

A2 Building the Periodic Table

Key Question: *How is the periodic table organized?*

In this lesson, students will use the Periodic Table Tiles to build the periodic table to become familiar with the periodic table structure and organization and the meaning of the symbols and numbers. They will then work through guided questions about the arrangement of the elements and the difference between a period and group. The colors of the tiles will show patterns among the elements to help students identify trends and properties of elements in specific groups.

Learning Goals

- ✓ Describe the basic organization of the periodic table.
- ✓ Compare and contrast groups and periods.
- ✓ Identify trends of elements in groups.

GETTING STARTED

Time 50 minutes

Setup and Materials

1. Make copies of investigation sheets for students.
2.  Watch the equipment video.
3. Have students work in small groups of three to five.
4. Become familiar with the Periodic Table Tiles prior to teaching the investigation.

5. Have textbooks and other reference materials available for students as they complete questions in the investigation.
6. Review all safety procedures with students.

Materials for each group

- Periodic Table Tiles
- Paper strips or sticky notes for labeling group names
- Research materials



Online Resources

Available at curiosityplace.com

- Equipment Video: Periodic Table Tiles
- Skill and Practice Sheets
- Whiteboard Resources
- Animation: The Periodic Table of the Elements
- Science Content Video: Metals, Nonmetals, and Metalloids
- Student Reading: The Periodic Table of the Elements

NGSS Connection This investigation builds conceptual understanding and skills for the following performance expectation.

HS-PS1-2. *Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models	PS1.A Structure and Properties of Matter	Energy and Matter

BUILDING THE PERIODIC TABLE

Vocabulary

alkali metals – elements in the first group of the periodic table

atomic number – the number of protons in the nucleus of an atom. The atomic number determines what element the atom represents.

chemical properties – characteristics of matter that can be observed only when one substance changes into a different substance, such as iron into rust

chemical symbol – a one-, two-, or three-letter symbol that represents an element

element – a pure substance that cannot be broken down into simpler substances by physical or chemical means

group – a column of the periodic table

halogens – elements in the group containing fluorine, chlorine, and bromine, among others

noble gas – an element that has a completely filled outermost shell and usually does not form chemical bonds with other atoms

period – a row of the periodic table

periodic table of elements – a chart that organizes the elements by their chemical properties and increasing atomic number

transition metals – elements in groups 3–12, including titanium (Ti), iron (Fe), and copper (Cu), among others

BACKGROUND

How many **elements** make up the universe? As of this writing, scientists have identified 118 elements. Over 90 of these elements occur naturally. The others have been synthesized in laboratories. As chemists worked on identifying the elements, they noticed that some elements had similar properties. By keeping track of how each element chemically combined with other elements, scientists also began to recognize patterns.

In 1869, a Russian scientist named Dmitri Mendeleev tried placing the elements in a table. When he organized the elements into horizontal rows by their atomic weights, he noticed that elements with similar **chemical properties** formed a pattern of vertical columns, but only if he left gaps in the table. Mendeleev hypothesized that elements would someday be discovered that would fill in the gaps. He even predicted the properties that these yet undiscovered elements would have, based on

where they would fall in the table. As new elements were discovered, his theory was proven correct. This table became the **periodic table of elements**.

The periodic table organizes the elements according to how they combine with other elements due to their chemical properties. The elements are arranged in order of increasing **atomic number**. Each element corresponds to one box on the periodic table, identified with its chemical symbol.

The periodic table is further divided into **periods** and **groups**. Each horizontal row is called a period. Each period corresponds to the outermost energy level of the elements' valence electrons. Across any period, the properties of the elements gradually change. Each vertical column is called a group. All of the elements in the different groups on the periodic table have similar chemical properties and the same number of valence electrons.

On the far right on the periodic table is Group 18, the **noble gases**, including the elements helium (He), neon (Ne), and argon (Ar). These elements do not naturally form chemical bonds with other atoms. They are almost always found in their pure state, not as part of compounds.

Elements in Groups 3 through 12 are called the **transition metals**. These elements are usually good conductors of heat and electricity. The inner transition metals, called lanthanides and actinides, are often shown below the bottom row of the table in order for the chart to fit on a page.

Group 1 is known as the **alkali metals**. This group includes the elements lithium (Li), sodium (Na), and potassium (K). The alkali metals are soft and silvery in their pure form and are highly reactive. Each of them combines in a ratio of two to one with oxygen.

