Teacher Version/KEY

Student Reading or "Script" for Discussion

PART ONE: Review of Periodic Table of Elements

The Periodic Table of Elements is a tremendously useful instrument to use in science to understand, predict, and explain how matter behaves. Remember:

- an element is the simplest substance that cannot be broken down by chemical or physical means without losing its properties;
- an atom is the smallest unit of an element; and
- that elements of the periodic table are arranged into columns and rows.

The columns are frequently called families. Elements in the same column or family will generally have the same arrangement of electrons in their outermost orbitals.

Understanding the Basics

The calcium atoms that you need for strong bones have an atomic number of 20.

What is calcium's atomic symbol? ***Ca***

Is calcium a metal, nonmetal, or semimetal? ***metal***

Fluorine is a very reactive element. Acids that have fluorine atoms can eat through glass. Fluorine has an atomic number of 9.

What is fluorine's atomic symbol? ***F***

Is fluorine a metal, nonmetal, or semimetal? ***nonmetal***

If the arrangement of outermost orbital electrons is similar, what do you predict about the chemical activity of elements that are in the same family on the periodic table?

Elements in the same family should "act" in very similar ways

List three elements that are in the same family:

Any acceptable answers. Any three elements in the same column.

The rows on the periodic table are frequently called periods. Elements in the same row or period may share some general properties, but changes occur as one goes across the table within a row.

Why do you think the chemical properties of elements in the same period change as one goes through a period?

The atomic number (number of protons) increases, resulting in the number of electrons to increase, therefore the reactivity of the successive elements will change.

List five consecutive elements that are in the same period:

Any acceptable answers. Any five elements in the same row.

One of the properties that change is the atomic radius. This is the distance from the center of an atom to its outermost electron.

In the space provided, properly graph the atomic radius versus the Period or Group Member Number (that is the number within the parentheses) for these elements. Draw one line for elements in the same Period and a second line for elements in the same Group.

Element (*)	**Atomic Radius (picometers, 10^{-12} m)**
Lithium (1)	155
Beryllium (2)	112
Boron (3)	98
Carbon (4)	91
Nitrogen (5)	92
Oxygen (6)	73
Fluorine (7)	72
Neon (8)	71
Sodium (2)	190
Potassium (3)	235
Rubidium (4)	248
Cesium (5)	267

***** Period or Group Member Number

Using your graph, describe the change in atomic radius in a period. ***Decreases***

Using your graph, describe the change in atomic radius in a family. ***Increases***

Compare the changes in atomic radius of atoms of elements in a period versus the changes in the atomic radius of atoms of elements in a family. ***Opposite, as general trends***

Major Sections of the Periodic Table

In general, elements that are found in the middle and on the left side of the periodic table are metals and those on the right side are nonmetals. A staircase-like line can separate the metals from the nonmetals, beginning with the left side and bottom of the Boron box, then between Aluminum and Silicon, and so forth.

Does your Periodic Table have this line? ***Consult your charts. The FCAT Table does.***

The elements that border this line (except aluminum) are called semimetals.

List the semimetal elements: ***Boron, Silicon, Germanium, Arsenic, Antimony, Tellurium, Polonium, Astatine***

The family of elements called the Noble gases is in the right most column.

List all the Noble gases: ***Helium, Neon, Argon, Krypton, Xenon, Radon***

Which element do you predict has the same outermost electron arrangement as Carbon (C)? ***Silicon***

Sodium atoms react with chlorine atoms to form molecules of table salt. One molecule of the compound we call table salt is shown by the formula NaCl. What do you predict is the formula of a molecule of the compound that results when potassium atoms react with chlorine atoms? ***KCl***

PART TWO: Superconductivity and the Periodic Table

What is superconductivity?

Superconductivity can be defined as the ability of a material to allow an electrical current to pass through it without any (that means ZERO!) resistance. Remember how you can hook up copper wires to a battery and try to light up a bulb *[or this can be done as a student-involved demo]*. What happened to the wire when you had it all connected? Yes, the wire got hot. This is a result of the resistance of the copper wire to allowing a current to pass through.

What does that heat mean for the efficiency of that copper wire for conducting electricity?

Loses some energy as heat, not 100% efficient

What would it mean if a wire could conduct electricity and NOT generate any heat?

