ECT Lesson Plan: Patterns in the Periodic Table

Lesson plan at a glance...

Core subject(s)	Science
Subject area(s)	Chemistry
Suggested age	13 to 16 years old
Prerequisites	Familiarity with Google Sheets or extra time
Time	**Preparation:** 3 to 20 minutes **Instruction:** 100 to 175 minutes
Standards	**Core Subject:** NGSS **CS:** CSTA, Australia

In this lesson plan…

Lesson Overview

In this lesson students study patterns in the organization of the periodic table supplemented by the use of spreadsheet functions. Students will begin to see how **pattern recognition** can be used to understand natural phenomena. The engagement level of the students can be increased by breaking them into groups and have them develop answers to discussion questions. At the end of this lesson students should have a better understanding of periodic table and begin to see how pattern recognition is a scientific skill.

Educators can refer to the Teacher's version of the Complete Periodic Trends sheet and the Complete Periodic Table sheet for an example of how spreadsheets should appear upon completion of this lesson.

Materials and Equipment

- For the teacher:
  - *Required:* Presentation set-up
    - Internet-connected computer
      - Chrome browser (https://www.google.com/chrome/browser/desktop) recommended
    - Projector and projection screen or other flat projection surface
- For the student:
  - *Required:* Internet-connected computer (1 computer per student recommended)
  - *Required:* Google Sheets (https://docs.google.com/spreadsheets/) or other spreadsheet

Preparation Tasks

	Confirm that your computer is on and logged-in	1 to 5 minutes
	Confirm that your projector is turned on and is projecting properly	1 to 5 minutes
	Confirm that all students' computers are turned on, logged-in, and connected to the Internet	1 to 10 minutes

The Lesson

Warm-up Activity: Exploring tables	15 to 20 minutes
Activity 1: Grouping	15 to 30 minutes
Activity 2: Discovering the pattern	20 to 40 minutes
Activity 3: Melting points	35 to 55 minutes
Wrap-up Activity: Summarizing	15 to 30 minutes

Warm-up Activity: Exploring tables (15 to 20 minutes)

Activity Overview: In this activity, students will explore the organization of two tables of the elements from the periodic table. Students will use pattern recognition to begin exploring the tables.

Notes to the Teacher:
The activities below suggest what you can tell and ask your students. In some cases you will want to lead the entire class as a whole. In other cases you will want to initiative the activity by putting instructions on a whiteboard or projecting them or perhaps distributing a handout and then roam around the class assisting students. You can increase your students' engagement level by breaking your students into groups and having them jointly develop answers to the discussion questions. You can appoint students to serve in the role of "teacher", recorder and/or reporter.

Activity:
Lead your students through the following activity:

The periodic table is loaded with data on the properties of each element, organized into rows and columns. In two separate windows, open the Periodic Trends spreadsheet and the Periodic Table spreadsheet to begin to understand the organization of the elements.

Q1: Study the data in the Periodic Trends spreadsheet. Which column does the spreadsheet appear to be sorted by?

Q2: Study the Periodic Table spreadsheet. Describe how the atomic numbers are organized on the periodic table.

Assessment:
A1: The Periodic Trends spreadsheet is sorted by the **Atomic Number** column.

A2: The atomic numbers display in order across the periodic table, increasing from left to right and top to bottom, with some exceptions in the sixth and seventh rows.

Activity 1: Grouping (15 to 30 minutes)

Activity Overview: In this activity, students will use the Periodic Trends spreadsheet to attempt to discover a relationship of atomic number to the three classifications of the elements. In doing so they will use pattern recognition.

Activity:
Take your students through the following steps:

1. **In the Warm-up Activity you saw how the atomic numbers are organized in the periodic table. In the following activity you will see how elements are grouped together in the table.**
2. **Each element in the periodic table can be classified into one of the following groups: metal, nonmetal, or metalloid.**
3. **While viewing the Periodic Trends spreadsheet choose *Make a Copy* in the *Files* menu to make your own copy of the spreadsheet.**
4. **Follow the instructions to color code each element in your copy of the Periodic Trends spreadsheet, according to the three classifications.**
5. **Conditional Highlighting in Google Docs:**
    a. **Highlight all the data in the *Classification* column**
    b. **Under the *Format* menu, choose *Conditional Formatting***
    c. **Set the first button to *Text is exactly***
    d. **In the first text box type *nonmetal (must be spelled exactly as in the spreadsheet)***
    e. **Check the *Background* box**
    f. **Choose a new color for the background of all the nonmetals**
    g. **Click on *+Add another rule***
    h. **Repeat the process for the metalloids using a different color**
    i. **By process of elimination, the elements that still have the original color coded are all metals**

Q1: Which type of element is most common, metal, nonmetal, or metalloid? Which is least common?

