri Mendeleev.
- The basis for Mendeleev's organization was the chemical behavior of the elements.

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## Further Reading / Supplemental Links

The following websites explore the history behind the periodic table.

- <http://www.wou.edu/las/phisci/ch412/perhist.htm>
- <http://www.aip.org/history/curie/periodic.htm>

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## Review Questions

1. On what basis did Mendeleev organize his periodic table?
  - a. atomic number and atomic mass
  - b. atomic mass and chemical behavior
  - c. atomic number of number of valence electrons
  - d. atomic mass and the Latin alphabet
  - e. none of these