Organizing the Elements

Context

Elements are substances that cannot be broken down into simpler forms of matter, and they are the primary constituents of all matter. The elements are the basis of all chemical interactions, and the implications of the ways in which atoms interact are relevant to every aspect of our lives, from health to technology, energy, and the environment.

Essential Questions

- What is atomic structure? How do the atomic structures of different elements vary?
- Why are the elements organized as they are on the periodic table?
- What information about each element is provided by the periodic table?
- Are there other ways of organizing the elements?

Enduring Understandings

- Each element has a unique atomic structure.
- Elements are arranged on the periodic table according to aspects of their atomic structure.
- The position of an element on the periodic table provides information about that element.
- Elements have unique properties related to their atomic structure.

Time

This activity can be completed in 2–3 class periods of approximately 50 minutes.

Grade Level

Grades 6–12

Differentiation

Activities can be completed as a class guided by the teacher, in groups, pairs, or individually based on students' abilities.

Materials

- Core Concepts: Periodic Table
- Printed Exploration Charts for each student (Supplement 1)
- Printed Element Cards (Supplement 2)
- Paper/pencils

Lesson Objectives

- Students will be able to describe the atomic structure of an element and how the atomic structure of elements relates to the organization of the periodic table.
- Students will be able to organize the first 20 elements of the periodic table according to atomic number, number of electron shells, and valence electrons.
- Students will understand that the arrangement of elements on the periodic table is meaningful, and provides information about each element.

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Next Generation Science Standards Addressed	
MS-PS1-1.	**Develop models to describe the atomic composition of simple molecules and extended structures.** [Clarification Statement: Emphasis is on developing models of molecules that vary in complexity. Examples of simple molecules could include ammonia and methanol. Examples of extended structures could include sodium chloride or diamonds. Examples of molecular-level models could include drawings, 3D ball and stick structures, or computer representations showing different molecules with different types of atoms.] [*Assessment Boundary: Assessment does not include valence electrons and bonding energy, discussing the ionic nature of subunits of complex structures, or a complete description of all individual atoms in a complex molecule or extended structure is not required.*]
HS-PS1-1.	**Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.** [Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.] [*Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.*]
HS-PS1-8.	**Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.** [Clarification Statement: Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations.] [*Assessment Boundary: Assessment does not include quantitative calculation of energy released. Assessment is limited to alpha, beta, and gamma radioactive decays.*]
HS-PS2-6.	**Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.** [Clarification Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.] [*Assessment Boundary: Assessment is limited to provided molecular structures of specific designed materials.*]

Common Core ELA Standards

CCSS.ELA-Literacy.RST.6-8.1, 9-10.1, 11-12.1

Cite specific textual evidence to support analysis of science and technical texts.

CCSS.ELA-Literacy.RST.6-8.2, 9-10.2, 11-12.2

Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.

CCSS.ELA-Literacy.RST.6-8.4, 9-10.4, 11.12.4

Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–8, grades 9-10 texts and topics.

CCSS.ELA-Literacy.RST.6-8.7, 9-10.7, 11-12.7

Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

NGSS Science and Engineering Practices Addressed

- Asking questions (for science) and defining problems (for engineering)
- Developing and using models
- Constructing explanations (for science) and designing solutions (for engineering)
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

NGSS Crosscutting Concepts Addressed

- Patterns. Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them.
- Systems and system models. Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.
- Energy and matter: Flows, cycles, and conservation. Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.
- Structure and function. The way in which an object or living thing is shaped and its substructure determine many of its properties and functions.
- Stability and change. For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.

Observation

Review the atomic structure of an element like Hydrogen or Carbon; completing an Element Builder activity as a class is an excellent way to review atomic structure. As a class, define the following words/terms: *proton, neutron, electron, nucleus, electron shell, valence electron.*

Before beginning the lesson, put away or cover any periodic tables in the classroom.

Hypotheses

1. Provide each student with a copy of the Exploration Chart (Supplement 1) so that they may document their progress through the lesson (note that this is an advanced version of the classic KWL [Know, Want To Know, Learned] chart). Following on the class review, have students work independently for 5 minutes to document their knowledge of the

periodic table in the **Prior Knowledge/Preconceptions** column. Have students compare their information with a neighbor's.

Prior Knowledge/ Preconceptions	Questions/Hypotheses	Research	Conclusions/Further Questions

2. Explain that the periodic table is a meaningful and informative way of organizing the elements. Explain that the organization of the periodic table is based on aspects of the elements' atomic structures, and that there are potentially several ways to organize the elements. Have students work in groups or pairs to think of different ways in which the elements could be organized and record their ideas in the **Questions/Hypotheses** column of their Exploration Charts. Have students record at least two rules by which they could organize the elements.

Suggested Prompts

- Organize by atomic weight.
- Organize by number of electron shells.
- Organize by state of matter.
- Organize using more than one rule at a time.

Research or Experimentation

ELEMENT ORGANIZATION EXERCISE

Explain that the class will work together in small groups to try and arrange the elements in the best ways possible. Explain that the arrangements groups come up with must be meaningful, and they must be able to explain why they chose each arrangement.

