

## **Block 051:** **Building the Periodic Table**

NAME: \_\_\_\_\_

Dmitri Mendeleev's discovery of the Periodic Law ranks as one of the greatest achievements in the history of science. It has survived the test of time and stands to this day as the single most important tool to understand the chemistry of the elements. As we try to understand the essence of this discovery, it is worthwhile to go back in time and look at how it was achieved.

In the years 1868-1870, Dmitri Mendeleev, a professor of chemistry at the University of St. Petersburg in Russia, was writing a new textbook called *Principles of Chemistry*. More than 60 individual elements were known, along with a great many facts about their properties and compounds. Mendeleev knew the atomic masses of the elements, their densities, boiling points, and melting points, as well as the formulas of their compounds with hydrogen, oxygen, and chlorine. What was missing was a way to organize these facts, a way to understand how individual facts related to each other – in short, a way to classify the elements. The following quote from Mendeleev reveals his thoughts at the time:

*"I wished to establish some sort of system of elements in which their distribution is not guided by chance ... but by some sort of definite and exact principle."*

Mendeleev decided to arrange the elements according to their atomic mass. He wrote out the exact atomic masses (as they were known at the time) in the margin of a list of the elements, then wrote out separate cards for each of the elements, with their atomic mass and other chemical and physical properties. Using these cards, Mendeleev played "chemical solitaire" for several hours, finally copying to a sheet of paper the arrangement he had worked out with the cards. With slight modification, this became Mendeleev's first *Periodic Table of the Elements*.

The purpose of this activity is to re-create Mendeleev's discovery of the classification of the elements and the periodic law using a special deck of element cards. The real properties of the elements, but not their names or symbols, are written on these cards. As the cards are arranged and rearranged based on logical trends in some of these properties, the nature of the periodic law should reveal itself.

Define each property and give its typical units, if appropriate.

Ionization energy

Atomic radius

Atomic mass

Melting point

Density

Electronegativity

1. Form a group with three other students. Obtain a deck of element cards and spread the cards out on the table.
2. Each card lists the properties of a single element (X), as shown at the right:

\*Density values are in units of  $\text{g/cm}^3$  for solids and liquids,  $\text{g/L}$  for gases.

\*\*Dashed lines for a property indicate that no data is available. Some elements, for example, may not form a compound with hydrogen.

3. Working together, discuss the possibilities for arrangement of the element cards with all members of the group, and look for a logical arrangement of the cards. Consider the similarities and differences among the elements as well as possible numerical or logical trends in their properties.

<b>Ionization Energy</b>	<b>Atomic Radius</b>
<b>Atomic Mass</b>	<b>Formula of its -oxide <math>\text{X}_b\text{O}_c</math></b>
<b>Formula of its -chloride <math>\text{XCl}_a</math></b>	<b>Melting Point</b>
<b>Density*</b>	<b>Formula of its -hydride <math>\text{XH}_d</math>**</b>
<b>Electronegativity</b>	

4. It is NOT within the rules of this game of chemical solitaire to look up information in a textbook or to use a modern periodic table as a guide!

*Mendeleev's greatest insight in creating the periodic table was in recognizing there were some gaps when the elements were arranged in logical order. He had the ingenuity not only to leave blanks in his table for the missing elements, but also to predict their properties.*

5. One of the element cards is also missing in your deck of cards. Decide where the missing element belongs in the arrangement of the elements and rearrange the cards if necessary to accommodate the missing element.
6. Below, fill in the Table of the Elements to illustrate a logical arrangement of the element cards. To do this, write down only the atomic mass of each element, as shown on its card. Leave a blank space for the missing element.
7. Predict the properties of the missing element by averaging the properties of its nearest neighbors. On the worksheet, complete the card for the missing element by entering its predicted properties alongside the name of each property.
8. Answer Questions 1-7 on the pages 4-6 of this Block.

### Table of the Elements


**Properties of the Missing Element**

<b>Ionization Energy</b>	<b>Atomic Radius</b>
<b>Atomic Mass</b>	<b>Formula of its -oxide <math>X_bO_c</math></b>
<b>Formula of its -chloride <math>XCl_a</math></b>	<b>Melting Point</b>
<b>Density*</b>	<b>Formula of its -hydride <math>XH_d</math></b>
<b>Electronegativity</b>	

1. Mendeleev's Periodic Law can be stated: *"The physical and chemical properties of elements are periodic functions of their atomic masses"*. Looking at your arrangement of the element cards, describe in your own words what the term "periodic function" means.