The Group 2 metals include beryllium (Be), magnesium (Mg), and calcium (Ca). These metals also form oxides; however, they combine one to one with oxygen. This group is sometimes named the alkaline earth metals.

The **halogens** are on the right-hand side of the periodic table, in Group 17. These elements tend to be toxic in their pure form. Some examples are fluorine (F), chlorine (Cl), and bromine (Br). The halogens are also very reactive and are rarely found in pure form.

5E LESSON PLAN

Engage

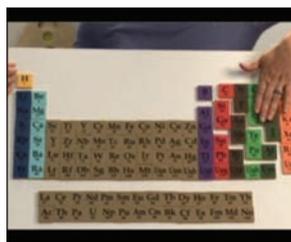
Prepare a bag with 10 different objects inside. Each object should be different. Some suggestions are rubber ball, paper clips, cardboard cut into shapes, different types of paper, rocks, marbles, pencil, pen, and spoon. Have students organize the materials into groups based on properties. Then ask them to write a paragraph explaining the reasoning behind their organization.

Explore

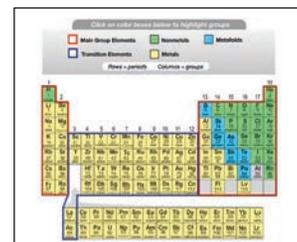
Have students complete Investigation A2, *Building the Periodic Table*. In this lesson, students will use the Periodic Table Tiles to build the periodic table to become familiar with the periodic table structure and organization and the meaning of the symbols and numbers. They will then work through guided questions about the arrangement of the elements and the difference between a period and group.

Explain

Revisit the Key Question to give students an opportunity to reflect on their learning experience and verbalize understandings about the science concepts explored in the investigation. Curiosityplace.com resources, including student readings, videos, animations, and whiteboard resources, as well as readings from your current science textbook, are other tools to facilitate student communication about new ideas.



Science Content Video
Metals, Nonmetals, and
Metalloids



Animation
The Periodic Table of the
Elements

Elaborate

Have students work in small groups to prepare presentations about groups of elements on the periodic table. Sample presentation topics may include the following: alkali metals, alkaline earth metals, halogens, noble gases, and transition metals. You may also choose to have a group of students do a “metals versus nonmetals” presentation. Encourage students to implement creativity in their presentations, but not at the cost of substance. Develop a detailed rubric and provide students with a copy in advance.

Once students have prepared their presentations, allow time (five to ten minutes each) for groups to “teach” the class about their group of elements.

Evaluate

- During the investigation, use the checkpoint ✓ questions as opportunities for ongoing assessment.
- After completing the investigation, have students answer the assessment questions on the *Evaluate* student sheet to check understanding of the concepts presented.

BUILDING THE PERIODIC TABLE

Explore

INVESTIGATION

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Name _____ Date _____

A2 Building the Periodic Table

How is the periodic table organized?

Virtually all the matter around you is made up of combinations of **elements**. Scientists know of 118 different elements, of which over 90 occur naturally. Each element has its own unique kind of atom. The periodic table is a chart that shows all of the elements in order of increasing **atomic number**.

You are going to build the entire **periodic table of elements**. The table has a very specific shape, which corresponds to the **chemical properties** of the elements. All of the elements fill in this shape in order of their atomic number starting from the upper left-hand corner. As you build the table, be sure to follow the diagram to get the right shape. Some of the squares in the diagram have the atomic numbers of the elements shown to help you get the shape correct.

Materials:

- ✓ Periodic Table Tiles
- ✓ Paper strips or sticky notes for labels
- ✓ Research materials

Periodic Table of the Elements

ROWS = PERIODS
COLUMNS = GROUPS

1																	18
H 1 hydrogen																	
Li 3 lithium	2											13	14	15	16	17	
Na 11 sodium	3	4	5	6	7	8	9	10	11	12							
K 19 potassium																	
Rb 37 rubidium																	
Cs 55 cesium																	
Fr 87 francium																	
↑																	
La 57 lanthanum																	
Ac 89 actinium																	

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A2 Building the Periodic Table
Chemistry Models

Explore

INVESTIGATION

A2

The only tile you should use yellow-side-up is the hydrogen tile. The colors will show a pattern when you are finished. There is a tricky part near the bottom of the table. The table breaks off between element 56 (Ba) and element 71 (Lu) and fills in the first of two long rows underneath the main part of the chart.

