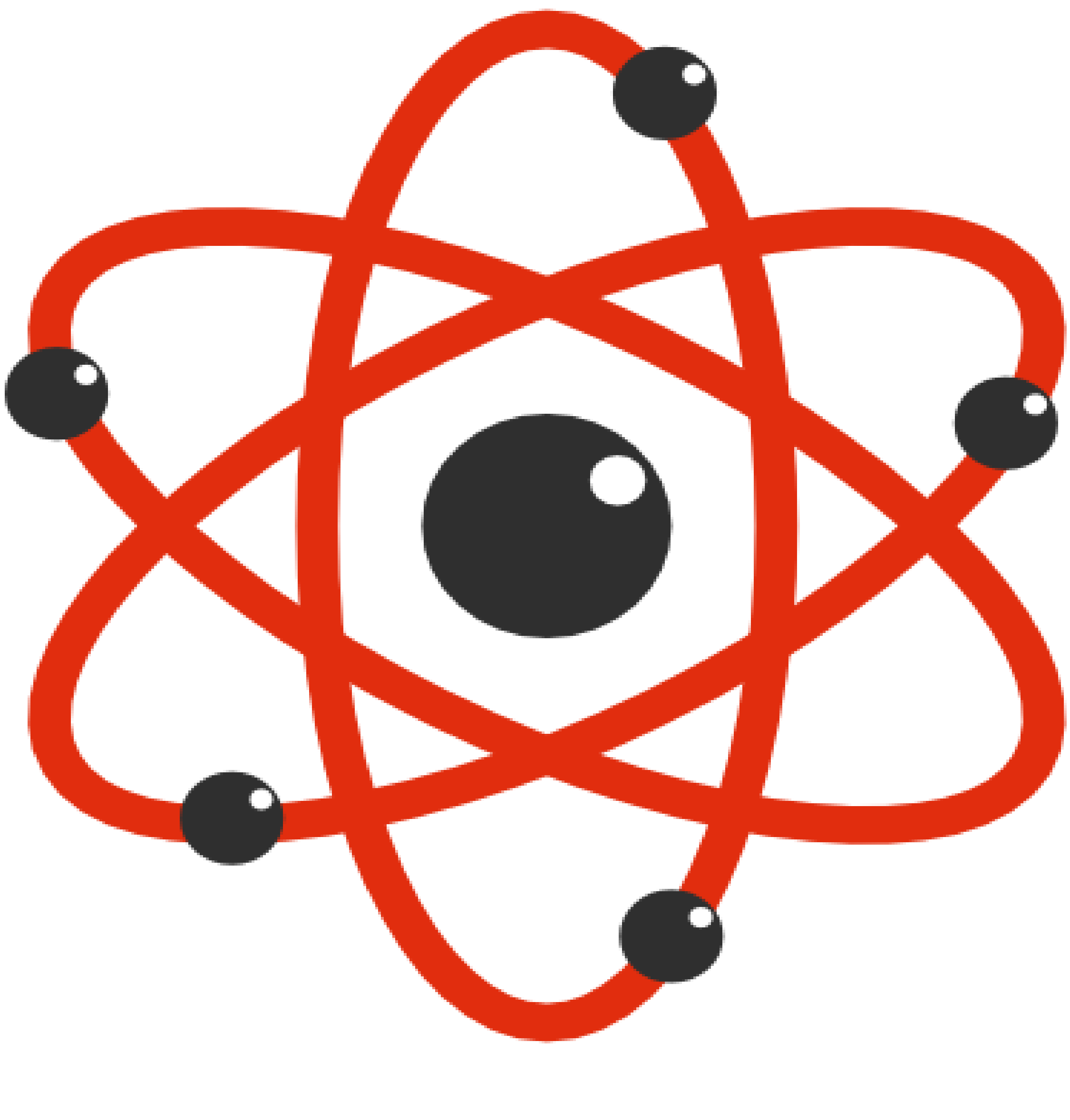
The Beginner's Guide To Atoms And The periodic Table

By Marci Goodwin



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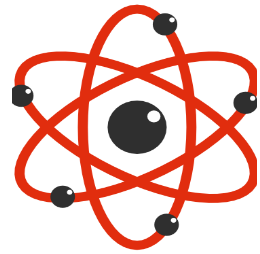
The Beginner's Guide To Atoms And The periodic Table

What Are Atoms?



Do you like playing with LEGOs or building blocks? Imagine you are building a castle with LEGOs. You start with one piece and then add another and another. Your structure grows. Using different sizes and shapes of basic pieces you can build almost anything.

Everything in the entire universe is made of basic building blocks called **atoms.** The clothes we wear, the chairs we sit on, the birds, the trees, the air we breathe, and our bodies are all made up of atoms of different types. With atoms, you can literally build *anything*.

The History Of Atomic Theory

The idea for the existence of atoms has been around for centuries. Around 400 BC, the Greek philosopher, **Democritus**, developed a theory to explain some of the properties of **matter**. Matter is basically anything that takes up space and has mass. Rocks, pencils, air, and water are all examples of matter.

Democritus had the idea that all matter is made up of small, separate particles. He wondered if you break a piece of matter in half, and then break it in half again, how many times can you break it before you can break it no further? He hypothesized that you would eventually end up with a basic, indivisible piece of matter - the atom.

Democritus' ideas about atoms were dismissed by other Greek philosophers of his day, and therefore not studied. It wasn't until nearly 2000 years later that scientists began thinking about the structure of matter again and actually obtained experimental evidence for the existence of atoms.