MATERIALS:

- Element Cards: Print a set of Element Cards (Supplement 2) for each group. The set includes one card for each of the first 20 elements of the periodic table. Cards list basic element information including atomic number, chemical symbol, and atomic structure. The cards print four to a sheet, so they must be cut out.
- Scissors or paper trimmer
- Paper
- Pencils

METHOD:

1. Divide class into groups and give each group a full set of Element Cards. Using the information provided on the cards (specifically, the atomic model), have students work as a group to add the following information to each card:

   a. Number of electron shells

   b. Number of valence electrons

2. Have students work in groups to try and organize the elements in different ways, referencing the **Questions/Hypotheses** column of their Exploration Charts. While teams are working provide assistance as needed.

3. After students have tried different ways of organizing the elements, ask all groups to organize the elements by the following rules:
   a. Cards must be placed in order according to their atomic number.
   b. All cards in the same column must have the same number of valence electrons.
   c. All cards in the same row must have the same number of electron shells.
4. After teams have completed this task, return to Core Concepts: Periodic Table's interactive homepage and explain that this is how elements are arranged on the periodic table. (You might need to explain that helium is a special case. Helium is placed in the table's last column because all the elements in that column have full outer electron shells. Helium's outermost shell only holds two electrons, while other element's outer shells hold eight.) Ask if any of groups used one or more of these rules to organize the elements on their own. Have students record the rules for organizing elements on the periodic table in the **Research** section of their Exploration Charts and compare them to the rules they came up with in the **Questions/Hypotheses** section.

Research

1. As a class, examine the structure of the periodic table. Using Core Concepts: Periodic Table's interactive homepage, hover over the rows and explain that the rows in the periodic table are called "periods." Hover over the columns and explain that they are called "groups." Ask students what elements in the same group all have in common (number of valence electrons). This means elements in the same group react in similar ways, and so have similar properties.
2. Using Core Concepts: Periodic Table's interactive homepage, identify the different family groups by hovering over the group names (at the bottom of the page). Read the information provided about each group.
3. Divide class into groups and assign each group an element family (for example, the alkali metals, alkaline earth metals, halogens, or noble gases). Have each group research their element family, identify some basic properties, and theorize whether the family's placement on the periodic table explains some of those properties. Have each group share their findings, and have students add them to the **Research** column of their Exploration Charts.

Teaching Tip

To reinforce classroom learning, students can study the Quizlet flashcard set on periodic table organization on the Core Concepts: Periodic Table database or by visiting Rosen Digital's Quizlet page.

Analysis

As a class return to the Exploration Chart. Through guided class discussion document students' observations and further questions about their research in the **Conclusions/Further Questions** section.

Suggested Prompts

- How did our own ideas for organizing the elements compare with the rules for organization use in the periodic table?
- What information is provided about an element by its position on the periodic table?
- Might there be other meaningful ways to organize the elements?

Report

Have students write several paragraphs in response to the following prompt: What are the benefits of organizing the elements into the periodic table?

Assessment Evidence

ONGOING ASSESSMENT

- Guided Discussions
- Organization of Element Cards

SUMMATIVE ASSESSMENT

- Individual Exploration Charts
- Report
- Lesson rubric:

	Absent 0	Insufficient 1	Sufficient 2	Exceeds Expectations 3	Total Points
Element Cards	No information added to cards about electron shells or valence electrons	Incomplete or inaccurate information	Accurate information added to cards	Student has gone above and beyond the required task	
Exploration Chart	No information in the individual Exploration Chart	Incomplete sections, or incomplete information in all sections	All basic information in all sections	Student has gone above and beyond the required task	
Report	Student did not hand in a report	Report consists of fewer than three paragraphs, and includes incomplete or inaccurate information	Report consists of three or more paragraphs and includes complete and accurate information	Student has gone above and beyond the required task	

Extension: Arguing for Alternatives to the Periodic Table

Grade Level: Upper high school

LESSON

Review the periodic table. Briefly discuss the history of the periodic table, explaining that as early as the 18th century, scientists were trying to a develop a logical and meaningful way of organizing the elements. Explain that many different tables were developed throughout the 19th century, and that there are some who advocate using an alternative to the current table.

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RESEARCH

1. Divide students into groups and assign each group a different form of the periodic table to research using print or online resources. Some possibilities include spiral periodic tables, circular periodic tables, 3-dimensional periodic tables, cylindrical periodic tables, pyramidal periodic tables, and the "Mayan" periodic table.
2. Have students work in teams to answer the following questions and complete the following tasks:
   - **a.** What is the history of this form of the periodic table?
   - **b.** How does this form compare to the standard table? Does it provide information that the standard table does not? Does it omit information that the standard table provides?
   - **c.** Create a list of pros and cons comparing the alternative and standard forms of the table.
   - **d.** Which do you think it better, the alternative form or the standard form? Does everyone in your group agree?
   - **e.** If you had to make a case for switching to this form of the table, what would your reasons be? Come up with at least three arguments to support your case.
3. Have each team present their findings to the class.

REPORT

Have students write several paragraphs answering the following questions: Do you think there is an optimal form of the periodic table? Do you think any of the forms you have studied are the optimal form? Have students use evidence from their research and from other groups' reports to support their position.