Electrons

Word	Definition
Anion	A negatively charged ion.
Cation	A positively charged ion.
Electron	A particle with a net charge of –1 and a mass of 1/1836 a.m.u., found in the energy levels outside the nucleus. They are lost, gained or shared in the formation of a chemical bond.
Electronegativity	An atom's attraction to electrons in a chemical bond. Used to determine bond type, polarity of a molecule and attractive force type and strength.
Excited State	A condition where and atom's electrons occupy higher energy levels than they normally would.
Frequency (ν)	The number of wavelengths that pass a fixed point per second.
Ground State	A condition where an atom's electrons are occupying the lowest possible energy states.
Ion	A charged atom or group of atoms formed by the gain or loss of electrons.
Ionic radius	The measure of the size of an ion.
Ionization energy	The energy required to remove an atom's most loosely held valence electron, measured when the element is in the gas phase.
Kernal	The atom beneath the valence electrons, including the rest of the electrons in the lower energy levels and the nucleus.
Orbital	A region of space around the nucleus that is the most likely location one can find an electron in an atom.
Orbital Notation	Also called "box diagrams", these schematics describe the location and spin of every electron in an atom.
Oxidation	The loss of electrons from an atom or ion.
Photon	An infinitesimally small particle that travels in a wave-fashion that is released when electrons fall from the excited state into the ground state. It is also known as a packet of light-energy or quanta.
Planck's Constant (h)	A proportionality constant that converts Hz (frequency) to J (energy). It is 6.6×10^{-34} J/Hz.
Reduction	The gain of electrons by an atom or ion.
Quantum Number	A four-digit series of numbers that identifies the location of a specific electron around the nucleus based on PEL, sublevel, orbital and spin.
Shell (Principal Energy Level, PEL)	The most general location an electron can be found around the nucleus.
Stable octet	An electron configuration that is reached when atoms gain, lose or share electrons in an attempt to get a noble gas electron configuration of eight valence electrons. Hydrogen is an exception to this "Rule of Eight".
Sublevel	Regions of space that electrons occupy make up a principal energy level.
Speed of Light (c)	The velocity of light photons in a vacuum, 3.0×10^{8} m/second.
Valence electrons	The electrons that reside in the outmost principal energy level of an atom. These electrons are lost, gained or shared in the formation of a chemical bond.
Wavelength (λ)	The distance from one peak to the next in a wave. Measured in meters.

1) The History of Atomic Structure: The Electron (HW: p. 21, 22)

Essential Question: How does knowledge evolve with the help of technology?

Technology Drives Science Drives Technology

The history of the structure of the atom is a story of technological innovation that led to our idea of what an atom looks like today. There were several key people along the way that made contributions to our current model of the atom. In the beginning, philosophers thought af the atom as being solid, with no separate parts. Gradually, as technology improved, scientists were able to see more deeply into the nature of the atom, first discovering the electron, then the nucleus, and then what the electrons were doing, in energy levels and beyond. It is remarkably similar to the history behind our idea of what the universe is. That started out as Earth as the only thing in the universe, with a shell around it where all of the heavenly bodies were stuck, like glow-in-the-dark stickers on the walls and ceiling of your bedroom. Think of the progression of the telephone over the years! They started out as hand-cranked, wall-mounted pieces. You spoke into a cone on the wall, and held the earpiece (connected by cable) to your ear. Gradually, they merged the two into the handset, connected to the main part of the phone with a cord to give you some mobility. They they invented the speakerphone, which left you hands-free. Then the cordless phone, so you could take your conversation anywhere in the house. Then the cell phone, so you could take your call anywhere in the world! As technology improved, so did the telephone. The same is true of our concept of what the atom is.

What Is A Model?

Like a model airplane or a map of the world, the model of the atom is a representation of something real. Since atoms cannot be directly seen, their existence has to be inferred from experimental observations. Atoms fit our observations about the behavior of matter, so we hypothesize that they exist. The same thing goes for the parts of an atom. No one has directly seen protons, neutrons or electrons, but their existence is inferred from experimental observations.

As technology improves, our concept of what an atom is get sharper as we can do better experiments. It's like viewing a mountain from a distance. To our eye, it is a grayish mass with a mountainy shape. This view tells us nothing about the mountain. Once binoculars were invented, we could get a somewhat closer look. We could see that the mountain had hills and bumpy stuff that is still not recognizable, but we have a better idea of what the mountain is made of. Then the telescope is invented and we can now see that the mountain has trees, boulders, grassy areas…the picture of what the mountain is all about becomes clearer.

The same applies to mapmaking. In the old days, the only technologies available for mapmaking were ships, sextants, clocks and eyeballs. Based on observations of the position of the sun and stars, a sailor could roughly determine the ship's latitude and longitude. The photograph on the next page shows a map that was made by this method. Once we developed aircraft, we were able to get above the features we were mapping. Radar allowed us to map elevations, so now our model was three-dimensional. Nowadays, we have satellites that can very accurately map the planet, and many space probes have mapped the surface of Venus and Mars. Saturn's moon Titan has also been mapped, and plans are underway to map Mercury.

As technology improves, our picture of the universe around is gets sharper and more defined. Observations are only as good as the technology that helps us make them. Better science leads to better technology which leads to better science, and the cycle continues.

The next few pages will walk you through the development of our model of the atom, starting with a couple of Greeks philosophizing about the nature of matter and ending with our most current model, the Quantum-Mechanical Model.

Sebastian Münster (1489-1552) was a German mapmaker, the first to produce separate maps of the four known continents and the first to publish a separate map of England.

This was the first map to show North and South America connected to each other but separate from any other land mass. The map was originally published in 1540, and therefore shows what mapmakers of the day thought our world looked like.

Münster's map was the most widely circulated New World map of its time. It presents a view of North America before the Spanish explorations to the interior of the continent, which is why there are mountains from New York headed westward into the Great Plains, and why Lake Erie and Lake Ontario seem to open up into an ocean to the north. Notice how Cuba is substantially larger than Florida, and it looks like somebody sat on South America!

The only tools available to make this map were ships, compasses, sextants and timepieces. Nowadays, we have satellites that fly overhead, leading to the most precise model of the world ever made…Google Earth!

(http://www.lib.virginia.edu/exhibits/lewis_clark/ch1-2.html)

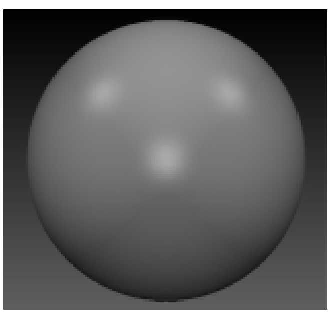
THE DEVELOPMENT OF THE ATOMIC MODEL THROUGH THE LAST 2500 YEARS

1) The Humble Beginnings: *Democritus (460-370 BC) and Leucippus (~500 BC)*

Their model of the atom	How they arrived at their model
The atom is an indestructible thing, it is the smallest piece that any substance can be broken in to. It is indivisible, that is, it cannot be broken down any further.	It was a thought experiment. They reasoned that if something is cut in half a certain number of times, there will eventually come a point where it cannot be cut any further. They called this smallest part of an atom "indivisible", which in Greek is "atomos". That is how the modern word "atom" came about.

2) Thousands of years passed: *John Dalton (1808)*

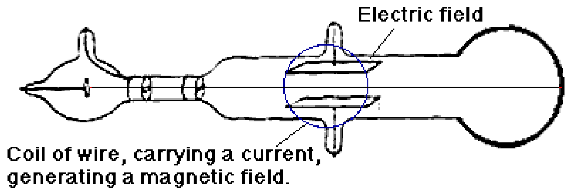
His model of the atom	How he arrived at his model
Atoms are the smallest part that any sample of element can be broken into. Atoms of the same element have the same atomic mass, atoms of different elements have different atomic mass.	Using the newly invented battery, Dalton used electricity to split water up into hydrogen gas and oxygen gas. He weighed the gases and found that the mass of oxygen was always eight times heavier than the mass of hydrogen. He came up with the Law of Definite Proportions, which states that all atoms of the same element have the same atomic mass, and atoms of different elements have different atomic masses. When combined in a compound, the ratio of the masses of the bonded elements will always be a definite whole-number proportion (1 H : 8 O for water).

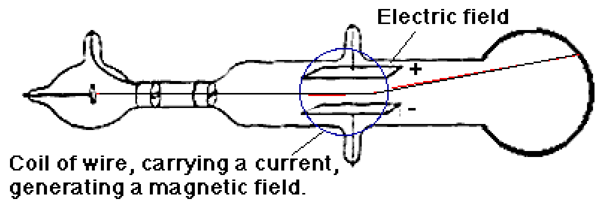


← **Dalton's Model: Solid indestructible sphere**.