In 1803, **John Dalton**, an English chemist and teacher, gave the first evidence that atoms existed as a result of his scientific experiments. Because of his research, he developed what is known as Dalton's Atomic Theory. This theory is still the backbone of modern atomic study.

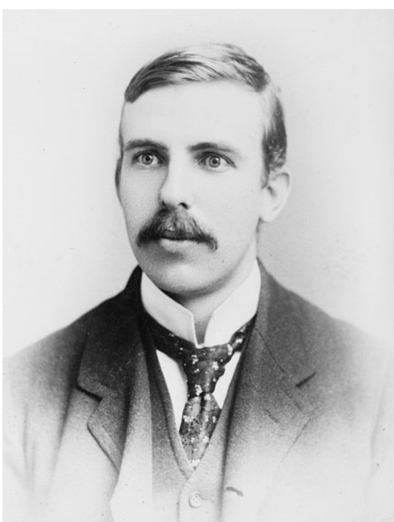
** Image licensed under Public Domain via Wikimedia Commons*

Dalton's Atomic Theory states that:

1. Matter is made up of atoms that are indivisible and indestructible.
2. All atoms of an element are identical.
3. Compounds are formed by a combination of two or more different kinds of atoms.
4. A chemical reaction is a rearrangement of atoms.

While scientists after Dalton knew that atoms really existed, they didn't know a lot about them. In 1897, while experimenting with electricity, the English physicist **J.J. Thomson** discovered the presence of negatively charged particles. He found that these particles were smaller than atoms and proposed that these particles were actually part of the atom itself. These particles were later named electrons.

In 1911, physicist **Ernest Rutherford** set out to find out more about atoms. He wanted to investigate the inside of atoms and discover more about their make-up. His experiments led to the discovery of the nucleus of the atom and the positively charged protons within the nucleus. ** Image licensed under Public Domain via Wikimedia Commons*



Rutherford also discovered that electrons orbit the nucleus. His initial theory was that the negative charge of the electrons would be attracted to the positive charge of the protons in the nucleus. This would cause the electrons to eventually spiral into the nucleus. However, this would mean that the energy levels of the atoms would be changing as the electrons were pulled in toward the nucleus. This posed a problem since atoms appeared to remain stable.

In 1912 a Danish physicist, **Niels Bohr**, came up with a theory that said the electrons do not spiral into the nucleus as Rutherford thought. Bohr proposed that electrons orbit the nucleus at fixed distances, thus remaining stable. This led to the use of the **Bohr Model** to show the composition of atoms. We will learn more about the Bohr Model later in the lesson.

For Further Atomic History Study

- A Brief History Of Atoms
- Interactive History Of The Atom Lesson
- John Dalton Biography
- J.J. Thomson Biography
- Ernest Rutherford Biography
- Niels Bohr Biography

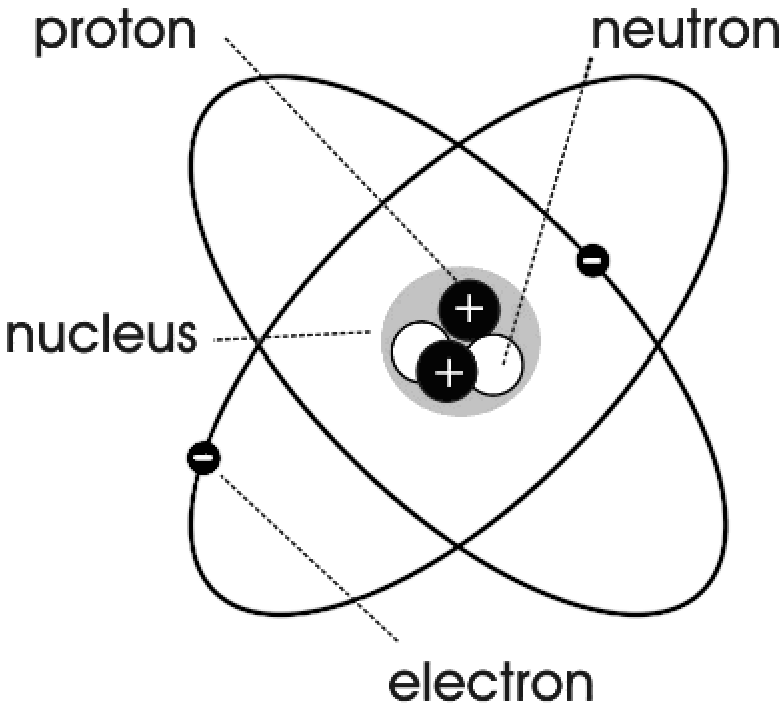
The History Of Atomic Theory

Scientists have been hypothesizing about the existence and role of atoms in the universe for centuries. Over that time, certain men made great breakthroughs in the study of atoms.

Write brief summaries of how the scientists you read about contributed to atomic theory. You can add a picture of the scientist or create a drawing representing their contribution.

Parts Of The Atom

Although atoms are the basic building blocks of the universe, atoms can be broken down into smaller particles. These particles are **protons**, **neutrons** and **electrons**. We mentioned their discovery in the previous lesson. Now, we'll learn more about them.