1 Building the periodic table

Every element is represented by a symbol of one, two, or three letters. For example, the symbol for hydrogen is a capital letter H. The symbol for lithium is two letters, Li. Each element also has a unique number, called its atomic number. The atomic number is the number of protons in the nucleus of all atoms of that element. Atomic number 1 is the element hydrogen. Hydrogen has 1 proton in its nucleus. Atomic number 92 is the element uranium. Uranium has 92 protons in its nucleus.

2 Organization of the periodic table

Look at the periodic table you put together out of the tiles, and answer the questions below.

- a. Atomic number increases as you read from left to right and from top to bottom on the periodic table. What does this tell you about the number of protons in the elements?

The number of protons in each atom of the elements increases through the periodic table.

- b. Which elements are in Group 1?

hydrogen, lithium, sodium, potassium, rubidium, cesium, and francium

- c. How many periods, or horizontal rows, are on the periodic table?

seven

- d. To which group does chlorine belong? What are some other elements in that group?

Chlorine belongs to Group 17. Other elements in that group include fluorine, bromine, iodine, and astatine.

- e. Which elements are in the 2nd period?

lithium, beryllium, boron, carbon, nitrogen, oxygen, fluorine, and neon

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Chemistry Models

Guiding the INVESTIGATION

2 Organization of the periodic table

Guide students to observe any trends and patterns in their completed periodic tables. They should notice that tiles of the same color ended up in the same column (with hydrogen as the exception for Group 1.) Explain that the vertical columns on the periodic table are called groups.

Students may belong to groups, like after-school clubs or sports. Ask them what makes an organization a group. Steer students toward the fact the people who are members of a group tend to have something in common or similar interests. For example, a person who is an orchestra member probably enjoys music. Have students cite other examples.

1																	2
H 1 hydrogen																	
Li 3 lithium	Be 4 beryllium																
Na 11 sodium	Mg 12 magnesium																
K 19 potassium	Ca 20 calcium																
Rb 37 rubidium	Sr 38 strontium																
Cs 55 cesium	Ba 56 barium																
Fr 87 francium	Ra 88 radium																

This is also true of the elements on the periodic table. Elements in a group have similar characteristics. For example, the elements in Group 2 are represented by light blue tiles. They are all metals and have similar chemical properties.

Some of the groups have special names. For example, the elements in Group 1 are called the alkali metals. Is every element in Group 1 a metal? Students should know that hydrogen is a gaseous nonmetal.

Explore

INVESTIGATION

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3 Identifying groups of elements

The vertical columns on the periodic table are called groups. Elements in a group have similar chemical properties. Some of the groups have special names. Add paper labels with the following common group names to your periodic table model: **noble gases, halogens, transition metals, alkali metals.**

- a. What kind of color pattern can you see in your model of the periodic table?

The vertical columns, or groups, contain tiles of the same color, with the exception of hydrogen in Group 1.

- b. Which group of the periodic table contains the element argon? What characteristics do the elements in this group share?

Argon is one of the noble gases in Group 18. Elements in this group have filled outer energy levels and are least likely to form chemical bonds with other elements. They are all gases at room temperature.

- c. Which group contains the element carbon? What characteristics do the elements in this group share? How do these elements differ?

Carbon is in Group 14. The elements in this group all have four valence electrons, meaning they are able to bond in four places. The elements in this group also have similar stable oxidation numbers (2+ and 4+). Carbon is a nonmetal, silicon and germanium are metalloids, while tin and lead are metals. Because of these differences, Group 14 elements exhibit a range of properties.

- d. Which group contains calcium? Name two properties of the elements in this group.

Calcium is in Group 2, sometimes called the alkaline earth metals. They are silvery metals that react with water. They are harder and more dense than the alkali metals.

- e. Name three transition metals. What properties do most transition metals have in common?

Answers will vary. Accept all reasonable answers from Groups 3–12. They are all metals, and usually are good conductors of heat and electricity.

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Chemistry Models

Explore

INVESTIGATION

A2

4 Physical properties of elements

The periodic table can be divided into three sections: metals, nonmetals, and metalloids. Each section contains elements with similar physical properties. Separate your model periodic table into metals, nonmetals, and metalloids. Try to keep the original shape as intact as possible as you divide the tiles.

- a. Use the reference materials to determine which elements fall into each of these sections.
b. Research the properties of metals, nonmetals, and metalloids.

