Name: ________________________________

3.3 – The Periodic Table
Science 9, Wolfe

Part 1: The Properties of Elements

Back before we knew a thing about how to count protons or even see individual atoms or molecules, we could see that some things looked, felt, smelled, and tasted different from one another. We could see that some things, such as rocks, would sink in water and some things, such as most woods, would float in water. And we knew that some things, such as gold, were solid until you got them very very hot; some were liquid, and some could be both at regular temperatures – like water!

A **property** is just a characteristic of something – its size, shape, colour, etc.

Watch the following videos for a little more explanation about properties:

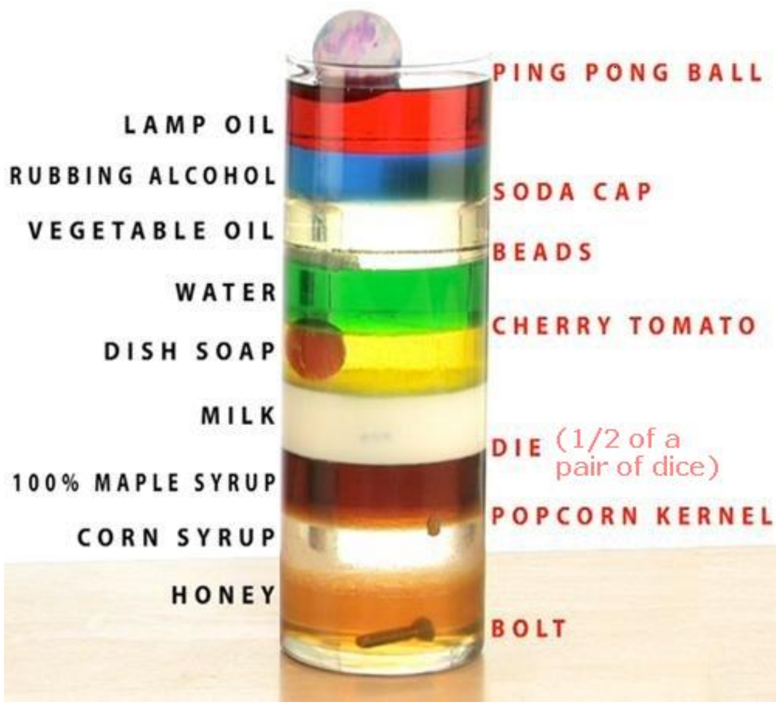
- *Organizing properties: Crash Course Kids #35.1*
  https://www.youtube.com/watch?v=zD7W5O0BH7g
- *What's my property? Crash course kids #35.2*
  https://www.youtube.com/watch?v=nlSemv2fLN8

Some properties are physical. You can see these with your eyes or measure them in the lab with basic tools such as rules and thermometers.

In chemistry, the **physical properties** we care about include things like:

Density – does it float or sink in water? How heavy does it feel?

This picture shows the density of various substances. Water is what we compare everything to, and in this diagram it is near the middle. Look at it to answer these questions:



Are oils more or less dense than water? ____

What is the densest thing in this diagram? _______________________

Why do you think honey and syrups are more dense than water? What ingredient do they all have in common, that water doesn't? ____

____

Boiling point – When does it turn from a liquid into a gas?
Melting point – when does it turn from a solid into a liquid?

Look at the following chart of some elements and their melting and boiling points:

Element name (symbol)	Melting point (C)	Boiling point (C)
Helium (He)	-272	-269
Oxygen (O)	-219	-183
Argon (Ar)	-189	-186
Iron (Fe)	1538	2861
Silver (Ag)	962	2162
Tin (Sn)	232	2602

The first three elements on the list are one we usually see as gases. You might notice that their boiling points are very low and there isn't much difference between melting and boiling.

The last three elements are all metals. You might notice that their melting points are all very high and their boiling points higher still.

At room temperature (say 20 C), which of these elements will be:

solid? ____

liquid? ____

gas? ____

Did you notice something odd? None of them were liquid at room temperature. It's actually really unusual for elements to be liquid on Earth. There are only six of them that would be liquid in the room you are in right now, and only a few more that would be liquid on a very hot or cold day outside!

Conductivity – does electricity go through it?

Remember way back when we looked at electricity? We found that metals are usually a good conductor, and air (a gas) is a poor conductor (or a good insulator.)