Protons - positively charged particles found in the nucleus of the atom

Neutrons - neutrally charged particles found in the nucleus of the atom

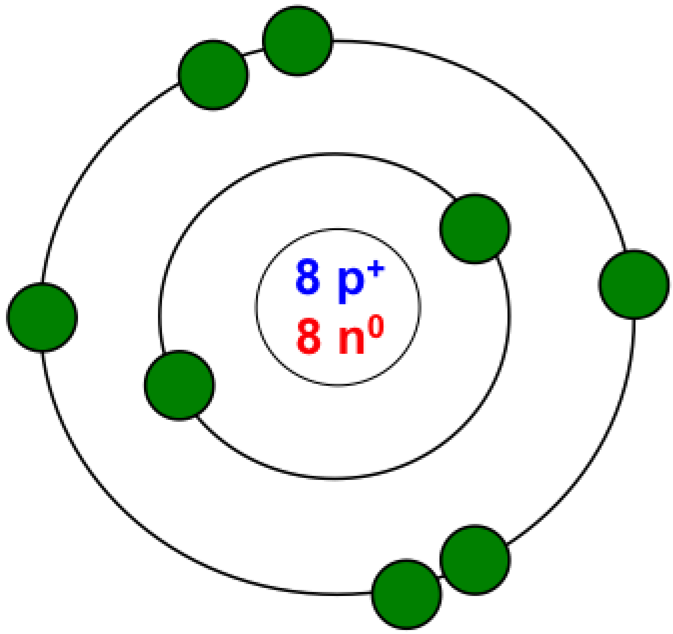
Electrons - negatively charged particles that orbit the nucleus of an atom

A simple way to think of atoms is to think about our solar system. The nucleus is like the sun and the electrons are like the planets that orbit around the sun. Except that instead of gravity holding the electrons in orbits like planets around the sun, the electrons are held in orbit around the nucleus by the electromagnetic force between their own negative charge and the positive charge of the protons in the nucleus.

In order for atoms to be stable, the number of orbiting negative electrons must be the same as the number of protons. Neutrons have no charge and therefore have no effect on the stability of the atom.

Bohr Model

As we discussed before, **Niels Bohr** came up with a theory that stated the electrons orbit the nucleus at fixed distances. These orbits are called energy levels.



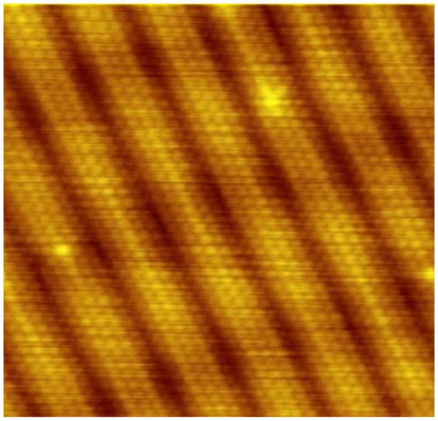
This discovery led to the formation of the **Bohr Model** that shows a simplified version of the structure and parts of atoms. The Bohr Model is called a **planetary model,** because it shows negatively-charged electrons orbiting a small, positively-charged nucleus (because of the protons located in the nucleus) similar to the way the planets orbit the sun.

This model shows these electrons orbiting in different energy levels, or shells, around the nucleus. Bohr discovered that various energy levels can hold different numbers of electrons: energy level 1 may hold up to 2 electrons, energy level 2 may hold up to 8 electrons, and so on.

This model works for simple atoms, like oxygen, but not for more complex atoms. However, the Bohr Model is used in many textbooks because of its simplicity and ease of understanding.

Can We See Atoms?

Atoms are very tiny. How tiny? A cube of sugar contains as many atoms as there are stars in the universe. Until recently, even the most powerful microscopes couldn't see atoms. Because atoms are more than 1000 times smaller than a wavelength of visible light, light cannot be used to see an atom. An entirely new type of microscope had to be invented, the **Scanning Tunneling Microscope**, that can actually see individual atoms.



This is an image of the surface of the element gold as viewed through a Scanning Tunneling Microscope. The dots you see are individual gold atoms.

Check out the How Big Is An Atom video from TED ED- http://ed.ted.com/lessons/just-how-small-is-an-atom

The Atom

Vocabulary

Atoms - ____

Matter - ____

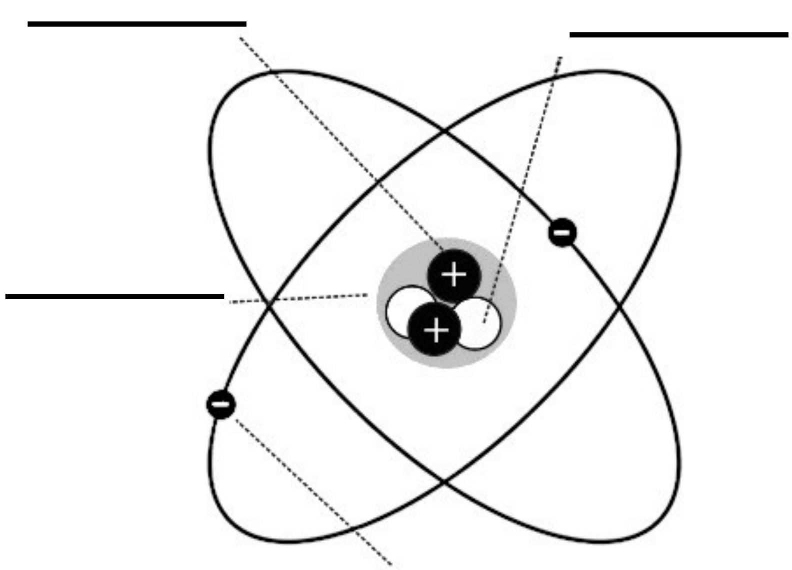
Protons - ____

Electrons - ____

Neutrons - ____

Label The Atom

Draw from the words above to label the atom.