3) Not so much time passed…a Crookes Tube inspires *J. J. Thomson*! (1897)

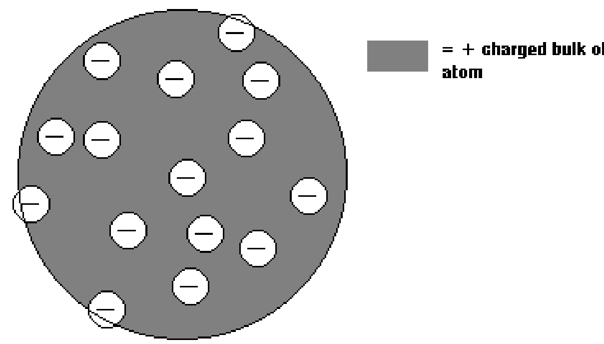
His model of the atom	How he arrived at his model
The atom is a sphere made of a diffuse (thin) positive charge, in which negatively charged electrons are embedded (stuck). He called his model the "plum pudding" model, but who eats plum pudding anymore? It's more like a "chocolate chip cookie dough" model, where the atom is a positively charged cookie dough ball with negative chocolate chip electrons stuck in it.	William Crookes invented the cathode ray tube, which has developed into our modern television and CRT computer monitor. The back end fires off what Crookes called "cathode rays". Using electromagnetic fields, Thomson discovered that the cathode rays are negatively charged. Since these negative particles had to come from somewhere, he reasoned that Dalton's indestructible atoms weren't indestructible at all…these negative particles could be plucked off of an atom and conducted through a metal and eventually be beamed as cathode rays. This same technology also makes electron microscopes possible…the subject is illuminated not by light, but by electrons. Electrons have a shorter wavelength than visible light, so they are capable of imaging much finer and smaller details than light microscopes.





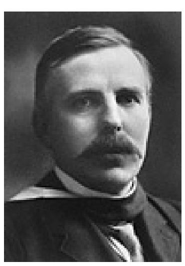
1) The Crookes tube, sending a beam of cathode rays (electrons) straight through the tube from left to right.	**2) When an electric field is applied, the beam shifts towards the + charged electrode. Since opposites attract, this proves that cathode rays are made of negatively charged particles. Thomson discovered electrons, and discovered that they are negatively charged.**

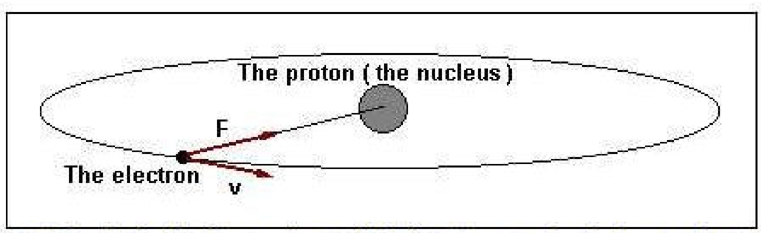
This is a picture of what Thomson thought the atom looked like, based on his experiment. The gray is the diffuse positive mass of the atom, with the negatively charged electrons embedded within in it.



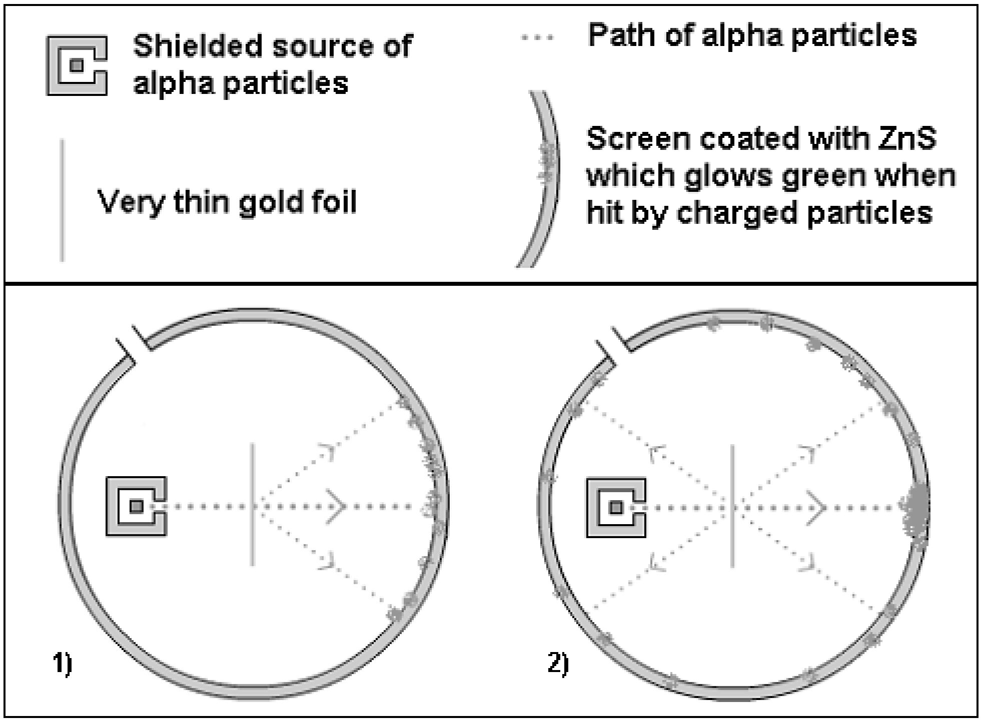
4) But then *Ernest Rutherford* discovered the alpha particle and HAD to play with it! (1911)

His model of the atom	How he arrived at their model
The atom is made of a small, dense, positively charged nucleus with electrons orbiting outside the nucleus at a distance with empty space making up the rest of the atom. The majority of an atom's volume is empty space, and the majority of the atom's mass is in the nucleus.	Rutherford wanted to put the models of the atom to the test. He shot alpha particles at a very thin piece of gold foil (like aluminum foil, only made of gold). If Dalton was right and the atom was a solid, indestructible sphere, then the alpha particles should bounce off the gold foil. If Thomson was right and the atom is a diffuse positive sphere with negative electrons stuck in it, then the alpha particles should go right through the gold foil without breaking it. It turned out to be a combination of the two. Most of the alpha particles passed right through (without tearing the gold foil), meaning that the atom was mostly made of empty space. A few of the alpha particles went through, but were deflected at an angle, and very few did bounce back. This hinted that there was something small, dense and positively charged at the center of the atom that was repelling the alpha particles (which are positively charged). This was the nucleus. The electrons orbit the nucleus at a distance, with empty space between the electrons and the nucleus.

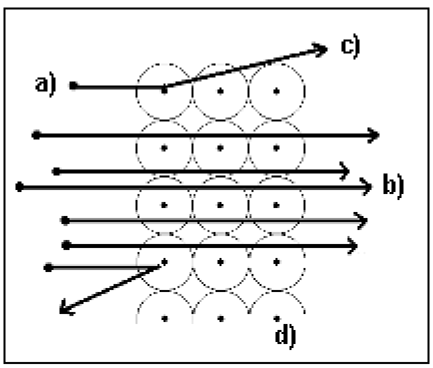




The Rutherford's atomic model. The electron circulating on the orbit around the nucleus with the velocity v is attracted by it with the force F



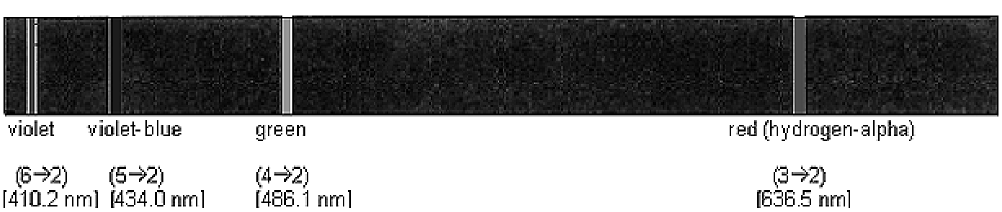
1) Prediction if Thompson was right. All alpha particles pass right through the gold foil	2) Actual results: most alpha particles went right through, a few were deflected and a few bounced back

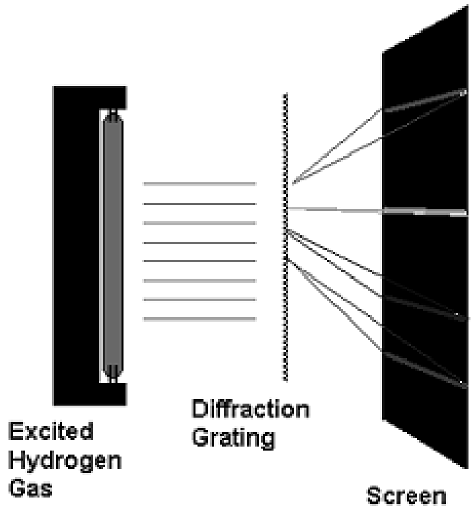


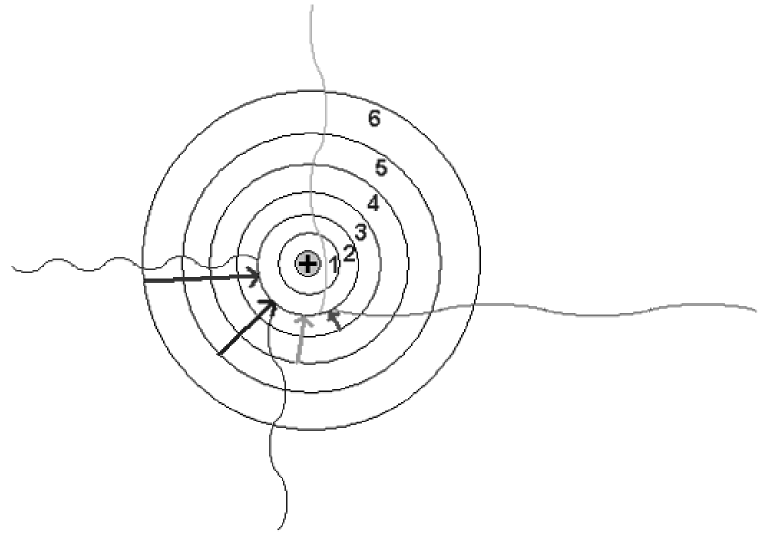
The alpha particles, (a), are shot at the gold foil. Most of the alpha particles go right though (b). A few were deflected (c). Rutherford interpreted this as meaning that there must be a small, dense, positively charged nucleus (d) in the center of the atom with empty space making up the majority of the atom's volume.

