Periodic Trends

In 1870, Dmitri Mendeleev first proposed a new way of studying and organizing the then known 63 elements. The modern form of the table has been modified and improved many times since Mendeleev's tables. Pioneers like Moseley (1913) and Seaborg (1941) have made the properties of the elements much simpler to study and understand.

In this activity, you are going to discover some of the trends of the properties that exist on the modern periodic table. To do this, you are going to graph a property to determine the trend then share your trends with the class.

OBJECTIVES

In this experiment, you will

- define some of the properties of an element
- graph the properties of the elements as a function of their atomic number
- determine the general trends found on the periodic table
- understand the power of the periodic table

MATERIALS

LabQuest
LabQuest App
Periodic Table App

PROCEDURE

1. See your teacher to determine which property you will study.
2. Use the Periodic Table Application found on your LabQuest to complete the data table.

Set up your LabQuest for data entry

3. With no sensors connected to your LabQuest, select New from the File menu.
4. Tap the Table tab to display the data table.
5. Set up the **Atomic Number** column
   a. Tap on the X column and change the column name to "Atomic Number."
   b. Select the Generate Values check box. Modify the Start value to **1**, the Stop value to **100**, and the Increment value to **1**.
   c. Adjust the Displayed Precision to **0** Decimal Places.
   d. Select OK.
6. Tap on the Y column and change the column name to "Group" then select OK.

7. Set up the properties column.
   a. From the Table menu, select New Manual Column.
   b. Change the column name to match the property you are studying.
   c. Enter the appropriate units.
   d. Adjust the Displayed Precision to match your data.
   e. Select OK.
8. Tap the first cell in the Group column and enter the data from your data table.

Viewing the data

9. Tap the Graph tab to view the graph.
10. From the Graph menu, choose Show Graph and select Graph 1.
11. Tap on the vertical axis label and select your property data. Use this graph to investigate trends in the data related to the different periods of the periodic table.
12. Sketch a graph of your data. Be sure to label the axes.

13. Tap on the horizontal axis label and select the Group data. This will display the data as if sorted by group. For example, the Alkali metals (group 1A) will graph between 1 and 2 and the Noble gases (group 0) will graph between 18 and 19.
14. From the Graph menu, choose Graph Options, uncheck the Connect Point check box, and tap OK.
15. To investigate trends in the data based on the Groups, tap and drag a region of the graph to highlight one of the Groups you wish to study (for example for the Halogens, highlight the region between 17 and 18.)
16. From the Graph menu, choose Zoom In to view the data. (To return to the original view, from the Graph menu select either AutoScale Once or Zoom Out.)
17. Sketch several graphs that show the trend of your property based on Group.

DATA

Property _____ **Units** _____

Atomic Symbol	Atomic Number	Group (coded)	Value	Atomic Symbol	Atomic Number	Group (coded)	Value
	1	1.1			26	8.4	
	2	18.1			27	9.4	
	3	1.2			28	10.4	
	4	2.2			29	11.4	
	5	13.2			30	12.4	
	6	14.2			31	13.4	
	7	15.2			32	14.4	
	8	16.2			33	15.4	
	9	17.2			34	16.4	
	10	18.2			35	17.4	
	11	1.3			36	18.4	
	12	2.3			37	1.5	
	13	13.3			38	2.5	
	14	14.3			39	3.5	
	15	15.3			40	4.5	
	16	16.3			41	5.5	
	17	17.3			42	6.5	
	18	18.3			43	7.5	
	19	1.4			44	8.5	
	20	2.4			45	9.5	
	21	3.4			46	10.5	
	22	4.4			47	11.5	
	23	5.4			48	12.5	
	24	6.4			49	13.5	
	25	7.4			50	14.5	

DATA (continued)