Notice on the conductor list, you have three metal elements (silver, gold, copper), one alloy which is 90% or more iron, and sea water – which isn't a single element at all.

The insulators are made up of mostly carbon, oxygen, hydrogen, and/or silicon. None of these are metals.

Malleable & ductile – can you squish it? Does it bend or break if you hit it with a hammer? Can you form it into a thin sheet or a long wire?

If you can hammer it into a thin sheet, it's malleable.
If you can make it into a wire, it's ductile.

Can you think of three elements that are very malleable
Think of foil, cans, jewellery… anything that is pressed or hammered into shape.

____

____

____

Can you think of two elements that are very ductile? Think of what wires can be made of. You may repeat some answers from above.

____

____

These usually go together but not always – lead is very malleable, but it doesn't like being stretched.

Do you notice what every element you thought of above has in common? That's right, again we see metals doing their thing. The difference between metals and non-metals is something we will talk about again in the next section.

Other physical properties include things that don't need as much explanation, such as whether they are dull or shiny, what colour they are, what they smell like, how transparent they are, etc.

Chemical properties include things like:

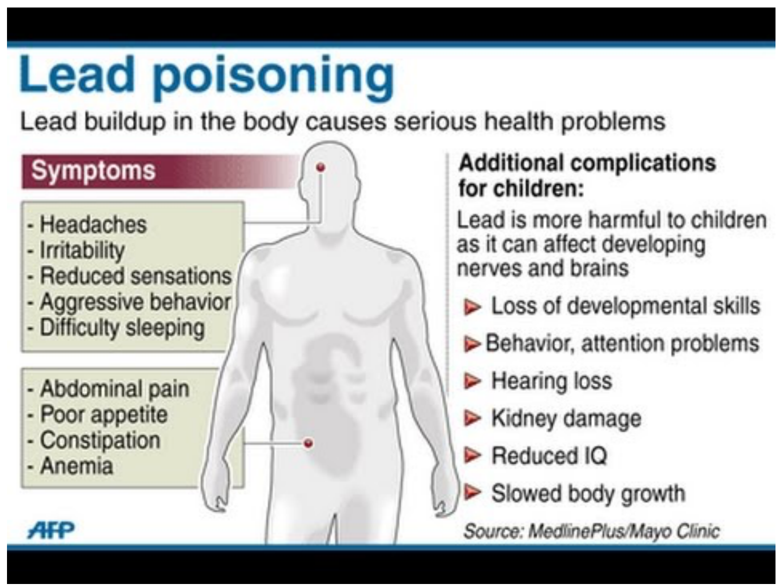
Flammable – how easily does it catch on fire?

Hydrogen and oxygen are two elements that are very flammable. Here's a quick video showing a science teacher exploding hydrogen and oxygen balloons by exposing them to a flame:

Three balloons:
https://www.youtube.com/watch?v=a6qGIMqDKwA

And of course, don't forget the Hindenburg. There's a reason we switched from hydrogen to helium to make balloons float!

Toxicity – is it poisonous?



Elements can be dangerous to humans, animals, or plants in a variety of ways. We usually look at toxicity in humans – is it dangerous to eat, breathe, touch, etc?

You probably know that "lead poisoning" is a thing. Lead used to be used in water pipes, paint, gasoline, and all kinds of places – with terrible effects. There are other metals that are dangerous too, as well as poisonous gases.

Reactivity – does it combine with other elements easily, or does it like to keep to itself?

Some elements, such as hydrogen and oxygen, and very reactive. Here's a science class demonstration of how various materials (known as the alkali metals) react with water: "Alkali metals reacting with water" https://www.youtube.com/watch?v=jI__JY7pqOM

Some, such as neon and argon, don't like to mix with other elements at all and so are non-reactive. You probably know about neon from neon lights, which are just tubes filled with neon gas (and sometimes other gases) that light up when you run a current through them. Argon has a lot of uses, but most people are less familiar with it. Watch this short video from Periodic Table of Videos: https://www.youtube.com/watch?v=nrHVOFG2V-c

Extras for enrichment:

And just for kicks… Here's a video on some of most dangerous elements that can be found: "MOST DANGEROUS Table of the Elements"
https://www.youtube.com/watch?v=tj05u6wuQmg

And going a little away from elements, Hank is ready to tell us about some of the most dangerous chemicals on Earth: https://www.youtube.com/watch?v=ckSoDW2-wrc

Part 2: How elements are organized

By now, you may have figured out that there are whole lot of different elements, from hydrogen – the smallest one known, which consists of only a lonely little proton with an electron circling around it – to the superheavy elements, which only exist in a lab and might be so radioactive they only live for part of second before turning into something else!