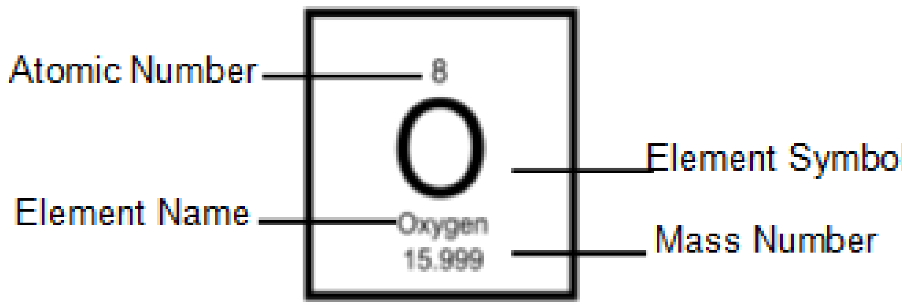
The Periodic Table Of Elements

As mentioned earlier, **elements** are substances made up of the same type of atom. Iron only contains iron atoms and gold only contains gold atoms. The atom is the smallest piece of an element that we can have and still have the characteristics of that element. For instance, an atom of iron is the smallest piece of iron we can have and still have the element iron. The Periodic Table Of Elements is a way to organize these elements according to the properties of their atoms.

hydrogen 1 **H** 1.0079																		helium 2 **He** 4.0026
lithium 3 **Li** 6.941	beryllium 4 **Be** 9.0122												boron 5 **B** 10.811	carbon 6 **C** 12.011	nitrogen 7 **N** 14.007	oxygen 8 **O** 15.999	fluorine 9 **F** 18.998	neon 10 **Ne** 20.180
sodium 11 **Na** 22.990	magnesium 12 **Mg** 24.305												aluminium 13 **Al** 26.982	silicon 14 **Si** 28.086	phosphorus 15 **P** 30.974	sulfur 16 **S** 32.065	chlorine 17 **Cl** 35.453	argon 18 **Ar** 39.948
potassium 19 **K** 39.098	calcium 20 **Ca** 40.078		scandium 21 **Sc** 44.956	titanium 22 **Ti** 47.867	vanadium 23 **V** 50.942	chromium 24 **Cr** 51.996	manganese 25 **Mn** 54.938	iron 26 **Fe** 55.845	cobalt 27 **Co** 58.933	nickel 28 **Ni** 58.693	copper 29 **Cu** 63.546	zinc 30 **Zn** 65.39	gallium 31 **Ga** 69.723	germanium 32 **Ge** 72.61	arsenic 33 **As** 74.922	selenium 34 **Se** 78.96	bromine 35 **Br** 79.904	krypton 36 **Kr** 83.80
rubidium 37 **Rb** 85.468	strontium 38 **Sr** 87.62		yttrium 39 **Y** 88.906	zirconium 40 **Zr** 91.224	niobium 41 **Nb** 92.906	molybdenum 42 **Mo** 95.94	technetium 43 **Tc** [98]	ruthenium 44 **Ru** 101.07	rhodium 45 **Rh** 102.91	palladium 46 **Pd** 106.42	silver 47 **Ag** 107.87	cadmium 48 **Cd** 112.41	indium 49 **In** 114.82	tin 50 **Sn** 118.71	antimony 51 **Sb** 121.76	tellurium 52 **Te** 127.60	iodine 53 **I** 126.90	xenon 54 **Xe** 131.29
caesium 55 **Cs** 132.91	barium 56 **Ba** 137.33	57-70 *	lutetium 71 **Lu** 174.97	hafnium 72 **Hf** 178.49	tantalum 73 **Ta** 180.95	tungsten 74 **W** 183.84	rhenium 75 **Re** 186.21	osmium 76 **Os** 190.23	iridium 77 **Ir** 192.22	platinum 78 **Pt** 195.08	gold 79 **Au** 196.97	mercury 80 **Hg** 200.59	thallium 81 **Tl** 204.38	lead 82 **Pb** 207.2	bismuth 83 **Bi** 208.98	polonium 84 **Po** [209]	astatine 85 **At** [210]	radon 86 **Rn** [222]
francium 87 **Fr** [223]	radium 88 **Ra** [226]	89-102 * *	lawrencium 103 **Lr** [262]	rutherfordium 104 **Rf** [261]	dubnium 105 **Db** [262]	seaborgium 106 **Sg** [266]	bohrium 107 **Bh** [264]	hassium 108 **Hs** [269]	meitnerium 109 **Mt** [268]	ununnilium 110 **Uun** [271]	unununium 111 **Uuu** [272]	ununbium 112 **Uub** [277]	ununtrium 113 **Uut** [284]	ununquadium 114 **Uuq** [289]	ununpentium 115 **Uup** [288]	livermorium 116 **Lv** [293]	ununseptium 117 **Uus** [292.208]	ununoctium 118 **Uuo** [294]