Students may recognize that metals are malleable, shiny, and good conductors of heat and electricity; nonmetals are dull, brittle, and poor conductors of electricity; metalloids possess a mixture of the characteristics of both metals and nonmetals.

5 Thinking about what you learned

- ✓ a. Each period, or row, on the periodic table contains only a certain number of elements. What does this have to do with the structure of the atom?

The number of elements in each row (period) corresponds to the number of electrons in each energy level. Period 1 contains two elements and the first energy level holds two electrons; Period 2 contains eight elements and the second energy level holds eight electrons, and so on.

- b. Why do you think the hydrogen tile is a different color from the rest of its group?

It has special properties that make it behave differently than the other elements in Group 1. It is a gas, while the other elements in the group are all metals.

- ✓ c. You saw that groups of elements tend to have similar physical and chemical properties. How do the properties of elements compare across a period?

The properties of the elements gradually change across a period.

- d. Approximately how many kinds of atoms have scientists identified? Conduct research to find out the latest information.

Scientists have identified approximately 118 atoms, or kinds of elements. Although elements 113, 115, 117, and 118 have possibly been synthesized in laboratories, none have been confirmed as discoveries as of 2014.

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Guiding the INVESTIGATION

3 Identifying groups of elements

Ask students, “Why do you think the atomic numbers increase horizontally and not vertically?” As students think about a response, point to the arrangement of the elements on a large periodic table for emphasis. Explain that scientists’ efforts to organize the elements were based on identifying similarities in properties. Over time, they realized that elements with certain atomic structures seemed to exhibit similar chemical properties.

Display the Periodic Table of the Elements whiteboard resource. Ask students, “How are the elements categorized here?” Students should observe the color scheme used to distinguish among metals, metalloids, and nonmetals. They should also notice the group

numbers written above the columns. Say to students, “Recall that the elements are organized according to similar properties. The numbers you see above each column indicates a group of elements. Let’s consider Group 1 first. What observations can you make about the elements in Group 1?” Allow time for students to examine the elements in this group. Among other observations, students should notice that all of the elements are metals except hydrogen. Continue this line of questioning for Groups 2–18. Record student answers in a chart similar to the one below.

Group	Common name	Observations
1	alkali metals	all metals except H
17	halogens	all nonmetals
18	noble gases	all nonmetals (gases)

SCIENCE AND HISTORY

The work of many scientists over a long period of time led to the development of the modern periodic table. Use the timeline below to lead a discussion about how scientists came to determine the organization of the periodic table. Also, remind students that the process of science involves making observations and collaborating with others to better understand our world.

Aristotle (~330 BCE)

Developed theory of four elements: earth, fire, water, air.

Lavoisier (~1770-1789)

Composed the first list of 33 elements. Distinguished metals and nonmetals.

Berzelius (1828)

Created a table of atomic weights. Introduced idea of chemical symbols.

Döbereiner (1829)

Developed triads—groups of three elements with similar properties.

Newlands (1864)

Arranged known elements in order of increasing atomic weights. Proposed the Law of Octaves.

Meyer (1869)

Compiled a periodic table with elements arranged by atomic weight. Elements with similar properties arranged in columns.

Mendeleev (1869)

Created a periodic table with elements arranged by atomic weight. Elements with similar properties arranged in columns.

Ramsay (1894)

Discovered noble gases.

Moseley (1914)

Determined atomic numbers of each element. Modified the periodic law—elements' properties vary periodically with atomic number.

Seaborg (1940)

Synthesized elements beyond uranium.

Evaluate

INVESTIGATION

A2

Name _____ Date _____

- Which of the statements below best describes the relationship between the following elements: argon (Ar), bromine (Br), hydrogen (H), and carbon (C)?
 - They are all nonmetals.
 - They are all gases at room temperature.
 - They are all halogens.
 - They are all very reactive.

- Which is a physical characteristic common to most metals?
 - Poor electrical conductivity
 - Brittleness
 - Malleability
 - Dull appearance

- What are horizontal rows on the periodic table called?

Horizontal rows are called periods.

- What property of elements was used to organize the periodic table?

The periodic table is organized in order of increasing atomic number, which is the number of protons in every atom of an element.

- How do the properties of elements in a group compare?

Elements in a group tend to have similar physical and chemical properties.

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A2 Building the Periodic Table
Chemistry Models

WRAPPING UP

Have your students reflect on what they learned from the investigation by answering the following questions:

- How is the periodic table of elements arranged?
- What is the difference between a period and a group on the periodic table?