<u>5) He saw the light! Broken up into bright lines though a spectroscope! Go, *Neils Bohr*! (1913)</u>

His model of the atom	How he arrived at their model
The atom is just like Rutherford says it is, but the electrons travel in energy levels around the nucleus. When an atom is given energy, it rises in energy levels. When the electron falls back to its original energy level, it gives off energy in the form of light.	Bohr observed the light given off when several elements are heated and give off light. Different elements gave off different colors of light. When this light was passed through a prism, the light was broken up into lines of color. Each element's lines were different. Bohr figured that electrons falling from high energy levels to low energy levels were causing the light. Each element's spectrum of colored lines was different, meaning that the energy levels of different elements have a different amount of energy. This process, called spectroscopy, is useful for identifying element samples.



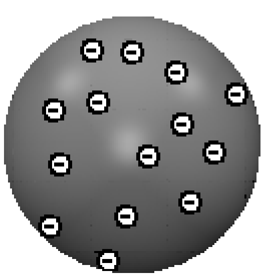
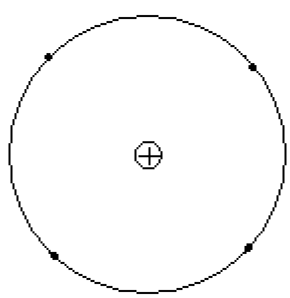
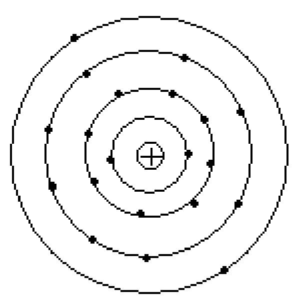
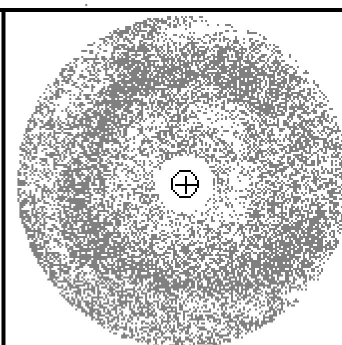




1) A spectroscope has two parts: a diffraction grating made of plastic with lots of parallel microscopic grooves that act like miniature prisms to break up light into its component parts, and a screen that the colors get projected onto.	**2) The wavy lines represent photons of light given off by electrons dropping from a higher energy level to a lower energy level (represented by the arrows). These energy level drops correspond to the bright lines in the spectrum on the bottom of the last page.**

<u>6) Werner Heisenberg may have slept here…we're uncertain! The *Quantum-Mechanical Model*</u>
<u>(contributors include Werner Heisenberg, Max Planck, Erwin Schrödinger, Wolfgang Pauli and many others)</u>

Their model of the atom
The atom contains a small, dense positive nucleus surrounded by electrons that travel in a wave-like motion around the nucleus. This motion is modified by mass and charge interactions between electrons and the nucleus. The interactions and the fast speed of the electron make it impossible to know with any certainty both where an electron is and where it is going in any particular instant. All we can know is the general area of space in which the electron might be found. They very from the most general location to the most specific. Electrons travel in principal energy levels, which are made up of sublevels, which are made up of orbitals that contain up to two electrons each. If two electrons are in the same orbital, they will spin in opposite directions. So what does this mean the electron's path around the nucleus looks like? Imagine a cloud of gnats buzzing about your head, and your head is the nucleus. That is what our most current model of the atom looks like.

			
Thomson Model (1897) Crookes Tube	Rutherford Model (1911) Alpha Particles	Bohr Model (1913) Spectroscope	Quantum-Mechanical Model (1920's to present) Many different experiments

2) Light (HW: p. 23)

Essential Question: Why do hot things give off light?

1) Electrons (charged –1 each, with a mass of 1/1836 amu each) surround the nucleus of the atom in distinct energy levels. Electrons occupy the lowest possible energy levels when the atom is in the ground state.

2) When electrons are given energy (in the form of light, heat or electricity), electrons will rise in energy level by the same amount of energy that the electrons were given. The more energy electrons absorb, the higher they rise. This is called the excited state. This is in accordance with the Law of Conservation of Energy, which states that energy cannot be created or destroyed by physical or chemical change.

3) Since electrons are negatively charged, and therefore attracted to the positively charged nucleus, they will eventually fall back to the ground state. As the electrons fall back to the ground state, they release the energy that caused them to rise in the first place.

4) The energy is released in the form of photons. These are the smallest particles known, essentially massless. They travel at the fastest theoretical speed possible, 3.00×10^8 m/sec, otherwise known as the speed of light. Photons are, in fact, particles of light.

5) The color of the light is determined by the amount of energy lost by the electron when it dropped back to the ground state. Light particles travel in a wave pattern. The length of each wave is called, strangely enough, a wavelength. The more energy a photon has, the shorter its wavelength is. Photons with high energy, and therefore short wavelength, include gamma rays, X-Rays and ultraviolet. Photons with medium energy make up a very small part of the electromagnetic spectrum called visible light. From high energy to low energy, the colors of visible light are violet, blue, green, yellow, orange and red. With less energy and therefore longer wavelength than visible light are infrared, radar, microwave and radio.

6) There are three properties of light waves: energy (E, measured in joules), wavelength (λ, measured in meters) and frequency (ν, measured in wavelengths per second, also called Hz or Hertz). Frequency is defined as the number of wavelengths that pass a given point in one second. Since all photons travel the same speed (3.00×10^8 m/sec) in a vacuum, photons with shorter wavelength will pass a given point with greater frequency than photons with longer wavelengths. Another way to look at it is this: Stand between two railroad tracks. On your left, a train with 30-foot-long cars passes you at 60 miles per hour. On your right, a train with 10-foot-long cars passes you at the same 60 miles per hour. Which train has cars that pass at a greater frequency over any given period of time? The one with the shorter cars!

To sum up, as the energy of a photon increases, the wavelength decreases (gets shorter) and the frequency of the photon increases because more short wavelengths can pass a point in one second than long ones.

Continuous Electromagnetic Spectrum

High E
Short λ
High ν — Low E
Long λ
Low ν

Gamma Rays	X-Rays	Ultraviolet	Visible Light	Infrared	Radar	Microwave	Radio
Given off by unstable nuclei, not electrons dropping energy levels	Given off by unstable nuclei, rarely electrons dropping energy levels	Causes skin cancer, sunburns, cataracts. Is blocked by ozone in the ionosphere	V B G Y O R Range of frequencies that are detectable with the human eye	Near Far Given off by objects that have heat. Used by remote control devices.	Used to clock cars, baseballs and raindrops to forecast storm activity.	Used for communi-Cations and heating molecules in food.	VHF UHF Radio, broadcast TV, RC models, ham, other communi-Cation

Bright-Line Spectra

Every atom has many electron energy levels. Electrons can drop from the excited state in many different pathways. If an electron is excited from the first to the fourth energy level, it can fall back in one of the following ways:

1) From the 4th to the 1st energy level.

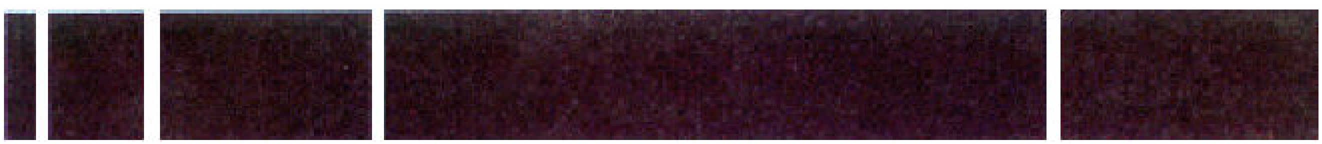
2) From the 4th to the 3rd to the 1st energy level.

3) From the 4th to the 2nd to the 1st energy level.

4) From the 4th to the 3rd to the 2nd to the 1st energy level.