Take a look at the "Periodic Table of the Elements, in Pictures" (attached on the back of this packet). This is great table that includes not only the science information we will learn about but also an example of where me find or use each one!

Look down the right side of the table. The number of the element is in the upper right of each box. What are the names of the elements numbered?

#10 ______________________

#18 ______________________

#36 ______________________

#54 ______________________

What do they all have in common? They are all used for ______________________________
____ . Hmm… they are all in the same column, and they all have really similar uses. Is this just a coincidence?

The periodic table isn't just organized by number – there's a reason it has that weird shape at the top and a reason it's as wide as it is! In fact, when the Periodic Table was created, no one even knew atoms could be broken down into smaller parts. The elements were organized by their properties – the way they looked and behaved – and it was only much later that we found out the way their electrons were arranged was responsible for most of those properties.

Watch the following video to learn a bit more about how the periodic table was created and why it's drawn like that:

"The genius of Mendeleev's periodic table" https://www.youtube.com/watch?v=fPnwBITSmgU

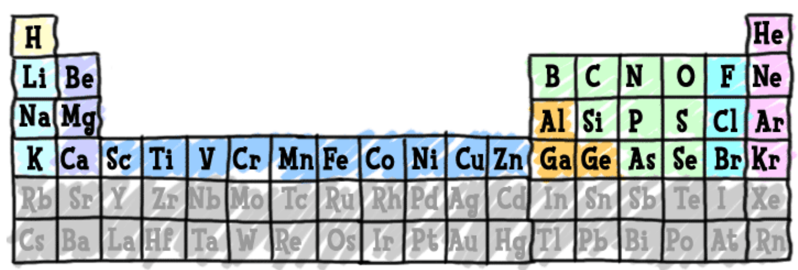
But how do we organize the periodic table today? The text in this section will go over this, and this video will show you in detail how it works and how we classify elements. It's 14 minutes long and has quite a bit of information, and you can watch it either BEFORE or AFTER reading the section:

"The Periodic Table Explained" https://www.youtube.com/watch?v=uPkEGAHo78o

The text below is adapted from http://www.chem4kids.com/files/elem_intro.html

Periodic Table and the Elements

Now we're getting to the heart and soul of the way the Universe works. You know that a generic atom has some protons and neutrons in the nucleus and some electrons zipping around in orbitals. When those pieces start combining in specific numbers, you can build atoms with recognizable traits.



If you have eight protons, neutrons and electrons, you will have an oxygen (O) atom.

If you have seven protons, neutrons, and electrons, you will have a nitrogen (N) atom.

If you have 14 protons, neutrons, and electrons, you will have a ________________ atom (check your periodic table!)

If you have 74 protons, neutrons, and electrons, you will have a __________________ atom.

And if you have _______ protons, neutrons, and electrons, you know you have a carbon (C) atom!

The atoms for each element are unique, even though they are all made of similar subatomic parts. The way they are arranged – especially the electrons – affects all of their properties and makes them different from atoms of another element.

Remember that 'atom' is the general term. Everything is made of atoms. The term 'element' is used to describe atoms with specific characteristics. There are almost 120 known elements. For example, you are made up of billions of billions of atoms but you probably won't find more than 40 elements (types of atoms) in your body.

Chemists have learned that over 95% of your body is made up of hydrogen (H), carbon (C), nitrogen, oxygen, phosphorus (P), and calcium (Ca).

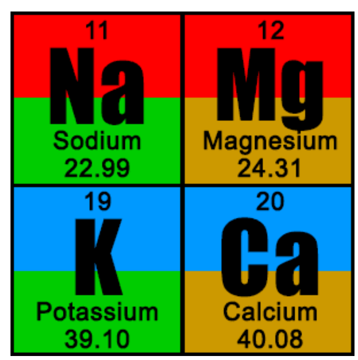
The Same Everywhere

As far as we know, there are a limited number of basic elements. Up to this point in time, we have discovered or created about 120. Scientists just confirmed the creation of element 117 in 2014. While there are more elements to discover, the basic elements remain the same.