Something that involves a better transfer of energy or more efficient or saving energy.

In January 1986, two scientists named Georg Bednorz and Alex Müller, who were working for IBM in Zurich, Switzerland, came upon an interesting phenomenon. They used observations made by others that chemicals known as oxides (because they have oxygen in them) have some interesting electrical properties. Bednorz and Müller were working by themselves and without much encouragement from others when they started mixing various compounds together in carefully recorded amounts. Then on January 27, a specific combination of the compounds barium carbonate ($BaCO_3$), lanthanum oxide (La_2O_3), and copper oxide (CuO) showed superconductivity at 30 K. This was important because this new superconductive material was of a class of chemical compounds that was new to the field of superconductivity. Very quickly people started trying to find even better superconductors.

How does the Periodic Table come into play?

The central portion of the periodic table is made up of the Transition Metals. The transition metals are slightly different than the groupings we have discussed so far. Transition Metals are very similar within their period *as well as* within a given column.

Copper is a transition metal.

Which elements do you predict would act most similar to Copper (Cu)?

Students should pick members of Cu's family: Silver and Gold; they might also pick a neighboring element, Nickel or Zinc, since the transition metals have some slightly different properties. But emphasize the first choice of silver and gold that are in the same column.

Explain the reasoning for your prediction that you just made.

Elements in the same family have similar outermost electron arrangements.

In addition, two special sections that fit in the middle portion of the periodic table are the Lanthanides (from atomic number 58 – 71) and the Actinides (from atomic number 90 – 103).

List the first three members of the Lanthanide series: ***Cerium, Praseodymium, Neodymium***

List the first three members of the Actinide series: ***Thorium, Protactinium, Uranium***

In November 1986, Bednorz and Müller published their research. A researcher in Houston, Texas named Paul Chu read this paper wherein the pair shared their discovery. Chu quickly realized the importance of this new class of materials that were shown to be superconductors.

Chu and his group of researchers in Houston worked with colleagues in Huntsville at the University of Alabama quickly set out to reproduce the discovery by Bednorz and Müller. Chu's next step was to try and find new combinations of materials that would be superconductive at temperatures higher than Bednorz's and Müller's $La_{1.85}Ba_{0.15}CuO_4$.

Using the periodic table of the elements, which element would you predict to have properties most similar to Lanthanum? ***Yttrium.***

Explain your reasoning for your selection to the previous question.
Same family, most similar electron arrangement

Name three other elements that may have similar properties to Lanthanum?
Scandium, Actinium (in the same column), and Cerium or Praseodymium (neighbors in the transition lanthanide series).

Using the periodic table of the elements, which element would you predict to have properties most similar to Barium? ***Strontium***

Explain your reasoning for your selection to the previous question.
Same family, most similar electron arrangement

Name three other elements that may have similar properties to Barium? Any three more in the same family: ***Beryllium, Magnesium, Calcium, Radium***

Given the formula of barium carbonate is $BaCO_3$, what would you predict is the formula for the calcium carbonate that makes up most of the limestone in our sinks and springs? ***$CaCO_3$***

Explain your answer. ***Ca and Ba are in the same family, thus they have similar outer electron arrangements, thus they will form molecules of compounds in similar ways.***

Given the formula of lanthanum oxide is La_2O_3,, what would you predict is the formula for yttrium oxide? ***Y_2O_3; for similar reasoning as above.***

In early 1987, Paul Chu and his group synthesized a new material represented by the formula $YBa_2Cu_3O_7$. This new material is superconductive at 90 K. The temperature of 90 K is of great importance because it is above the temperature of liquid nitrogen, which boils at 77 K. Thus a new class of matter was described that could be economically and efficiently cooled to its superconductive temperature. This breakthrough has resulted in many researchers and companies pursuing research for applying superconductor science in such areas as magnetic levitating (maglev) trains and magnetic resonance imaging (MRI).

Part of the problem in developing these materials is that they are ceramics. Think of how ceramics are different from copper wire.

What problems do you predict exist for using these new materials for conducting high amounts of electricity? ***Brittle, not flexible, not readily ductile, need LN_2, need substrate or protection***

Going Further: Use the www.google.com search engine on the internet to research and report back to the class on other applications of superconductor research. Create a poster with three illustrations and 250 words of text explaining your topic.