*Lanthanide series	lanthanum 57 **La** 138.91	cerium 58 **Ce** 140.12	praseodymium 59 **Pr** 140.91	neodymium 60 **Nd** 144.24	promethium 61 **Pm** [145]	samarium 62 **Sm** 150.36	europium 63 **Eu** 151.96	gadolinium 64 **Gd** 157.25	terbium 65 **Tb** 158.93	dysprosium 66 **Dy** 162.50	holmium 67 **Ho** 164.93	erbium 68 **Er** 167.26	thulium 69 **Tm** 168.93	ytterbium 70 **Yb** 173.04
* *Actinide series	actinium 89 **Ac** [227]	thorium 90 **Th** 232.04	protactinium 91 **Pa** 231.04	uranium 92 **U** 238.03	neptunium 93 **Np** [237]	plutonium 94 **Pu** [244]	americium 95 **Am** [243]	curium 96 **Cm** [247]	berkelium 97 **Bk** [247]	californium 98 **Cf** [251]	einsteinium 99 **Es** [252]	fermium 100 **Fm** [257]	mendelevium 101 **Md** [258]	nobelium 102 **No** [259]

The Periodic Table of Elements is an organized list of all 118 known elements. (Element 119, ununennium, has only very recently been discovered and is not on this periodic table yet.) Elements are listed according to their atomic number that we will learn about in the next section. They are also organized into rows, or periods, and columns, or groups, according to their properties.



Each element of the periodic table is listed in a box with some important information about the atoms of that element. The first thing you might notice is the larger letter or couple of letters in the center of the box. This is the **elemental symbol**. This is the abbreviation for the element's **common name**, which is usually printed just below the symbol.

Next, there is generally a number found either right above the symbol or in the upper right corner of the element's box. This is the **atomic number.** Below the element's common name, you will find the element's **mass number**. Both the atomic and mass numbers give important information about the atoms of the element.

Atomic Number

The atoms of each element contain a unique number of protons. If the number of protons changes, the properties of the atom change, and therefore, the type of element changes. All oxygen atoms have the same number of protons and all iron atoms have the same number of protons. The number of protons an atom possesses is called its **atomic number.**

When you see elements listed in a periodic table, they are in order of their atomic number. For instance, the element oxygen has 8 protons in its nucleus. Therefore, its atomic number is 8 and it is listed 8th on the Periodic Table Of Elements.

When we know the atomic number of an element, we not only know the number of protons an atom possesses, we also know the number of electrons. The number of negatively charged electrons is the same as the number of positively charged protons. For example, since we now know that oxygen has 8 protons in its nucleus, we also know that oxygen has 8 electrons orbiting that nucleus.

Mass Number

A simple definition of the **mass number** is the number of protons plus the number of neutrons, since it is the neutrons and protons that give an atom its mass. (Electrons are so small that they do not contribute to the mass of an atom.) However, this definition is not completely accurate. A more accurate definition of mass number is the average mass of one atom of an element.

While the atomic number of an element is always the same, the mass number of an element differs among individual atoms. Sometimes, an atom might have a different number of neutrons than another of the same type. This will give the atom a different mass. These same-type atoms with different numbers of neutrons are called **isotopes.**

For example, the element carbon is well-known for having isotope forms. Carbon in the universe is usually found as carbon-12, but there are also small amounts of carbon-13 and carbon-14, as well. When these isotopes are totalled and averaged out, the actual mass number is 12.0111, not 12. For simplicity's sake, the decimals are sometimes rounded to the nearest whole numbers on periodic tables.

How to determine the number of protons, electrons, and neutrons in an atom.

number of protons = atomic number

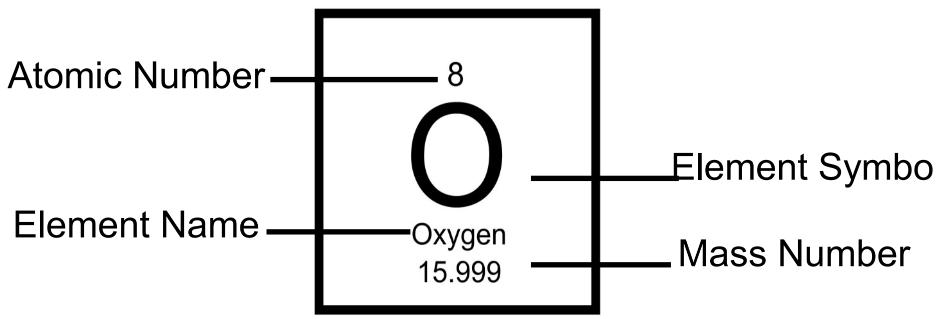
number of electrons = the number of protons

number of neutrons = the mass number - the number of protons

Online And Interactive Atom Resources

- Introduction To The Atom video lesson - Khan Academy
- Atomic Number and Mass Number video lesson
- Build An Atom Interactive
- Molecularium Interactive Site
- Atomidoodle App

The Periodic Table



Fill in the missing information for each Periodic Table element.

H	47 107.87	Boron
13	W	82 207.2
Tin	3	Al

Vocabulary

elements -_______________________________________

atomic number -__________________________________

mass number -___________________________________

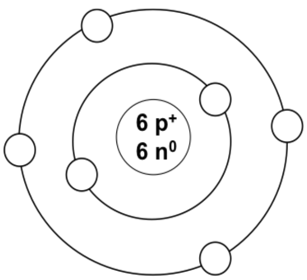
isotopes -______________________________________

Test your knowledge.