Property _____ **Units** _____

Atomic Symbol	Atomic Number	Group (coded)	Value	Atomic Symbol	Atomic Number	Group (coded)	Value
	51	15.5			76	8.6	
	52	16.5			77	9.6	
	53	17.5			78	10.6	
	54	18.5			79	11.6	
	55	1.6			80	12.6	
	56	2.6			81	13.6	
	57	20.601			82	14.6	
	58	20.602			83	15.6	
	59	20.603			84	16.6	
	60	20.604			85	17.6	
	61	20.605			86	18.6	
	62	20.606			87	1.7	
	63	20.607			88	2.7	
	64	20.608			89	20.701	
	65	20.609			90	20.702	
	66	20.610			91	20.703	
	67	20.611			92	20.704	
	68	20.612			93	20.705	
	69	20.613			94	20.706	
	70	20.614			95	20.707	
	71	3.6			96	20.708	
	72	4.6			97	20.709	
	73	5.6			98	20.710	
	74	6.6			99	20.711	
	75	7.6			100	20.712	

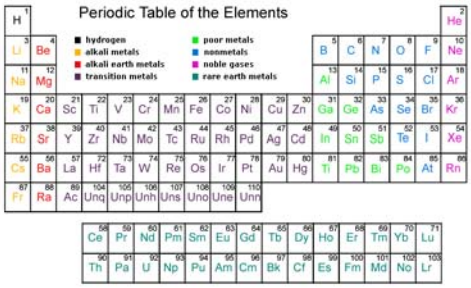
PROCESSING THE DATA

1. Define your property and how it is determined.

2. What is the trend as you move across a period (row)?

3. What is the trend as you move down a group (column)?

4. On the representation of the periodic table below, draw arrows to represent an ***increasing*** trend for period and group.



5. Share your results with your class. Compare the trends of your property with trends of other physical properties. If directed to do so by your teacher, complete the Periodic Trends Summary Sheet to record the class data.

QUESTIONS

1. Using the information from Processing the Data steps 4 and 5, describe the general trends of the physical properties investigated.

   a.

   b.

   c.

   d.

   e.

2. Describe, in terms of atomic structure, how each of the general trends from Question 1 might occur.

   a.

   b.

   c.

   d.

   e.

3. In general, what trends do you notice as you enter the transitional elements? Based on atomic structure, how might this occur?

4. In general, what trends do you notice as you enter the lanthanide and actinide series of elements? Based on atomic structure, how might this occur?

TEACHER INFORMATION

Periodic Trends

- This activity uses the LabQuest Periodic Table Application as the source of data. You can use other sources of data, including the internet. Be prepared to discuss differences in the data from different sources.
- For some situations, you may want to have the students investigate only the first 36 or 54 elements.
- You can use the Periodic Trends Summary Sheet as a way to have your students record the entire class data.
- You can copy the cards below, cut them, and distribute them as a means of assigning physical properties to investigate. You may choose to do any combination of these, some give better results then others. Since several of the ideas below are similar, you may choose to do only some of these.

PHYSICAL PROPERTIES

FIRST IONIZATION ENERGY	VALENCE ELECTRONS	DENSITY	MELTING POINT
BOILING POINT	ATOMIC RADIUS	COVALENT RADIUS	ATOMIC VOLUME
SPECIFIC HEAT	HEAT OF FUSION	HEAT OF VAPORIZATION	ELECTRO-NEGATIVITY

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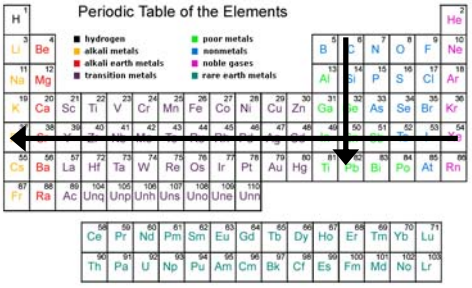
ANSWERS TO QUESTIONS

Atomic Radius, Atomic Volume, and Covalent Radius

Atomic Radius is the radius of the atom measured in picometers and is the basis for the calculated **Atomic Volume** measure in cm^3/mol**. Covalent Radius** is the measurement of the part of an atom that forms a covalent bond. Covalent Radius is measured in picometers

Atomic Radius and Volume decrease as you go across a period.