Each different drop in energy level gives off light with different amounts of energy, and therefore wavelength. Imagine a sample of pure element being subjected to electrical current so that its electrons are excited. The electrons will fall back down in the different ways, giving off different wavelengths of light. If you look at the element sample, it will appear to be glowing with a certain color. If the light is broken up by a prism (as raindrops can break sunlight up into a rainbow) and projected onto a white surface, the individual energies of light can be seen as bright lines of different color. These colored bright lines are different from element to element, making each spectrum unique to a particular element. Taking an unknown substance, exciting its electrons and viewing the spectrum in this manner can be used to identify the substance. A mixture of different elements will show a combination of the spectra of the different elements when excited. This process of observing atomic and molecular spectra is called *spectroscopy*, and the device used to observe the spectra is called a *spectroscope*.

Example bright-line spectrum for hydrogen (Numbers in parenthesis indicate the drop in electron energy level that gives off the light, numbers in brackets indicate the wavelength in nanometers (10^{-9} m) of the photons making up that bright line)**:**



violet	violet-blue	green	red (hydrogen-alpha)
(6→2)	(5→2)	(4→2)	(3→2)
[410.2 nm]	[434.0 nm]	[486.1 nm]	[636.5 nm]

This is the bright-line spectrum for hydrogen in the visible spectrum. Notice how there are no lines for energy level drops for, say, the 4th to the 3rd energy levels or the 2nd to the 1st energy levels? That's because those electron drops emit photons with energy outside the visible range. Some might be in the ultraviolet range (a drop from the 7th to the 2nd energy level gives off a photon in this range), some might be in the infrared, radar, radio or any of the other parts of the electromagnetic spectrum. We have ways of detected these photons. Infrared light can be absorbed by night-vision devices, where it is re-emitted as green visible light. Radar can be detected with…radar detectors! Photons in the radio range can be detected with a radio. When you turn the dial of your radio, you are tuning the radio's frequency oscillator to pick up photons with different frequencies. AM radio waves have frequencies in the KHz range, and FM radio waves have frequencies in the MHz range.

Radio transmitters have to be a whole wavelength long or a certain fraction of the transmitted wave in order to work. A radio transmitter that transmits on the 2-meter radio band (wavelength of 2-meters) must have an antenna that is 2 meters long (whole wavelength), 1 meter (half-wavelength) or 0.5 meter (quarter wavelength) in order to be most effective. Telescopes can also be used to detect light given off by stars, nebulae or galaxies a far distance from us. The kind you might have looked through uses visible light to operate, but some of the most useful telescopes operate in ranges outside visible. These can pick up all kinds of information about what is being looked at, including the chemical composition of the stars. This information can tell us how hot the star is, and how old it is. If the spectrum is shifted towards the red portion of the spectrum, it means that the object being looked at is moving away from us (red-shifted Doppler effect). Objects moving towards us have compressed wavelengths, shifting their spectra towards the blue end of the spectrum (blue-shift Doppler effect). The vast majority of all galaxies observed are red-shifted. This means that they are moving away from us, indicating an expanding universe. If the universe is expanding, it must have started out as a single point. This is the basis of the Big Bang Theory.

3) Electron Configuration (HW: p. 24)

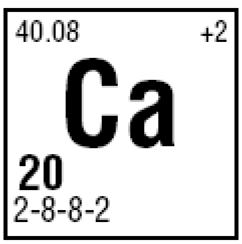
Essential Question: What is our best guess to date as to what an atom looks like?

The electron configuration of an atom tells you where the electrons are located. This is important because the outermost (valence) electrons in an atom are responsible for all physical and chemical properties of elements and compounds.

<u>There are four types of electron configuration:</u>

<u>1) Shell Configuration</u> (found at the bottom of each element box on the Periodic Table) tells you how many electrons are found in each shell (principal energy level). This is the configuration Niels Bohr would have come up with as the discoverer of the energy level!

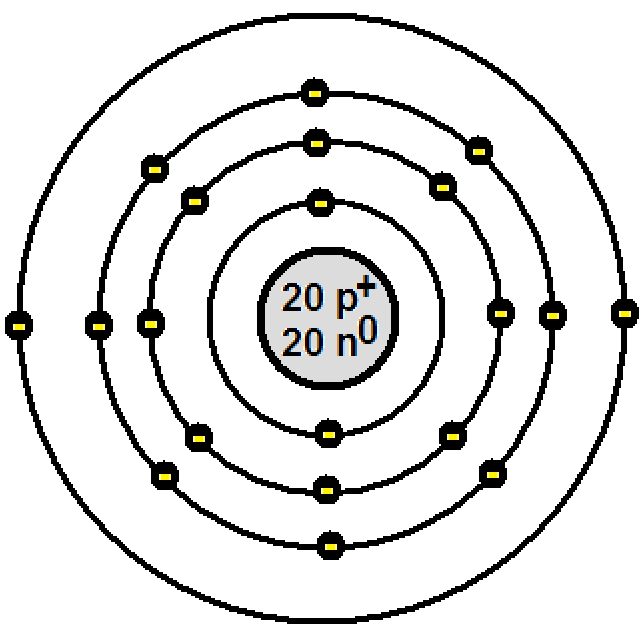
Principal Energy Level (Shell)	Maximum Number of Electrons
1st (closest to the nucleus)	2
2nd	8
3rd	18
4th	32



The shell configuration of Ca is 2-8-8-2.

How many electrons does Ca have in the:

1st PEL (shell)	2
2nd PEL (shell)	8
3rd PEL (shell)	8
4th PEL (shell)	2



This is the Bohr model for calcium:

1) Note the nucleus: 20 protons (atomic number of 20) and 20 neutrons (mass number of 40 – atomic number of 20).

2) Note that the first ring around the nucleus (**the first shell** (energy level)) has **two electrons** in it, as far away from each other as they can be. Electrons are all negatively charged, and so repel each other.

3) Note that the second ring around the nucleus (**the second shell**) has **eight electrons** in it

4) Note that the third ring around the nucleus (**the third shell**) has **eight electrons** in it.

5) Note that the fourth ring around the nucleus (**the fourth shell**) has **two electrons** in it.

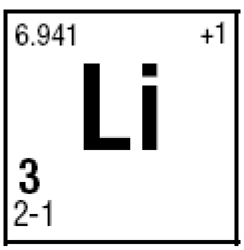
Significance Of Principal Energy Levels (Shells) In The Design Of The Periodic Table

Elements in the same PERIOD (horizontal row) across the Periodic Table all have the same number of shells. For example, all of the elements in Period 3 have three energy levels in their electron configuration, and all of the elements in Period 4 have 4 energy levels.

2) Sublevel Configuration: Principal energy levels are made up of **sublevels**, much as a town is made up of streets. The expanded configuration tells you how many electrons are found in each sublevel of each PEL. Most of the time (and for all of the configurations you will be responsible for), one sublevel must fill up completely before the next one can get any electrons.

Principal Energy Level (Shell)	Sublevels In the Shell	Maximum Electron Capacity
1	s	2
2	s	2
	p	6
3	s	2
	p	6
	d	10
4	s	2
	p	6
	d	10
	f	14

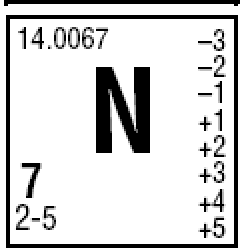
Writing Sublevel Configurations:



Lithium's shell configuration is 2-1. Sublevel: $1s^2$ $2s^1$

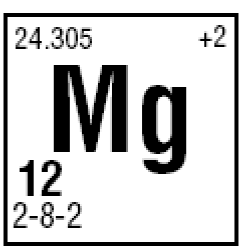
$1s^2$ means that the two electrons in the 1st energy level are in the s sublevel
$2s^1$ means that the one electron in the 2nd energy level is in the s sublevel

Look at the chart above…the first sublevel that fills in a shell is ALWAYS the s sublevel.



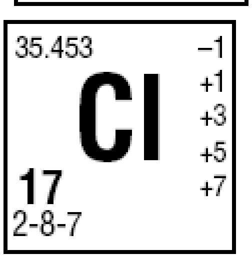
Nitrogen's shell configuration is 2-5. Sublevel: $1s^2$ $2s^2\,2p^3$

The 1st energy level has 2 electrons, they both go into the s sublevel ($1s^2$)
The 2nd energy level has 5 electrons. The first 2 go into the s sublevel ($2s^2$), the other 3 go into the p sublevel ($2p^3$). The electrons fill the sublevels in order until they run out.



Magnesium's shell configuration is 2-8-2. Sublevel: $1s^2$ $2s^2\,2p^6$ $3s^2$

The 1st energy level has 2 electrons, they both go into the s sublevel ($1s^2$)
The 2nd energy level has 8 electrons. The first 2 go into the s sublevel ($2s^2$), the other 6 go into the p sublevel ($2p^6$), filling up both sublevels.
The 3rd energy level has 2 electrons, they go into the s sublevel ($3s^2$).