Iron (Fe) atoms found on Earth are identical to iron atoms found on meteorites. The iron atoms in the red soil of Mars are also the same.

With the tools you learn here, you can explore and understand the Universe. You will never stop discovering new reactions and compounds, but the elements will be the same.

Elements as Building Blocks



The **periodic table** is organized like a big grid. Each **element** is placed in a specific location because of its atomic structure. As with any grid, the periodic table has rows (left to right) and columns (up and down). Each row and column has specific characteristics.

You've got Your Periods...

Even though they skip some squares in between, all of the rows read left to right. When you look at the periodic table, each row is called a **period** (Get it? Like PERIODic table.). All of the elements in a period have the same number of atomic orbitals, or electron shell.

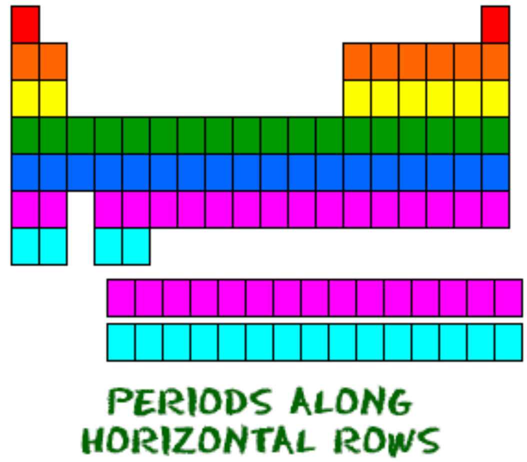
Remember the worksheet in the last section? The first ring of electrons only held two. The first two elements on the periodic table are in the top row – Hydrogen (H) has one electron and Helium (He) has two.

After that, a second row starts. How many elements are in the second row? ________

How many are in the third row? __________

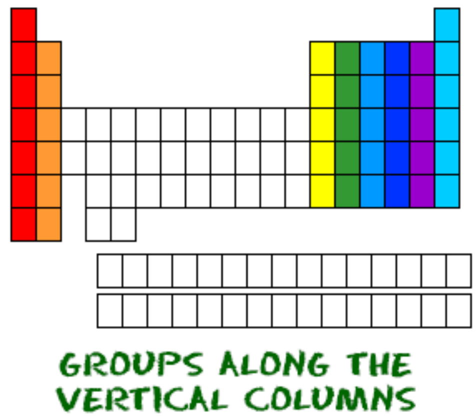
Each of those electron shells, or orbitals, can hold up to eight electrons.

The fourth row, or period, is _______ elements across. The fourth electron shell can hold that many electrons! Get it?



...and Your Groups

Now you know about periods going left to right. The periodic table also has a special name for its vertical columns. Each column is called a **group**. The elements in each group have the same number of electrons in the outer **orbital**. Those outer electrons are also called **valence electrons**. They are the electrons involved in chemical bonds with other elements.



Every element in the first column (group one) has one electron in its outer shell.
Every element in the second column (group two) has two electrons in the outer shell.
As you keep counting the columns, you'll know how many electrons are in the outer shell. There are exceptions to the order when you look at the transition elements, but you get the general idea.

For example, Lithium (Li) has the atomic number 3. This means is has ___ protons and ___ electrons. Since we filled up the first shell (with two electrons), there is one left over to start the next. Lithium has ____ valence electron.

The atomic number tells you there are seven electrons in a neutral atom of nitrogen. How many electrons does it have total? _______ How many are in its outer orbital? _____

Take a much “larger” element, Zinc (Zn.) Find it on the periodic table:

Atomic number: _____

Total number of electrons: _____

Electrons in valence shell: ____

Why does the number of valence electrons matter? Because it affects the element’s behaviour.

Atoms really like to have a full valence shell. The last column on the periodic table (Column 18) is known as the “noble gases”. The elements are so happy just being by themselves that they rarely mix to form compounds (so they’re called noble, like they are rich folks that don’t have to hang out with the rest of us.)