Atomic Radius and Volume increase as you move down a group.

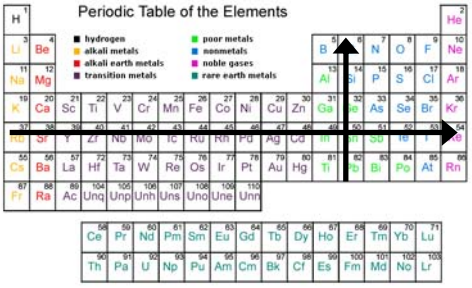


Electronegativity and First Ionization Energy

Electronegativity is an arbitrary scale from 0 – 4 and is used to measure how much an atom wants one more electron from another atom. **First Ionization Energy** is the amount of energy required to remove an electron from an atom.

Electronegativity and first ionization energy increase as you more across a period.

Electronegativity and first ionization energy decrease as you move down a group.

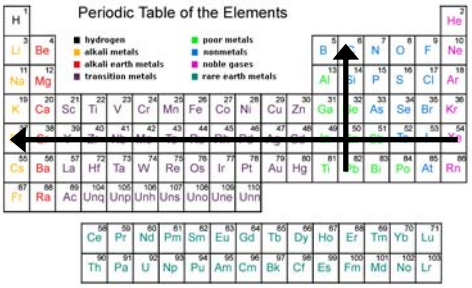


Heat of Fusion, Heat of Vaporization, and Specific Heat

Heat of Fusion is the amount of heat necessary to change one mole of solid into one mole of liquid at the melting point. **Heat of Vaporization** is the amount of heat necessary to change one mole of liquid into one mole of vapor at the melting point. Both Heat of Fusion and Heat of Vaporization are measured in kJ/mol. **Specific Heat** is the amount of heat necessary to raise 1 kg of a substance 1 degree Kelvin. Specific Heat is measured in J/g·K.

Heat of fusion, heat of vaporization, and specific heat all decrease as you increase atomic number within a period.

Heat of fusion, heat of vaporization, and specific heat all decrease as you increase atomic number within a group.



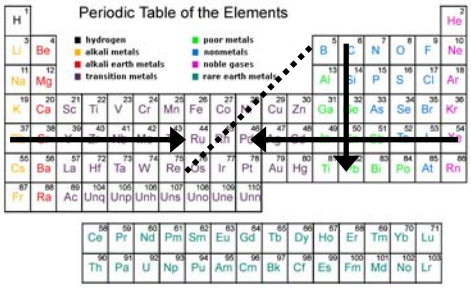
Based on an activity by Jacklyn Bonneau

Density

Density is a calculated value of mass divided by volume. Density is measured in g/cm^3.

Within a period the density is greatest towards the middle of the period.

Density increases going down a group.

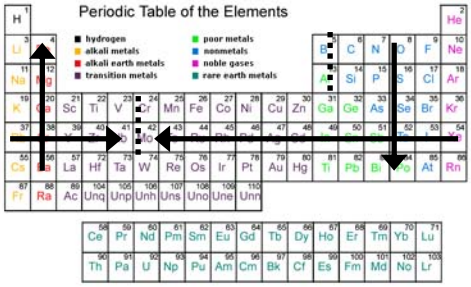


Melting Point and Boiling Point

Melting Point and Boiling Point are the temperatures where changes in phase occur. Melting point is the temperature where a solid changes to a liquid. The boiling point is the temperature at which a liquid changes to a gas. Melting point and boiling point are measured in degrees Kelvin.

Melting and boiling points tend to increase as you move toward the center of the period.