Q2: Was it easier to identify the metals, nonmetals, and metalloids before or after we used the conditional highlighting tool?

Assessment:
A1: The majority of the elements are metals.

A2: Answers may vary, however students should notice that once each type of element is highlighted with a different color it is easier to recognize which elements belong to which classification.

Activity:
Have your students do the following activity:

The spreadsheet initially is sorted by atomic number. Follow these steps to re-sort it into groups of metals, nonmetals, and metalloids.

a. **Highlight *all* the data on the spreadsheet (do not include the headers in the first row).**
b. **Go to the *Data* menu and select *Sort range*.**
c. **Sort the Classification column (*Column C*) from *a* → *z*.**

Q3: Now that your data is sorted and highlighted, count how many metals, metalloids, and nonmetals are in the periodic table.

Q4: List the atomic number of each metalloid. Is there a clear pattern in these numbers?

Assessment:
A3: metals - 83, metalloids - 9, nonmetals - 18

A4: Atomic numbers of metalloids: 5, 14, 32, 33, 51, 52, 84; there is no clear pattern to the atomic number of metalloids.

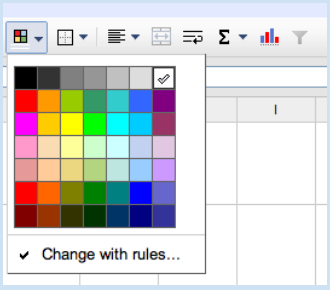
Notes to the Teacher:
Sorting and color coding data makes it easier to visualize the elements.

Activity 2: Discovering the pattern (20 to 40 minutes)

Activity Overview: In this activity, students will use the periodic table format to discover patterns in the three categories of elements. This activity will continue to use pattern recognition.

Activity:
Have your students do the following:

1. **In a spreadsheet list it is difficult to identify any patterns between the atomic number and the classification of an element into metal, nonmetal, and metalloid. However, when we study the arrangement of these elements in the periodic table we begin to notice a connection between an element's location and its classification.**
2. **While viewing the Periodic Table spreadsheet choose *Make a Copy* in the *Files* menu to make your own copy of the spreadsheet.**
3. **Look to your copy of the *Periodic Trends* spreadsheet to identify the atomic number of each metalloid. Change the background of the cells containing the metalloids in your copy of the *Periodic Table* spreadsheet to match the color that you used for metalloids on the *Periodic Trends* spreadsheet. Repeat this process for the nonmetals in the periodic table.**
4. **Instructions for color coding the Periodic Table**
    a. **On the Periodic Table sheet, highlight a cell that contains a metalloid.**
    b. **In the toolbar above the periodic table, click on the *Text background color* button and choose the color that you used for metalloids in the Periodic Trends sheet. (see below)**



    c. **Repeat the process until all the metalloids are the same color on the periodic table.**
    d. **Repeat the process for the nonmetals, using a the color you chose for nonmetals in the Periodic Trends sheet.**

Q1: Describe the location of the metals, metalloids, and nonmetals on the periodic table.

Assessment:
A1: The nonmetals are located in the upper right hand corner of the table, followed to the left/below by the metalloids, and the remainder of the table is filled with metals.

Activity 3: Melting points (35 to 55 minutes)

Activity Overview: In this activity students will look for a relationship between the **melting point** of an element and its placement in the periodic table. All melting points are in **kelvin**. Students will discover a pattern relating melting point to element category as well as exceptions to the pattern.

Notes to the Teacher:
Organizing the data by melting point allows us to look for more patterns in the arrangement of elements in the periodic table. Once students understand that there are patterns in the properties of the elements in the first column and those in the last few columns they can begin to explore the relationship to understand why.

Activity:
Walk through the following with your students:
In the Periodic Trends spreadsheet, highlight *all* of the data and sort it by melting point (*Data*→ *Sort range*→ *Column D*).

Q1: What element has the lowest melting point? Which has the highest melting point?

Q2: Which type (classification) of elements tend to have the lowest melting points?

Q3: Does this pattern always hold? If not, name at least two exceptions to the general trend.

To easily identify the elements with the lowest melting points on the *Periodic Table* spreadsheet, choose a new font color for the atomic number of all elements whose melting temperature is less than 500 degrees. One partner should read these numbers from the *Periodic Trends* spreadsheet while the other changes the font color of these elements on the *Periodic Table* spreadsheet. If you find that these elements are grouped together, highlight them in groups to save time.