Chlorine's shell configuration is 2-8-7. Sublevel: $1s^2$ $2s^2\,2p^6$ $3s^2\,3p^5$

The 1st energy level has 2 electrons, they both go into the s sublevel ($1s^2$)
The 2nd energy level has 8 electrons. The first 2 go into the s sublevel ($2s^2$), the other 6 go into the p sublevel ($2p^6$), filling up both sublevels.
The 3rd energy level has 7 electrons. The first 2 go into the s sublevel ($3s^2$), the other 5 go into the p sublevel ($3p^5$).

<u>3) Orbital (Box) Diagrams:</u> tells you how many electrons are in each ORBITAL of each sublevel, and what each electron's SPIN is. Sublevels are broken down further into orbitals, much as streets of a town can be broken down into individual houses. Just as different sized streets can have different numbers of houses on them, the more electrons a sublevel can hold, the more orbitals it can be broken down into. Orbitals are all the same size, they can all fit up to two electrons in them. The electrons in the orbitals spin, much like the Earth about its axis. The spin of electrons is indicated by arrows…up and down. If there is only one electron in the orbital, it will have an up spin. If the orbital has two electrons in it, the first will have an up spin, and the second will have a down spin.

Orbitals are represented as boxes, into which one or two arrows may be placed. The electrons fill the orbitals of each sublevel in a special order. First, all of the up arrows are placed in each box, followed by the down arrows. The number of arrows will equal the number of electrons in the sublevel.

<u>RULES:</u>

1) The number of orbitals is equal to half the number of electrons each sublevel can hold.

Sublevel Type	**Number of Electrons**	**Number of Orbitals**
s	2	1
p	6	3
d	10	5
f	14	7

What each sublevel's orbitals looks like, filled with electrons

[↑↓]

One box, filled with two arrows, one up, one down

[↑↓][↑↓][↑↓]

Three boxes, each filled with two arrows (total of 6 electrons)

[↑↓][↑↓][↑↓][↑↓][↑↓]

Five boxes, each filled with two arrows (total of 10 electrons)

[↑↓][↑↓][↑↓][↑↓][↑↓][↑↓][↑↓]

Seven boxes, each filled with two arrows (total of 14 electrons)

2) When two electrons occupy the same orbital, they must have opposite spin. When electrons fill the boxes, the UP arrows go in first.

An orbital with one electron in it looks like:

[↑]

An orbital with two electrons in it looks like:

[↑↓]

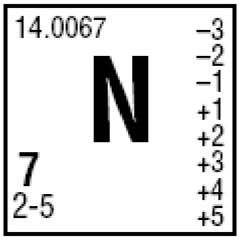
The sublevel name (1s, 2p, etc) is written above each set of orbitals.

6.941 +1
Li
3
2-1

Lithium's shell configuration is 2-1. Sublevel: $1s^2$ $2s^1$

Box Diagram:

1s [↑↓] 2s [↑]

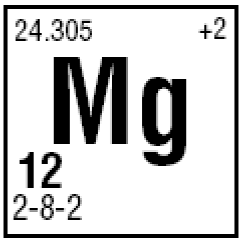


Nitrogen's shell configuration is 2-5. **Sublevel: $1s^2$ $2s^2$ $2p^3$**

Box Diagram:

1s	2s	2p		
↑↓	↑↓	↑	↑	↑

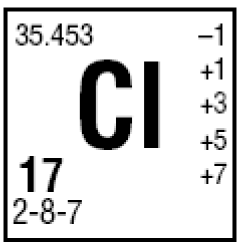
Notice how the 2p sublevel fills each of the three orbitals with just up arrows? $2p^3$ tells us that there are 3 electrons in the 2p sublevel. There are 3 orbitals in the 2p sublevel. Since the up arrows go in before any down arrows do, each of the three 2p electrons fill up each box, one at a time, in the UP position. If there was a fourth electron to put in, it would go in the first 2p box as a down arrow.



Magnesium's shell configuration is 2-8-2. **Sublevel: $1s^2$ $2s^2$ $2p^6$ $3s^2$**

Box Diagram:

1s	2s	2p			3s
↑↓	↑↓	↑↓	↑↓	↑↓	↑↓



Chlorine's Shell configuration is 2-8-7. **Sublevel: $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^5$**

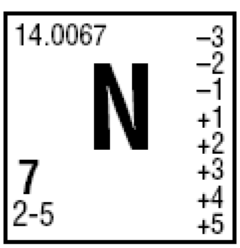
Box Diagram:

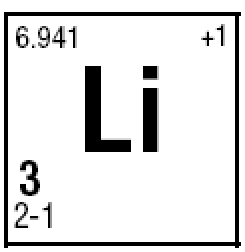
1s	2s	2p			3s	3p		
↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑

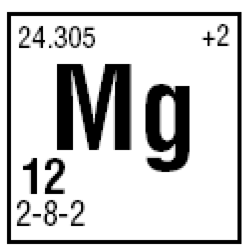
Orbital notation is useful for picking out UNPAIRED electrons. These are the electrons responsible for chemical bonding. If there are two arrows in a box, then the electrons are PAIRED. The up arrows that occupy boxes all by themselves are the UNPAIRED electrons.

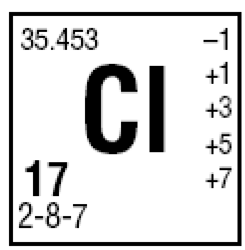
VALENCE ELECTRONS

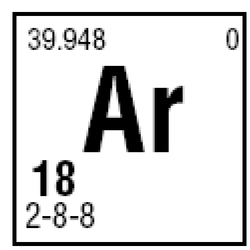
the electrons in the outermost shell (furthest energy level from the nucleus), which is also called the **valence shell**. The number of valence electrons that an atom has can be determined by the **last number** in the basic electron configuration.







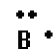
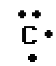
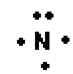
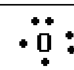
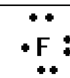
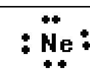




Nitrogen has TWO energy levels. The 2^{nd} energy level contains 5 electrons. **These are the valence electrons.**	Lithium has TWO energy levels. The 2^{nd} energy level contains 1 electron. **This is the valence electron.**	Magnesium has THREE energy levels. The 3^{rd} energy level contains 2 electrons. **These are the valence electrons.**	Chlorine has THREE energy levels. The 3^{rd} energy level contains 7 electrons. **These are the valence electrons.**	Argon has THREE energy levels. The 3^{rd} energy level contains 8 electrons. **These are the valence electrons. 8 valence electrons is the most any element can have.**

The number of valence electrons that an atom has determines its physical and chemical properties. It will explain most of the things you will be learning about for the rest of the course.

<u>LEWIS DOT DIAGRAMS -</u> using dots in groups of 2 around the symbol of the atom to represent the valence electrons. For every atom you are responsible for, the valence electrons will occupy only s and p orbitals. The s electrons fill up first, then the p electrons fill, up electrons first, followed by the downs, just like in the box diagram.

Element	Shell Config	# Valence Electrons	Lewis Dot Diagram
Li	**2-1**	**1** (one s electron)	
Be	**2-2**	**2** (two s electrons)	
B	**2-3**	**3** (two s electrons and one p electron)	
C	**2-4**	**4** (two s electrons and two p electrons, ups go in before downs)	
N	**2-5**	**5** (two s electrons and three p electrons, ups go in before downs)	
O	**2-6**	**6** (two s electrons and four p electrons, ups are all in, so go back and put in the downs)	
F	**2-7**	**7** (two s electrons and five p electrons, ups are all in, so go back and put in the downs)	
Ne	**2-8**	**8** (two s electrons and six p electrons, all orbitals filled)	

KERNAL - the atom underneath the valence shell. This includes all of the non-valence electrons and the nucleus. This part of the atom has no part at all in chemical bonding (making compounds).

<u>Significance Of Valence Electrons In The Design Of The Periodic Table</u>

The elements on the Periodic Table are arranged in order of increasing atomic number. In 1869, Dmitri Mendeleev, the designer of the Table, noticed that every so often, as atomic number increases, elements will come up that have similar chemical properties to elements that came before. He put these elements in the same vertical column, or GROUP. All elements in the same group share very similar properties to each other. Later, it was discovered that all of the elements in the same group have the same number of valence electrons, and form ions with the same charges.

Stable Octet: eight valence electrons. Every atom on the Periodic Table will gain or lose enough electrons so that they will end up with a stable octet. Noble gases already have a stable octet, which is why they do not react with any other element.

4) Excited & Ground and Interpretation (HW: p. 25)

Essential Question: How can we make practical use of the quantum-mechanical model of the atom?

Ground state – When electrons occupy the lowest possible PEL and sublevels. This is the configuration shown on the Periodic Table.

Excited state - electrons absorb energy, and rise up to higher energy levels.

Light - When the electrons fall back down, this energy is released in the form of **photons** of light. The farther the fall, the higher the energy of the photon will be.