Atoms just to the left of the noble gases have one electron less than a full valence shell. They are desperate to find that last electron.
The name of this column is ____________________. Fluorine, chlorine, bromine, and other halogens will easily form bonds with other elements to make different compounds. This way, they get that extra electron to fill their valence shell…

In the first two periods, atoms only have one or two valence electrons. These elements have an extra electron or two and like to bond with elements that are missing electrons. They “donate” an electron to someone else’s valence shell to get rid of the extra. What are column 1 and 2 called?
_________________________________ and ____

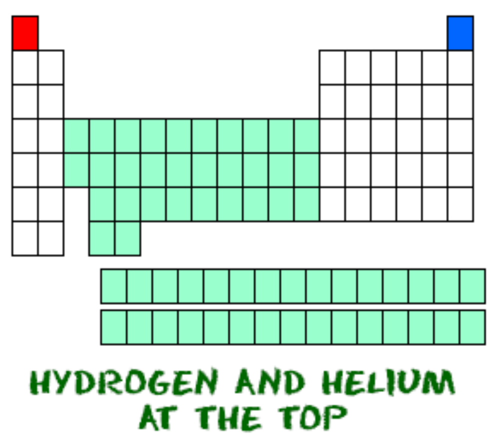
We usually don’t bother talking about the other groups by name too much. Their behaviour is a little more complicated and something you will get into if you take Chemistry.

The main thing to remember is that atoms with the same number of electron shells, or orbitals, are in the same ______________ (row in the periodic table) and atoms with the same number of valence electrons are in the same _________ (column in the periodic table.)

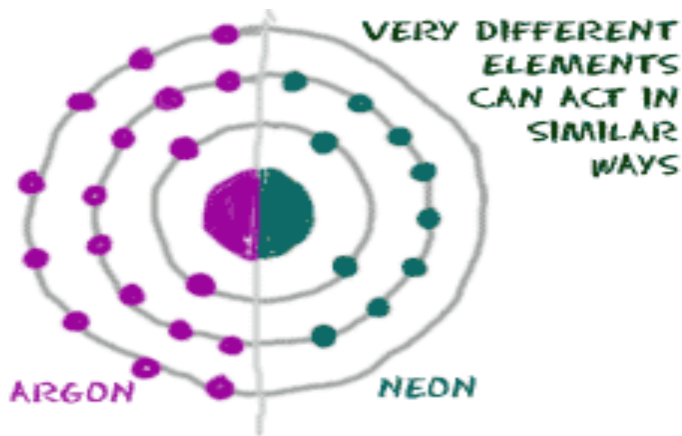
Two at the Top

Hydrogen (H) and helium (He) are special elements. Hydrogen, in its neutral form, does not have a neutron. There is only one electron and one proton.

Helium (He) is different from all of the other elements. It is very stable with only two electrons in its outer orbital (valence shell). Even though it only has two electrons, it is still grouped with the noble gases that have eight electrons in their outermost orbitals. The noble gases and helium are all "happy," because their valence shell is full.



Families Stick Together



We just covered the columns and rows of the periodic table. There are also other, less specific, groups of elements. These groups are all over the table. Scientists group these **families** of elements by their chemical properties. Each family reacts in a different way with the outside world. Metals behave differently than gases, and there are even different types of metals. Some elements don't react, while others are very reactive, and some are good **conductors** of electricity.

The columns of the periodic table are often used to define families. The noble gases are all located in the far right column of the table. That column is labeled **Group Zero**. Other families can be made of elements in a series. A good example of a series of elements is the **transition metal** family.

The thing to remember is that a family of elements can be found in several ways. You need to run tests and study the elements to determine their properties. Only after that testing can you determine what family an element belongs in.

Part 3: Tell me about an element

Use the next page to create an informative mini-poster that looks like the square for an element on the periodic table. Refer to your periodic tables for where things should go. It should include:

- Name
- Symbol
- Atomic number
- Family (given at the top of the column it is in)
- Melting and boiling points
- Picture(s) of the element and/or something that contains it
- When it was discovered and by whom
- Three more facts about the element (for example: how common is it? Where is it found? What is it used for? Does it have any interesting properties, like being magnetic or radioactive?)

Most of these can be easily found by googling. Try something like "history of boron" or "boron facts," or watch the Period Table of Videos segment for your element (www.periodicvideos.com)