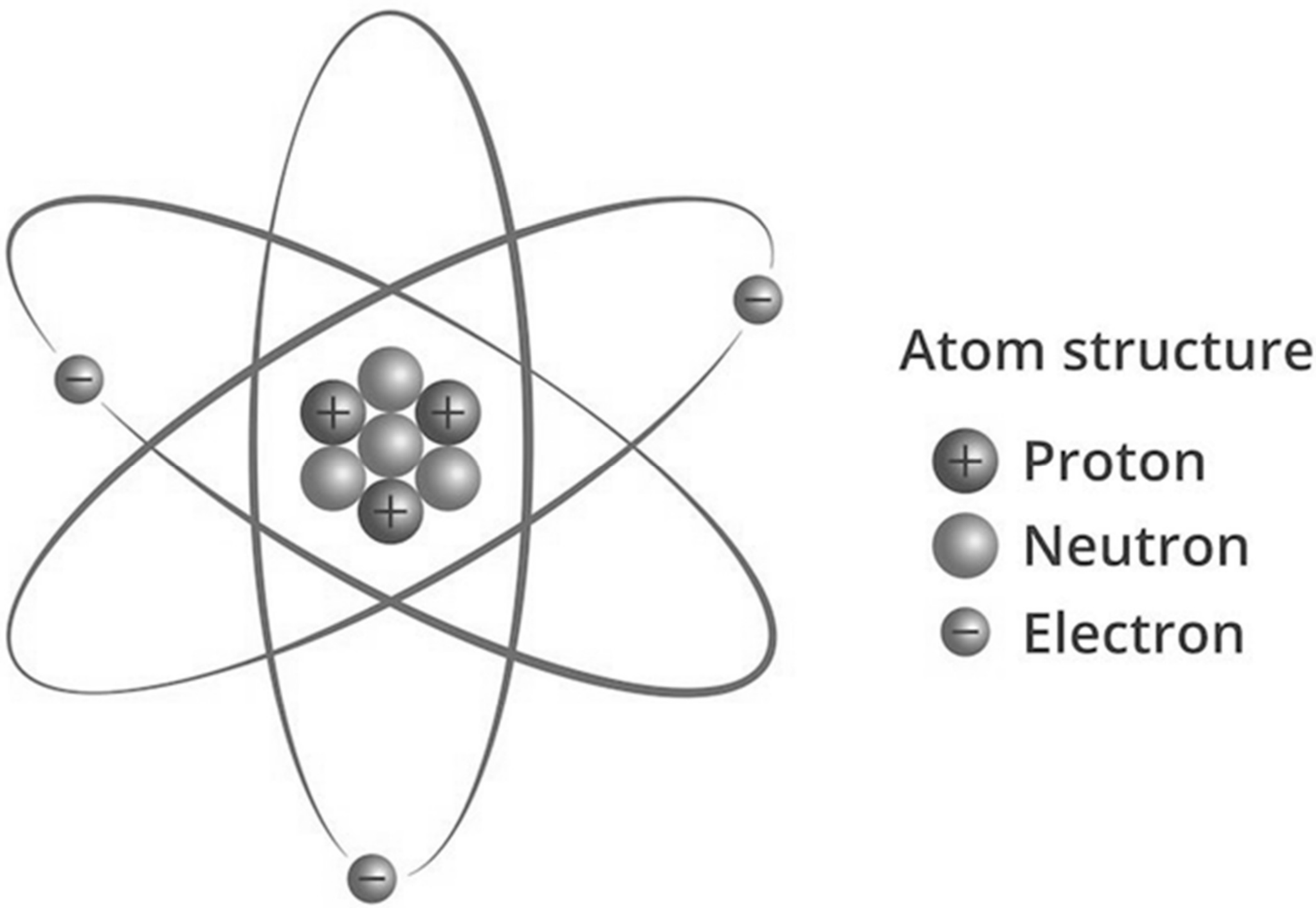
# Atomic Theory

***Arbuiso Chem***

Name______________________________________________________________________ period ____



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# Atomic Theory Notes

OB: Students will examine basic structure of the atom, learn what the numbers on the Periodic table mean, and look at electron configurations.