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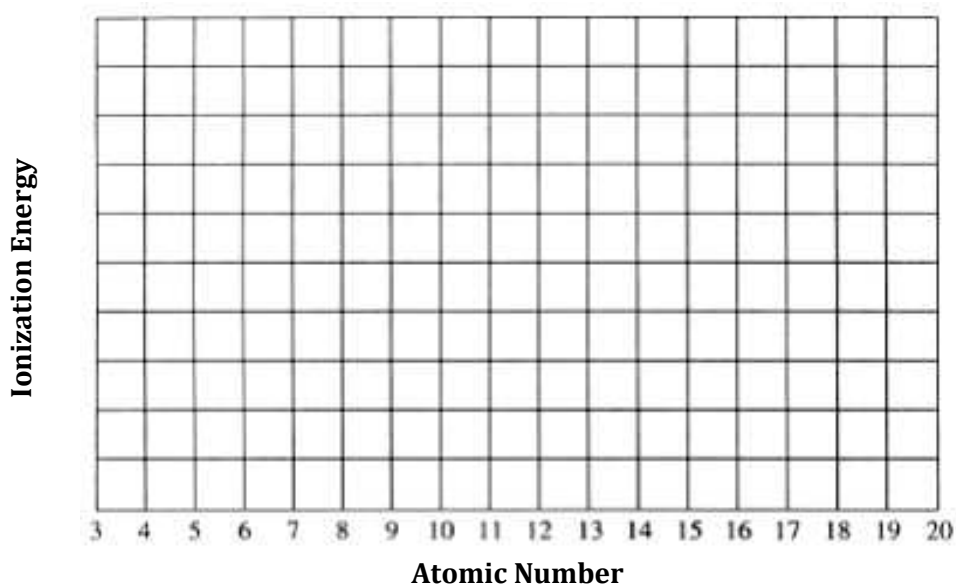
2. Some of the properties listed on each card are periodic properties, others are not. Name one property that is periodic and one that is not.

Periodic Property: \_\_\_\_\_ Non-periodic Property: \_\_\_\_\_

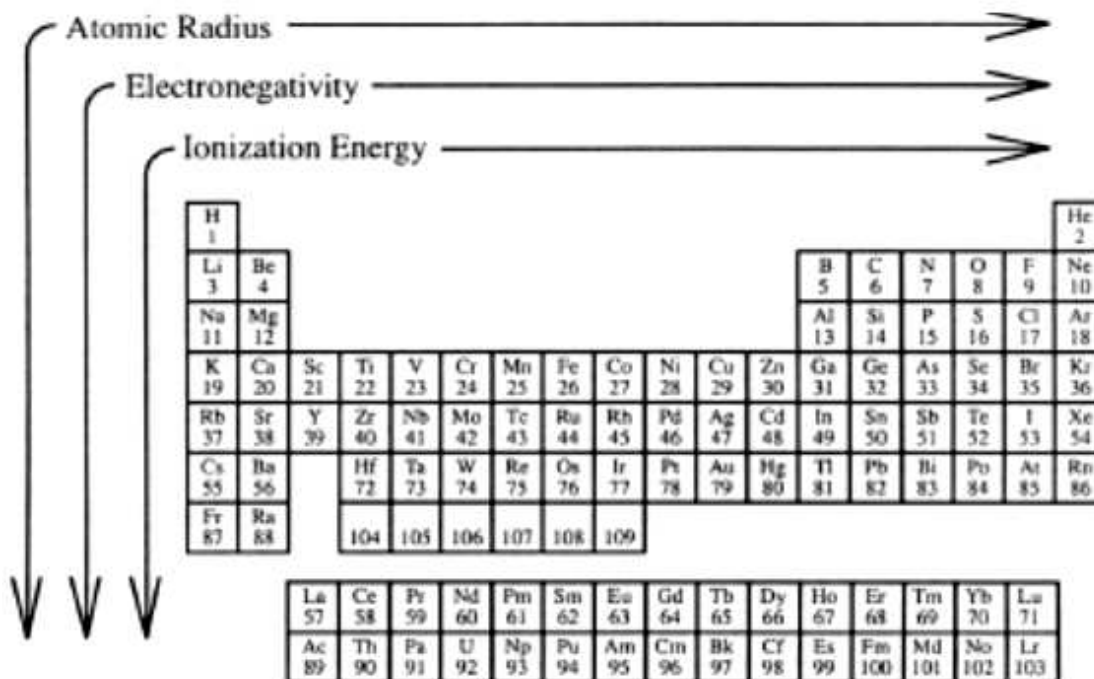
3. The elements in the modern periodic table are arranged in order of increasing atomic number (instead of increasing atomic mass). Why didn't Mendeleev use atomic number to arrange the elements?

4. From your instructor, obtain a handout showing one possible arrangement of the element cards. Identify each element on the handout with its *atomic number* and *chemical symbol*. Use your textbook to obtain this information.

5. Using the possible arrangement of the element cards obtained from your instructor, plot the values of ionization energy in the graph below. You will have to come up with your own y-axis values.



6. There are certain trends in the properties of the elements, both within a column (from top to bottom) and across a row (from left to right) in the periodic table. On the arrow for each property, write the word *increases* or *decreases* to describe how that property changes.



7. On the outline of the periodic table shown below, locate and label the *metals* and *nonmetals*. Use your textbook to define these terms, if necessary.