Examples:

Element	Ground State (Shell) Config	Ground State (Sublevel) Config	Possible Excited Shell Config	Possible Excited State Sublevel Config
Mg	2-8-2	$1s^2\ 2s^2\ 2p^6\ 3s^2$	2-7-3	$1s^2\ 2s^2\ 2p^5\ 3s^2\ 3p^1$
Al	2-8-3	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$	2-8-2-1	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 4s^1$
F	2-7	$1s^2\ 2s^2\ 2p^5$	2-6-1	$1s^2\ 2s^2\ 2p^4\ 3p^1$
B	2-3	$1s^2\ 2s^2\ 2p^1$	2-1-1-1	$1s^2\ 2s^1\ 3p^1\ 4s^1$
Cl	2-8-7	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$	1-8-8	$1s^1\ 2s^2\ 2p^6\ 3s^2\ 3p^6$

Note that there may be many possible configurations for the excited state, but regardless of what it is, the number of total electrons may not change.

<u>A) How Do You Tell If The Configuration Is Ground State Or Excited State?</u>

1) Shell Configuration (Principal Energy Levels) - Add up all of the electrons in the configuration. Use the total (which equals the atomic number) to identify the element that the configuration belongs to. If the basic configuration matches the configuration on the Periodic Table, then it is in the ground state. If the configuration does not match that element's configuration, then it is in the excited state.

Given Shell Configuration	Add Up The Electrons	Which Element Is It?	What is the Shell Configuration on the Periodic Table For this Element?	Does it match your given configuration?	Ground state or excited state?
2-8-8-3	21	Sc	2-8-8-3	YES	Ground
2-7-2	11	Na	2-8-1	NO	Excited
2-8-3-1	14	Si	2-8-4	NO	Excited
2-8-15-2	27	Co	2-8-15-2	YES	Ground

2) Sublevel Configuration - Add up all of the electrons in the configuration. Use the total (which equals the atomic number) to identify the element that the configuration belongs to. Write the expanded configuration of the element on the periodic table. If the expanded configuration matches the configuration you wrote based on the Periodic Table, then it is in the ground state. If the configuration does not match that element's expanded configuration, then it is in the excited state.

Given Configuration	Add Up The Electrons	Which Element Is It?	What is the Configuration on the Periodic Table For this Element? (Sublevel)	Does it match your given configuration?	Ground state or excited state?
$1s^2\ 2s^1$	3	Li	2-1 ($1s^2\ 2s^1$)	YES	GROUND
$1s^2\ 2s^2\ 2p^3\ 3s^1$	8	O	2-6 ($1s^2\ 2s^2\ 2p^6$)	NO	EXCITED
$1s^2\ 2s^1\ 3p^2$	5	B	2-3 ($1s^2\ 2s^2\ 2p^1$)	NO	EXCITED
$1s^2\ 2s^2\ 2p^5$	9	F	2-7 ($1s^2\ 2s^2\ 2p^5$)	YES	GROUND

B) How Do You Determine if PEL's, Sublevels and Orbitals are Occupied or Full?

Occupied: there is at least one thing in the space. A room may be occupied by one person (or more). As long as there is at least ONE electron in the PEL, sublevel or orbital, it is considered to be occupied.

Full: The maximum possible number of electrons are in that space.

PEL	Max. # e-	Sublevel	Max # e-
1	2	s	2
2	8	p	6
3	18	d	10
4	32	f	14

Orbitals with ONE arrow are OCCUPIED, and with TWO arrows are FULL.

Examples:

In an atom of sodium (Na):

SHELL: 2-8-1 SUBLEVEL: $1s^2\ 2s^2\ 2p^6\ 3s^1$

1s	2s	2p			3s
↑↓	↑↓	↑↓	↑↓	↑↓	↑

How many…	Occupied? (Which ones and why)	Full? (Which ones and why)
PEL's	**3** (PEL's, 1st, 2nd and 3rd.)	**2** (1st and 2nd. 3rd has only 1 electron.)
Sublevels	**4** (1s, 2s, 2p and 3s)	**3** (1s, 2s and 2p are all filled, 3s needs one more be be filled.)
Orbitals	**6** (There are 6 boxes with arrows in them.)	**5** (There are 5 boxes with 2 arrows in them.)

For cobalt (Co):

SHELL: 2-8-15-2 SUBLEVEL: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^2$

1s	2s	2p			3s	3p			3d					4s
↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑	↑	↑	↑	↑	↑↓

How many…	Occupied? (Which ones and why)	Full? (Which ones and why)
PEL's	**4** (PEL's, 1st, 2nd, 3rd and 4th)	**2** (Only the first two. Check the chart!)
Sublevels	**7** (1s, 2s, 2p, 3s, 3p, 3d and 4s).	**6** (1s, 2s, 2p, 3s, 3p and 4s. 3d needs five more to be filled.)
Orbitals	**15** (There are 15 boxes with arrows in them.)	**10** (the five 3d orbitals are all half-filled, the other 10 have two arrows in each.)

5) Ions (HW: p. 26-30)

Essential Question: How to the essential fundamental properties of atoms relate to each other?

Electronegativity: An atom's attraction to electrons when involved in a chemical bond. The higher the electronegativity is, the more strongly attracted an atom will be for another atom's electrons. Therefore, when two atoms bond, the atom with the higher electronegativity will tend to gain electrons from the atom with lower electronegativity.

An arbitrary scale designed by Linus Pauling, based on **fluorine** (F) having the strongest attraction, given a value of **4.0** and all others compared to it. Electronegativity values can be found on Reference Table S.

Ionization Energy: The amount of energy that must be absorbed by an atom to remove the most loosely bound valence electron from an atom in the gas state and form a +1 ion.

It is measured in KJ/mole of atoms. A mole is the number of atoms needed for an element to weigh its atomic mass in grams. More on that later. The higher the ionization energy, the more energy is required to remove the most loosely held valence electron from an atom. Ionization Energy values can be found on Reference Table S.

Atomic Radius: The size of an atom, from the center of the nucleus to the outer edge of the electron cloud.

Atomic radius INCREASES as the elements on the Periodic Table are considered from top to bottom down a group. This is due to the increasing numbers of principal energy levels, putting the valence electrons further from the nucleus.

For the elements in Group 1:

Element	Shell Configuration	# of PEL's	Atomic Radius (picometers)
H	1	1	**37**
Li	2-1	2	**155**
Na	2-8-1	3	**190**
K	2-8-8-1	4	**235**
Rb	2-8-18-8-1	5	**248**
Cs	2-8-18-18-8-1	6	**267**
Fr	2-8-18-32-18-8-1	7	**270**

Atomic radius DECREASES as the elements on the Periodic Table are considered from left to right across a period. The elements in a period all have the same number of energy levels, but as their atomic numbers increase, their nuclear charge increases. This extra nuclear charge attracts the electrons closer to the nucleus, making the atom smaller than one with less nuclear charge.

Element	Li	Be	B	C	N	O	F
Shell Config	2-1	2-1	2-3	2-4	2-5	2-6	2-7
Atomic Number	3	4	5	6	7	8	9
Nuclear Charge	+3	+4	+5	+6	+7	+8	+9
Atomic radius (pm)	**155**	**112**	**98**	**91**	**92**	**65**	**57**

So, the general trend is: Closer to Fr = larger atomic radius and closer to F = smaller atomic radius.

Complete the Electronegativity, Ionization Energy and Atomic Radius Chart on page 29 and answer the questions on page 30 to discover the relationships that these three properties have to each other!

IONS

Atoms with LOW electronegativity (metals) tend to LOSE electrons (oxidation) and form + charged ions (cations).

Atoms have a neutral charge, because the number of positive protons equals the number of negative electrons. When electrons are lost, there are now more positive protons than negative electrons, giving the ion a positive charge.

The charge of the ion = + (# of electrons lost)

So, if an atom loses 2 electrons, the ion will be charged +2. If 3 electrons are lost, the ion will be charged +3.

Atoms with HIGH electronegativity (nonmetals) tend to GAIN electrons (reduction) and form – charged ions (anions).

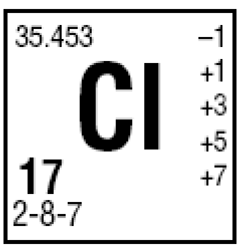
Atoms have a neutral charge, because the number of positive protons equals the number of negative electrons. When electrons are gained, there are now more negative electrons than positive protons, giving the ion a negative charge.

The charge of the ion = - (# of electrons gained)

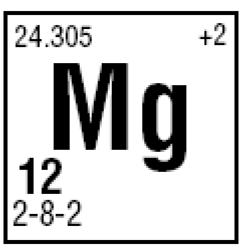
So, if an atom gains 2 electrons, the ion will be charged -2. If 3 electrons are gained, the ion will be charged -3.

The charge of an ion may be found on the Periodic Table in the upper right corner of each box. If negative charges are listed first (Example, N has many charges, the first one listed is -3) then use the first charge listed. Some elements are capable of forming more than one charge.

When atoms form ions, the ions will have 8 valence electrons (stable octet), the same as a noble gas!



- The first charge listed is -1, which is chlorine's ionic charge. The other charges mean something else, which we get to later in the course.
- To form this ion, chlorine must GAIN 1 electron (reduction).
- An atom of Cl has 17 electrons and a configuration of 2-8-7. When Cl becomes Cl^{-1}, the new configuration is 2-8-8, the same configuration as argon (Ar), a noble gas, with a stable octet.