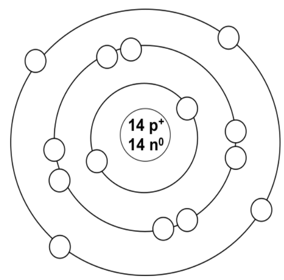
1. If an atom has an atomic number of 6, it has ______ protons and _____ electrons. How do you know? _________________
   ____
2. If an atom has an atomic number of 3 and a mass number of 7, it has ______ neutrons. How do you know? _____________
   ____
3. What element has an atomic number of 10? _______________
4. How many electrons does a chlorine atom have? ___________
5. How many neutrons does a hydrogen atom have? __________
6. How many protons does a nickel atom have? ______________
7. What is the element symbol for gold? ____________________
8. What the name of the element with the symbol Pb? ________

Bohr Model

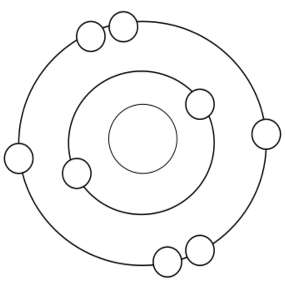
The Bohr Model is used to show a simplified version of atoms and their energy shells. Fill in the blanks below based upon what you know about atoms and the Bohr Model. You can use the Periodic Table Of Elements for help.



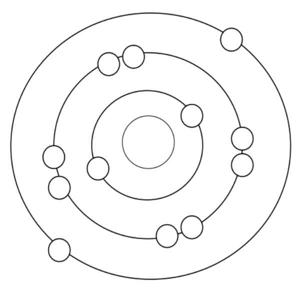
Atom name ________
# of electrons_______
# of protons ________
# of neutrons _______



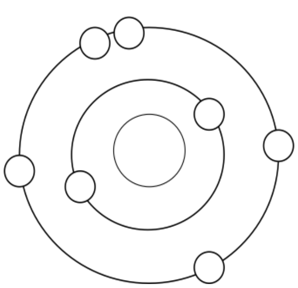
Atom name ________
# of electrons_______
# of protons ________
# of neutrons _______



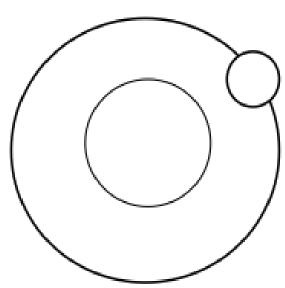
Atom name _________
# of electrons________
# of protons _________
# of neutrons ________



Atom name _________
# of electrons________
# of protons _________
# of neutrons ________



Atom name _________
# of electrons________
# of protons _________
# of neutrons ________



Atom name _________
# of electrons________
# of protons _________
# of neutrons ________

Make Your Own Atom Model

Now that you know the basic structure of atoms, let's build a 3D model of one! You can get creative with your materials. Think about the structure and what you have around the house.

First, think about the parts of the atom. We've learned about protons, neutrons, and electrons. Visualize these particles as small spheres or balls. Picture the protons and neutrons about the same size as each other, and electrons much smaller. Here are some ideas of materials you might use to model those parts of the atom:

Craft pom-poms
Marshmallows
Gumdrops
Ping pong balls
Foam balls
Clay

The next step is to determine what atom you want to create. That will determine the amount of material you will need to represent the atomic particles. For instance, if you are building a lithium atom, your atom model would have 3 protons, 4 neutrons, and 3 electrons.

After you've determined the type of atom and gathered your materials, it's time to build the nucleus, or center, of the atom, which contains the protons and the neutrons. Using glue or tape, stick your protons and neutrons together.

As you have learned the electrons orbit the nucleus of the atom in energy shells, or levels. You can represent this by using a wire or pipe cleaners to represent the orbits and attach the electron to the wire. We have used long wooden skewers sticking out from the nucleus with the electrons on the ends, also. Remember, the negatively charged electrons repel each other, so they will be as far apart from each other as possible!

More Atom Model Ideas - [Atom Model Pinterest Board]