The melting and boiling points for metals generally decreases as you go down a group. Melting and boiling points for non-metals generally increases as you go down a group.

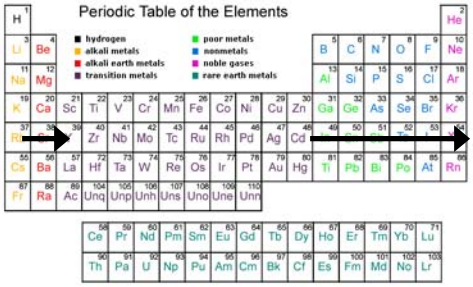


Valence Electrons

Valence Electrons are the electrons in the outermost electron shell. This is a count and does not have any associated units.

The number of valence electrons generally increases as you move across a period. Exceptions include the transition metals that generally have two valence electrons.

The number of valence electrons is constant for elements in the same group.

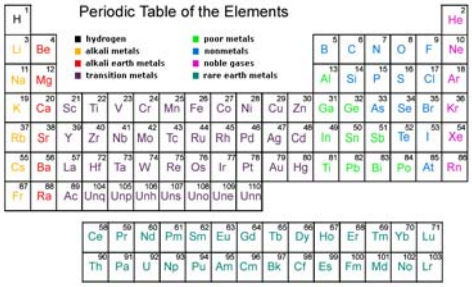


Periodic Trends Summary Sheet

Property _____

1. Define your property and how it is determined.

2. On the representation of the periodic table below, draw arrows to represent an ***increasing*** trend.



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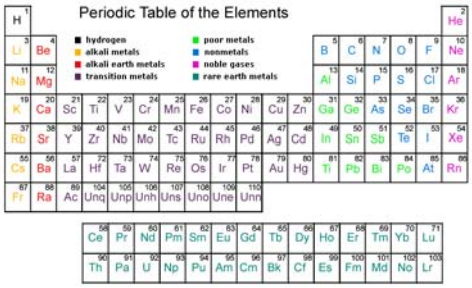

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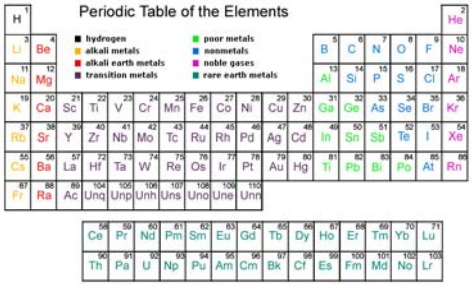

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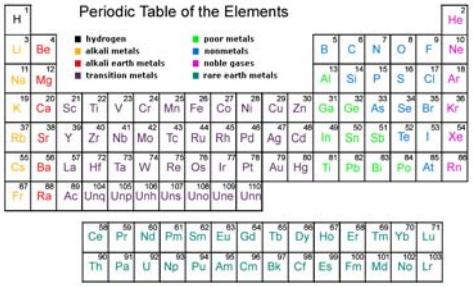

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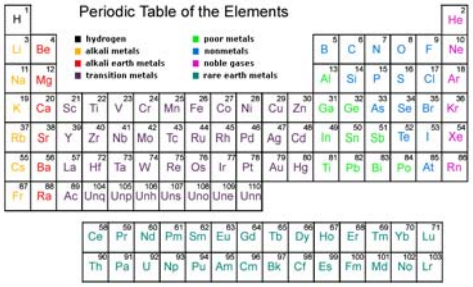

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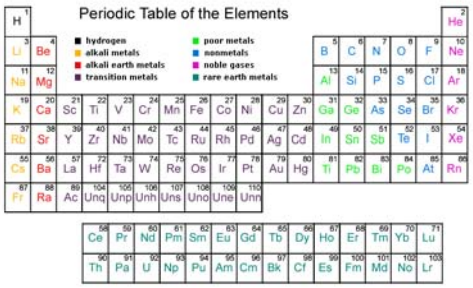
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