- Mg forms a +2 ion. To form this ion, magnesium must LOSE 2 electrons (oxidation).
- An atom of Mg has 12 electrons and a configuration of 2-8-2. When Mg becomes Mg^{+2}, the new configuration is 2-8, the same as neon (Ne), a noble gas, with a stable octet.

IONIC RADIUS

1) NEGATIVE ions are larger than the original atom, because the gained electrons repel each other.
When Cl (2-8-7) gains an electron to form Cl^{-1} (2-8-8), the extra valence electron repels the others, making the ion larger than the original atom was.

2) POSITIVE ions are smaller than the original atom because all of the outermost electrons have been lost.
When Mg (2-8-2) loses two electrons to form Mg^{+2} (2-8), the third energy level is lost, making the ion smaller than the original atom was.

Dot Diagrams of Ions

Positive ions have a pair of brackets around the element symbol, the positive charge outside the brackets on the upper right side, and NO dots showing around the symbol. This shows that the atom has lost all of its valence electrons.

Negative ions have a pair of brackets around the element symbol, the negative charge outside the brackets on the upper right side, and EIGHT dots showing around the symbol. This shows that the atom has gained enough valence electrons to have a stable octet of 8.

EXAMPLES:

Element (ion charge listed on Periodic Table)	**Shell Config ------------ # Valence Electrons**	**How many electrons are gained or lost to form the ion?**	**Oxidation or Reduction?**	**Ion has the same electron config as which neutral element? (Shell Config)**	**Is the ionic radius larger or smaller than the original atom?**	**Ion's Dot Diagram**
Li (+1)	2-1 ----------- **1**	Lose 1	Oxidation	He (2)	Smaller	$[\mathbf{Li}]^{+1}$
Be (+2)	2-2 ----------- **2**	Lose 2	Oxidation	He (2)	Smaller	$[\mathbf{Be}]^{+2}$
B (+3)	2-3 ----------- **3**	Lose 3	Oxidation	He (2)	Smaller	$[\mathbf{B}]^{+3}$
C (-4)	2-4 ----------- **4**	Gain 4	Reduction	Ne (2-8)	Larger	$[:\ddot{\underset{..}{\mathbf{C}}}:]^{-4}$
N (-3)	2-5 ----------- **5**	Gain 3	Reduction	Ne (2-8)	Larger	$[:\ddot{\underset{..}{\mathbf{N}}}:]^{-3}$
O (-2)	2-6 ----------- **6**	Gain 2	Reduction	Ne (2-8)	Larger	$[:\ddot{\underset{..}{\mathbf{O}}}:]^{-2}$
F (-1)	2-7 ----------- **7**	Gain 1	Reduction	Ne (2-8)	Larger	$[:\ddot{\underset{..}{\mathbf{F}}}:]^{-1}$

SUBATOMIC PARTICLES IN IONS

When an atom becomes an ion, only the number of ELECTRONS changes. The number of protons is still the atomic number, and the number of electrons is still the mass number minus the atomic number.

How many protons, neutrons and electrons are there in a $_{20}^{41}Ca^{+2}$ ion?

- The atomic number is 20, so there are **20 protons.**

- The mass number is 41, so there are (41-20) = **21 neutrons.**

- The ion charge is +2, which means the Ca lost 2 electrons. Since the atomic number is 20, the atom started out with 20 electrons. Losing two electrons brings the total down to **18 electrons.**

How many protons, neutrons and electrons are there in a $_{17}^{35}Cl^{-1}$ ion?

- The atomic number is 17, so there are **17 protons.**

- The mass number is 35, so there are (35-17) = **18 neutrons.**

- The ion charge is -1, which means the Cl gained 1 electron. Since the atomic number is 17, the atom started out with 17 electrons. Gaining one electrons brings the total up to **18 electrons.**

NAMING IONS

Positive Ions (metals):

Only ONE positive charge listed: The ion name is the same as the name of the element.

Examples: Na^{+1} is sodium, Cd^{+2} is cadmium, Sr^{+2} is strontium and H^{+1} is hydrogen.

TWO OR MORE positive charges listed: Put the charge after the ion name, as Roman numerals, in parentheses.

Examples: Cu has 2 charges listed, +1 and +2. Cu^{+1} is called copper (**I**) and Cu^{+2} is copper (**II**).

Mn has four charges listed, +2, +3, +4 and +7. Mn^{+2} is manganese (II),
Mn^{+3} is manganese (**III**), Mn^{+4} is manganese (**IV**) and Mn^{+7} is manganese (**VII**).

Negative Ions (nonmetals):

The ion charge is the first one listed. Ignore all of the other charges. The name of the ion is the first syllable of the element name with the suffix *–ide*.

Examples:
Cl is chlorine. Cl^{-1} is chloride.
O is oxygen. O^{-2} is oxide.
C is carbon. C^{-4} is carbide.

Student Name:__________________________________ Grades: ______, ______, ______, ______, ______

History Light Config E&G Ions

1) History Of Atomic Structure Homework

A) Multiple Choice Questions: Place your answer in the space in front of each question.

_____1) Which list, below, lists the location an electron can be found, from most general to most specific?

a) principal energy level, orbital, sublevel, spin
b) orbital, principal energy level, spin, sublevel
c) principal energy level, sublevel, orbital, spin
d) spin, orbital, sublevel, principal energy level

_____2) Bohr's model of the atom says that electrons

a) are mixed in evenly with positive charge
b) are found orbiting a positively-charged nucleus
c) are found orbiting a positively-charged nucleus in energy levels (shells)
d) are found in regions of probability around the nucleus called orbitals

_____3) The quantum-mechanical model of the atom says that electrons

a) are mixed in evenly with positive charge
b) are found orbiting a positively-charged nucleus
c) are found orbiting a positively-charged nucleus in energy levels (shells)
d) are found in regions of probability around the nucleus called orbitals

_____4) Rutherford's model of the atom states that electrons

a) are mixed in evenly with positive charge
b) are found orbiting a positively-charged nucleus
c) are found orbiting a positively-charged nucleus in energy levels (shells)
d) are found in regions of probability around the nucleus called orbitals

_____5) Thomson's model of the atom states that electrons

a) are mixed in evenly with positive charge
b) are found orbiting a positively-charged nucleus
c) are found orbiting a positively-charged nucleus in energy levels (shells)
d) are found in regions of probability around the nucleus called orbitals

B) Short Answer Questions: Please answer in the space provided beneath each question.

1) Why do you think that the electron was the first part of the atom that was discovered, and not the proton or neutron?

2) One model of the atom states that atoms are tiny particles composed of a uniform mixture of positive and negative charges. Scientists conducted an experiment where alpha particles were aimed at a thin layer of gold atoms. Most of the alpha particles passed directly through the gold atoms. A few alpha particles were deflected from their straight-line paths. (This question was taken directly from a Regents Exam).

a) Most of the alpha particles passed directly through the gold atoms undisturbed. What does this evidence suggest about the *structure* of gold atoms?

b) A few of the alpha particles were deflected from their straight path as they passed through the gold foil. What does this evidence suggest about the *structure* of the gold atoms?

c) How should the original model (the one that says that atoms are tiny particles composed of a uniform mixture of positive and negative charges) be revised based on the results of this experiment? *This question is not asking how the EXPERIMENT should have been changed, but how the MODEL (the idea of what the atom looks like) should be changed.*

3) Internet Research!!!! About forty years ago, it was discovered that protons and neutrons are made up of smaller particles called *quarks*. There are six types (flavors) of quarks.

a) What are the six flavors of quarks called?

________________, ________________, ________________,

________________, ________________, ________________,

b) What flavors and how many of each go into making a proton?

____

c) What flavors and how many of each go into making a neutron?

____

d) List the URL's (web addresses) of the sites you got this information from:

____

____

____

2) Light Homework

1) How is light formed, in terms of *energy levels*?

2) What is a particle of light called?______________________________

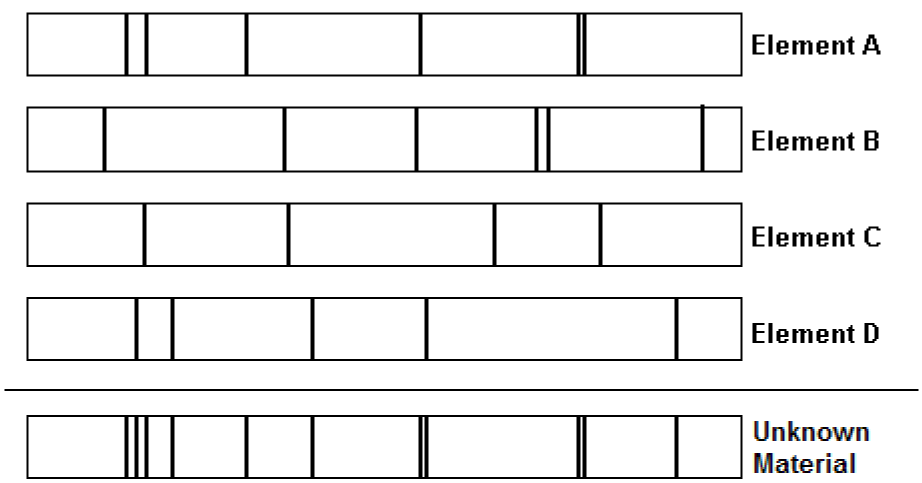
3) If the frequency of a photon of light is increased, what happens to its wavelength?___________________

4) If the energy of a photon of light is decreased, what happens to its frequency?______________________

5) Elemental spectra are sometimes called an element's *fingerprints*. Why can the bright-line spectrum of an element be used to identify an element?