The Beginner's Guide To Atoms Vocabulary

atom - the basic building block of the universe

matter - anything that takes up space and has mass

protons - positively charged particles found in the nucleus of the atom

electrons - negatively charged particles that orbit the nucleus of an atom

neutrons - neutrally charged particles found in the nucleus of the atom

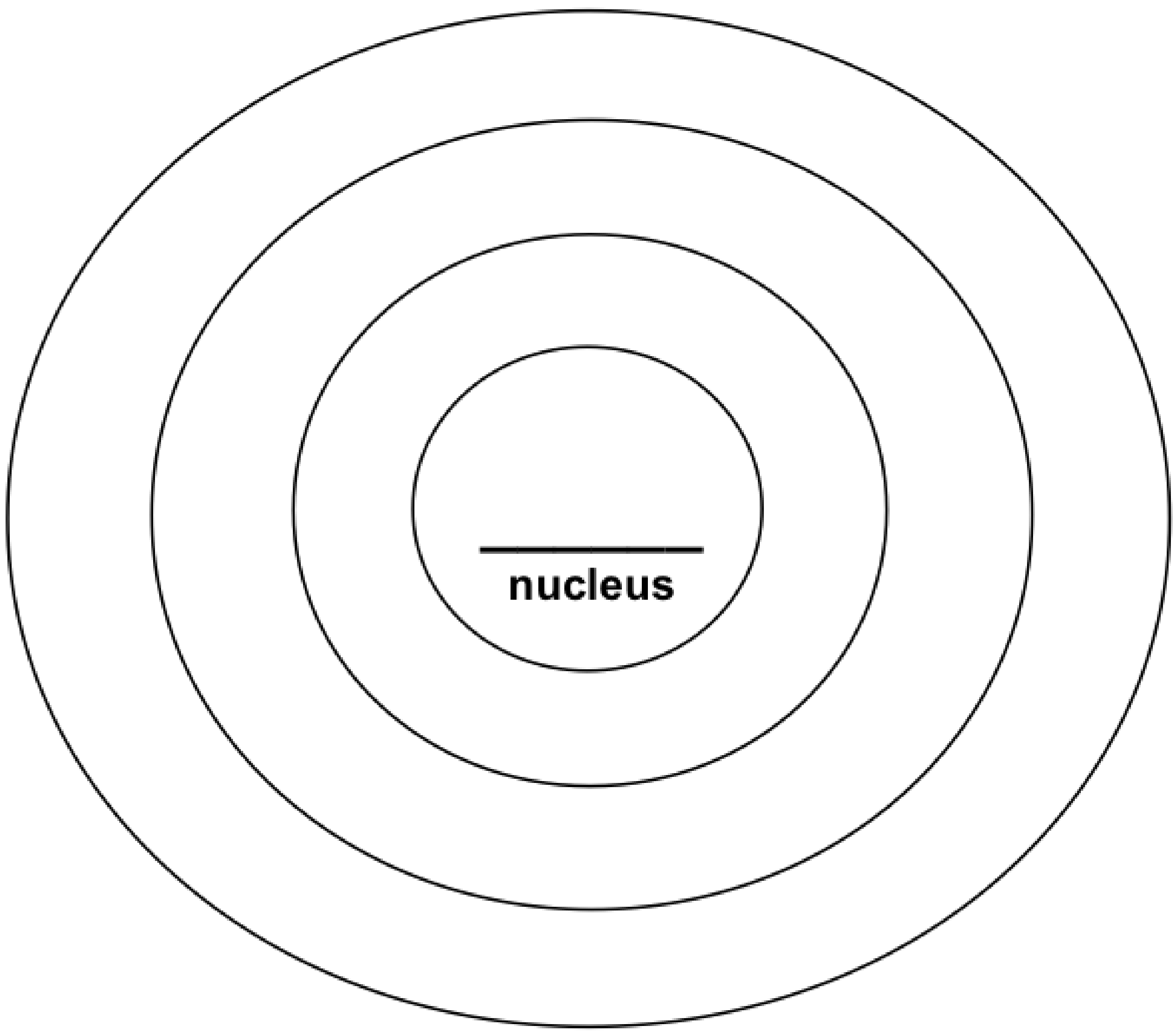
elements - substances made up of the same type of atom