Q4: Describe the location of the elements with these melting points. Are they scattered randomly across the table or are they clustered together?

Q5: Which column of the table contains metals whose melting temperatures are closest to the melting temperatures of most nonmetals?

Q6: Which nonmetal is an outlier with a melting temperature far above 500 degrees? Does this element border the metalloids or is it surrounded by other nonmetals?

Assessment:
A1: Helium is at the top of the sheet with the lowest melting point, and at the end of the sorted list we have carbon with the highest recorded melting point.

A2: Most of the nonmetals are clustered at the top of the list with the lowest melting points, although there are several exceptions.

A3: No, although most nonmetals have lower melting points than most metals and metalloids, there are several exceptions. For example the metal Cs (cesium) has a lower melting point than the nonmetal S (sulfur), and the nonmetal C (carbon) has one of the highest melting temperatures of all.

A4: The elements with the lowest melting temperatures are clustered in one group on the right hand side of the table

and then in another group on the left hand side. Students should notice that if we wrapped the periodic table around a cylinder these elements would all be grouped together.

A5: The elements in the first column of the left hand side of the table also have relatively low melting points, even though they are metals.

A6: Carbon is a nonmetal with a high melting temperature. It borders the metalloids; we see properties begin to shift as we get closer to different categories of elements.

Wrap-up Activity: Summarizing (15 to 30 minutes)

Activity Overview: In this activity, students will review some key patterns in the periodic table. They will discuss how atomic number, metals, metalloids, nonmetals and melting temperature are arranged in the periodic table. Students will continue to use **pattern recognition**.

Notes to the Teacher:
While you can engage the classroom as a whole with the discussion question below, it will probably be more effective if you divide the students into groups and ask one student in each group to play the role of the teacher asking the question, one to take notes about the answers and the rest of the students to suggest answers to the question. After the time is up, the student taking notes can summarize the group's conclusions.

Activity:
Prompt discussion with the following:
Summarize all of the patterns/trends in how the elements are grouped in the periodic table. Consider the atomic numbers, the classification of the elements, and the melting points.

Answers will vary, however students should note the following:

- Atomic number increases across rows (left to right) and down columns
- Elements are grouped together as metals, metalloids, and nonmetals
- Melting temperatures are lowest in the top right hand side of the table, and remain relatively low in the first column on the left hand side of the table as well.

Learning Objectives and Standards

Learning Objectives	Standards
LO1: Students should be able to predict generally where in the periodic table metals, metalloids and nonmetals are found.	*Core Subject* NGSS PE 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. *Computer Science* AUSTRALIA 10.4 (Collecting, managing and analyzing data): Analyse and visualise data to create information and address complex problems; and model processes, entities and their relationships using structured data CSTA L3B.CT.9: Analyze data and identify patterns through modeling and simulation.

LO2: Students should be able to explain patterns of melting points of elements with reference to the periodic table.	*Core Subject* NGSS PE HS-PS1-1 *Computer Science* CSTA L3B.CPP.7: Use data analysis to enhance understanding of complex natural and human systems.

Additional Information and Resources

Lesson Vocabulary

Term	Definition	For Additional Information
Periodic table	A tabular chart of the chemical elements according to their atomic numbers so that elements with similar properties are in the same column.	http://en.wikipedia.org/wiki/Periodic_table
Metal	Any of a number of chemical elements in the periodic table that form a metallic bond with other metal atoms; generally shiny, somewhat malleable and hard, often a conductor of heat and electricity.	http://en.wikipedia.org/wiki/Metal
Metalloid	An element, such as silicon or germanium, intermediate in properties between that of a metal and a nonmetal; especially one that exhibits the external characteristics of a metal, but behaves chemically more as a nonmetal.	http://en.wikipedia.org/wiki/Metalloid
Nonmetal	An element, such as phosphorus or chlorine, that does not have the chemical or physical properties of a metal	http://en.wikipedia.org/wiki/Nonmetal
Melting point	The temperature at which the solid and liquid phases of a substance are in equilibrium; it is relatively insensitive to changes in pressure.	http://en.wikipedia.org/wiki/Melting_point
Kelvin	A unit for a specific temperature on the Kelvin scale.	http://en.wikipedia.org/wiki/Kelvin

Computational Thinking Concepts

Concept	Definition
Pattern Recognition	Breaking down data, processes or problems into smaller, manageable parts.

Administrative Details

Contact info For more info about Exploring Computational Thinking (ECT), visit the ECT website (g.co/exploringCT)

Credits Developed by the Exploring Computational Thinking team at Google and reviewed by K-12 educators from around the world.

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