6) An unknown material is found at a crime scene and analyzed with a flame spectroscopy unit. The spectrum is compared with four elements that lab techs believe might be in the compound. Based on the spectrum that is generated when the substance is heated, it was determined that the material was composed of a mixture of elements.

a) Based on the reference spectra for elements A, B, C and D, which of these elements make up this unknown material? Circle the elements that make up the unknown material.



b) Explain how you made your determination, using two or more complete sentences.

3) Electron Configuration Homework

1) Instructions: Using the one filled box as a clue, fill in the rest of the boxes.

CIRCLE THE VALENCE ELECTRONS IN THE BASIC ELECTRON CONFIGURATION

	# e^-	Shell Configuration -------------------------------------- Sublevel Configuration	BOX DIAGRAM	DOT DGM
H		-------------------------------		
	3	-------------------------------		
		2-7 -------------------------------		
Ne		-------------------------------		
	11	-------------------------------		
		------------------------------- $1s^2 2s^2 2p^6 3s^2 3p^3$		
Cl		-------------------------------		
	20	-------------------------------		
		------------------------------- $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^2$		

2) How many valence electrons do the noble gases (Ne, Ar, Kr, etc.) have?

3) How many valence electrons do the elements in Group 1 (Li, Na, K, etc.) have?

4) Excited & Ground and Interpretation Homework

A) Identify the following electron configurations as being excited or ground state:

Config	G or E?	Config	G or E?	Config	G or E?
$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$		2-8-17		$1s^2\ 2s^2\ 2p^6\ 3s^1$	
$1s^2\ 2s^2\ 2p^6\ 3s^1\ 3p^1$		2-8-10-2		2-1	
$1s^2\ 2s^1\ 2p^6\ 3s^2\ 3p^6$		2-1-1		$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1$	
$1s^2\ 2s^2\ 2p^4\ 3s^1\ 3p^4$		1-1-1		2-8-8-8	
$1s^2\ 2s^2$		2-8-7-3		$1s^2\ 2s^2\ 3s^2$	
$1s^2\ 2s^2\ 2p^2\ 3s^2$		2-8-2		2-8-4-1	

Choose ONE of your GROUND STATE choices and ONE of your EXCITED STATE choices and explain how you can tell which state the configuration represents.

a)_______________________: ____

b)_______________________: ____

B) Complete the following:

1) For the element Se:

Electron Config (Shell) Electron Config (Sublevel)	Box Diagram	Dot Diagram
---		

How many…	Occupied?	Full?
PEL's		
Sublevels		
Orbitals		

2) For the element K:

Electron Config (Shell) Electron Config (Sublevel)	Box Diagram	Dot Diagram
---		

How many…	Occupied?	Full?
PEL's		
Sublevels		
Orbitals		

5) Ions Homework

A) Multiple Choice Questions: Place your answer in the space in front of each question.

_____1) Which atom has the strongest attraction to electrons in a chemical bond?
a) Na b) C c) N d) F

_____2)An atom of which element is most likely to lose an electron when bonded to O?
a) Na b) C c) N d) F

_____3) An atom of which element is most likely to gain an electron when bonded to Mg?
a) Na b) C c) N d) F

_____4) Which atom will it take the most amount of energy to remove the most loosely held valence electron?
a) Cl b) Li c) Rb d) Ne

_____5) Which element's atoms are most likely to lose valence electrons and form a positively charged ion?
a) Cl b) Li c) Rb d) Ne

_____6) How many valence electrons does an atom of N have?
a) 4 b) 5 c) 7 d) 8

_____7) According to Reference Table S, as the elements Na to Cl are considered from left to right, what happens to the atomic radius of the atoms?
a) increases b) decreases c) remains the same

_____8) According to Reference Table S, as the elements in Group 2 are considered from top to bottom, what happens to atomic radius?
a) increases b) decreases c) remains the same

_____9) Explain why the radius of Br is larger than the radius of F.
a) More electrons b) More PEL's c) More nuclear charge d) more neutrons

_____10) Explain why the radius of O is smaller than the radius of B.
a) More electrons b) More PEL's c) More nuclear charge d) more neutrons

_____11) What is the relationship between the electronegativity of an atom and its covalent atomic radius?
a) Direct b) Indirect c) No relationship

_____12) What must a atom of nitrogen do In order to make an ion with a stable octet?
a) gain 3 electrons (reduction) b) lose 3 electrons (oxidation)
c) gain 3 electrons (oxidation) d) lose 3 electrons (reduction)

_____13) How many electrons does an ion of Na^{+1} have?
a) 0 b) 1 c) 10 d) 11

_____14) When N forms a –3 ion, it forms the electron configuration of which element?
a) Be b) N c) Ne d) Na

_____15) What is the charge of an ion that has 10 electrons and 9 protons?
a) +1 b) -1 c) +9 d) -10

_____16) What is the name of the Fe^{+3} ion?
a) iron b) iron (I) b) iron(II) d) iron (III)

_____17) What is the name of the S^{-2} ion?
a) sulfur b) sulfur (II) c) sulfide d) sulfide (II)

B) If an atom of Br were to combine with an atom of Ca, which one is likely to be oxidized and which one is more likely to be reduced? Explain, in terms of *electronegativity*.

C) A sample of Ca and a sample of Li are both subjected to increasing heat. Which one will lose its outermost electron first? Explain, in terms of *ionization energy*.

D) Fill In the following chart, determining the number of subatomic particles in ions of the following isotopes:

Isotope	Number of Protons	Number of Neutrons	Number of Electrons	Electron Config is the same as ***which Noble Gas***?
$^{24}_{11}Na^{+1}$				
$^{80}_{35}Br^{-1}$				
$^{14}_{6}C^{-4}$				

E) Complete the following chart, filling in the missing pieces using the clues given:

Ion	# of Protons	# of Electrons	Ion formed from ***loss*** or ***gain*** of e-?	Ion formed from ***oxidation*** or ***reduction***?	Cation or Anion?
Mg^{+2}					
	29	27			
P^{-3}					
	16	18			

F) For each of the following elements, draw write the ion charge from the periodic table, then the dot diagram for the ion (including the ion charge) and then state how many electrons were gained or lost ("gained 2, lost 3") to form the ion. Finally, identify the gain or loss of electrons as being oxidation or reduction.

Element	Ion Charge (from Periodic Table)	Dot Diagram of ***Ion***	How many electrons are ***gained or lost*** to make this ion?	Is the ion ***larger*** or ***smaller*** than the original atom?	Electron Config is the same as ***which Noble Gas***?
Br					
K					
Al					
S					
Ca					

G) Complete the following chart by naming the ions in the first half and writing the symbols and charges of the rest given the names.

Ion	Name
Be^{+2}	
Br^{-1}	
Cu^{+1}	
Cu^{+2}	
Zn^{+2}	
	Fluoride
	Nitride
	Chromium (II)
	Silver
	Gold (III)

Sy	EN
IE	
Radius	

Electronegativity, Ionization Energy and Atomic Radius Chart

Use Reference Table S to find the electronegativity, ionization energy and atomic radius of each of the elements here, and fill in the chart. Answer the questions on the back based on this table.

1	2	13	14	15	16	17	18
H							He
Li	Be	B	C	N	O	F	Ne
Na	Mg	Al	Si	P	S	Cl	Ar
K	Ca	Ga	Ge	As	Se	Br	Kr
Rb	Sr	In	Sn	Sb	Te	I	Xe
Cs	Ba	Tl	Pb	Bi	Po	At	Rn

Questions:
1) Define ELECTRONEGATIVITY:____

2) Define IONIZATION ENERGY:____

3) Define ATOMIC RADIUS:____

4) As the elements in Group 1 are considered from TOP to BOTTOM, what happens to the

a) Electronegativity?______________ b) Ionization Energy?_________________c) Atomic Radius?__________

5) As the elements in Period 3 are considered from LEFT to RIGHT, what happens to the

a) Electronegativity?________________ b) Ionization Energy?___________________c) Atomic Radius?___________

6) What kind of relationship exists between electronegativity and ionization energy?_________________________

7) Do metals or nonmetals in period 3 have the **higher** electronegativity? _______________________

8) Do metals or nonmetals in period 3 have the **higher** ionization energy? _______________________

9) Does a metal or a nonmetal in period 3 have the **smaller** radius? _______________________

10)What is the relationship between atomic radius, electronegativity and ionization energy? _________________________

____