atomic number - number of protons an atom possesses

mass number - number of protons plus the number of neutrons

isotopes - same-type atoms with different numbers of neutrons

Draw Your Own Atom



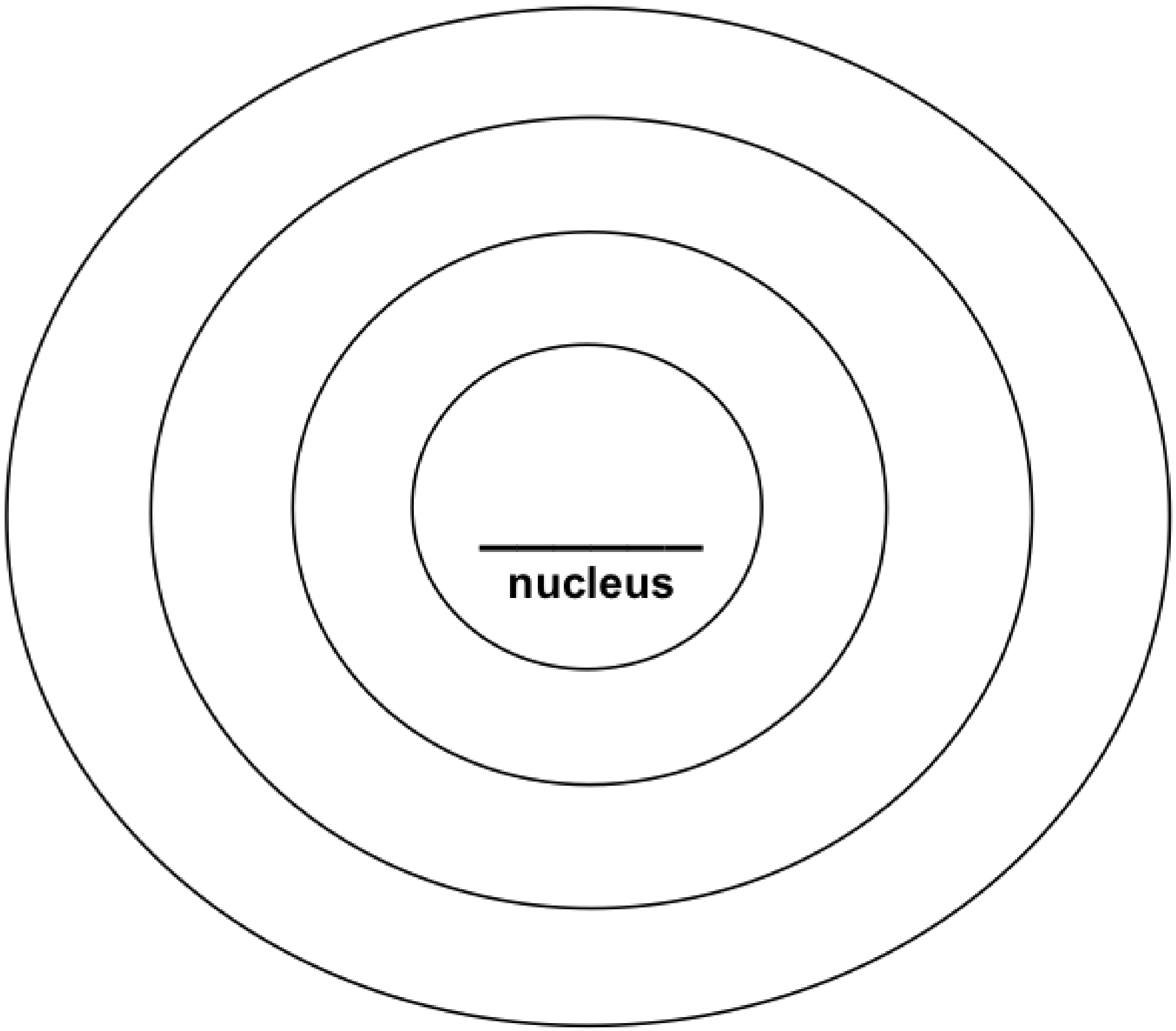
Atom name ________________

Number of protons _________

Number of neutrons ________

Number of electrons ________

Draw Your Own Atom



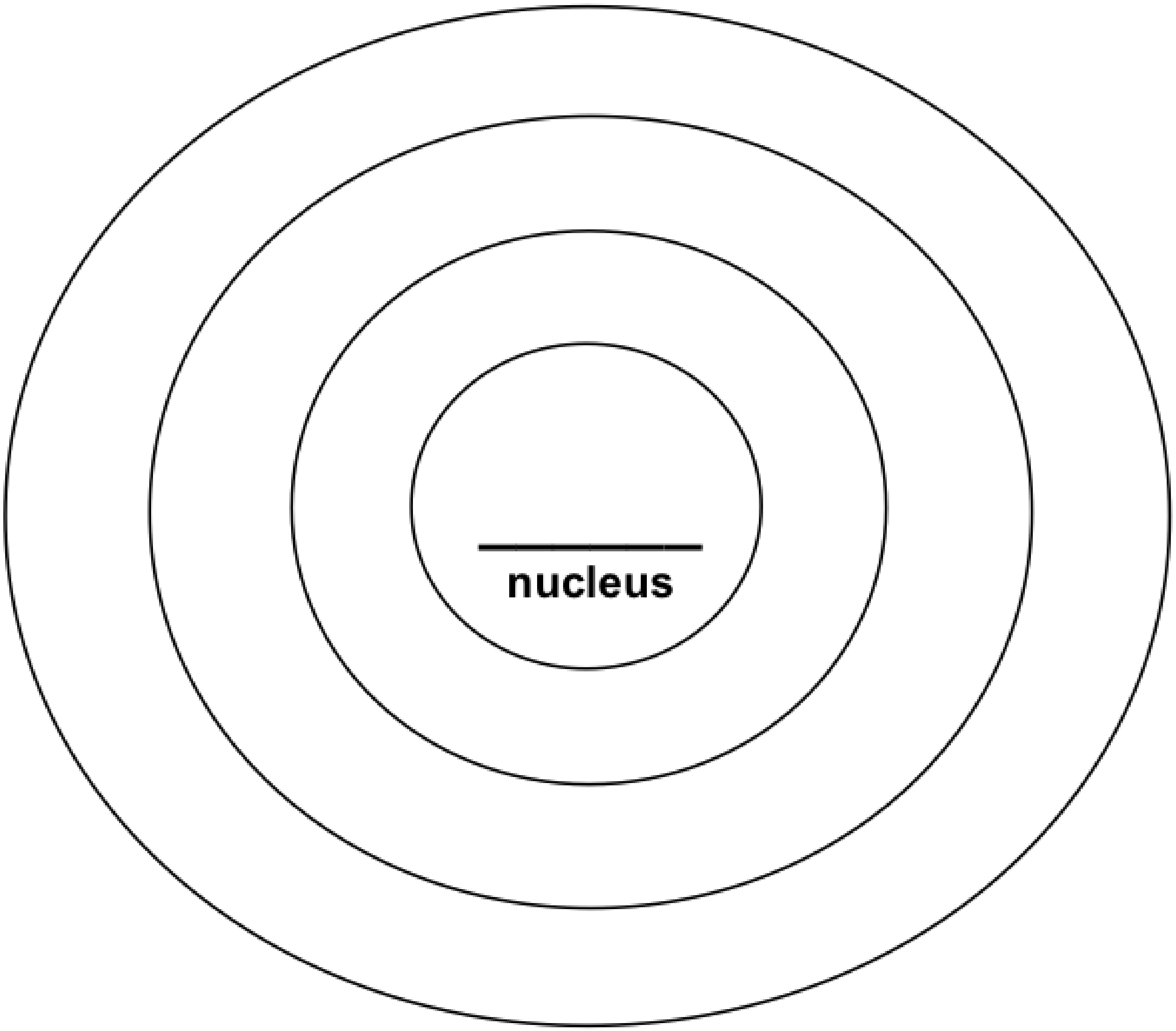
Atom name ________________

Number of protons _________

Number of neutrons ________

Number of electrons ________

Draw Your Own Atom



Atom name ________________

Number of protons _________

Number of neutrons ________

Number of electrons ________

Credits

Bohr Model diagrams were created by
Teaching Elements.

Atom images courtesy of WPClipart.com.

For more more ways to make science fun, visit
The Homeschool Scientist!