1. All atoms are made up of 3 sub-atomic (smaller than atoms) parts. They are...

| Part | Charge | Symbol | Mass | location |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |

2. The mass of an electron is NOT ZERO, only about            th of a proton or neutron, so small that in high school we will disregard it's mass. This is an intro class, and we can't measure these masses in our class anyway, but it's not zero in the real chemistry.

3. The nucleus is the ________________________________________ center of an atom where the protons and the neutrons live.

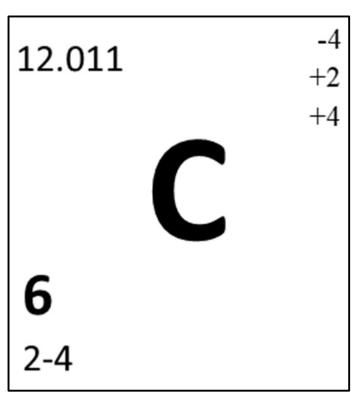
4. Electrons _____________________________________________________ outside, relatively far away.

5. __________________ is _______________________________________________________________

6. In high school a proton is = ___________. A neutron is = _____________ too.

7. In high school, the mass of an electron is ________________________________ (but it's not really 0)

8. The periodic table of the elements has a KEY, label these



9. Atomic Mass Numbers will be rounded to the ____________________________________________
in our class. We will learn why the decimals exist and why they are important too, have patience.

10. Mass Number = mass of ____________________________ PLUS __________________________

11. The mass of sodium is 23 amu, so mercury has a total of 23 protons plus neutrons.
*How many of each??? Let's learn how to figure this out*

12. How many protons, neutrons, and electrons in the element TIN?

14. All atoms are electrically neutral. The number of ____________ = the number of _______________

The positives = the negatives. *Always.* Every atom is neutrally charged. The p+ = $e^-$ always

| Determine how many protons, neutrons, and electrons are in these atoms.<br>Write in their NAMES too. | | |
|---|---|---|
| 15. In | 16. Nb | 17. Fe |
| name | name | name |
| | | |

There are several ways to “write” symbols that stand for atoms, here’s another, more formal method.
Copy calcium and labels the numbers

Ca

18. Write the formal symbols, with the proper numbers, in the RIGHT PLACE, for

| Mercury | Chlorine | Copper |
|---|---|---|
| | | |

19. Electrons do not fly around randomly. They stay in ____________________

which are also called ________________________________________________.

20. Shells closer to the nucleus have __________________________________ energy electrons.

Electrons in shells further away from the nucleus, have ______________________________ energy.

21. The shells are sized to hold a ________________________________ number of electrons.

Don’t memorize how many can fit into each shell, you just look at group ________ on the Periodic Table.

| | Noble gases | The Electron Configurations show how many electrons in each shell | | | | | |
|---|---|---|---|---|---|---|---|
| 22 | Helium He | | | | | | |
| 23 | Neon Ne | | | | | | |
| 24 | Argon Ar | | | | | | |
| 25 | Krypton Kr | | | | | | |
| 26 | Xenon Xe | | | | | | |
| 27 | Radon Rn | | | | | | |

| 28. Shell # | Maximum electrons that fit | "Full" is relative. It is better understood as perfectly stable arrangement. |
|---|---|---|
| 1 | | The electron shells can be stable in different ways. |
| 2 | | The first two never adjust. |
| 3 | | Bigger shells are fancy. Group 18 shows us how many electrons can fit into each shell. |
| 4 | | Just put your finger in the right box and think. |
| 5 | | |
| 6 | | |

29. Find silver on the Periodic Table. How many electrons does it have in total? _____________

30. How many electrons are in the 3rd shell of silver? ___________

31. How many protons are in the element hafnium? ___________

How many electrons are in the 2nd shell of hafnium? ______________

32. What element has 18 neutrons and 17 electrons? _________

Atomic Theory Class #2, Models of the Atom through history.

33. Democritus said: the INDIVISIBLE PARTICLE is called the ___________________________.

In English call it an _____________________.

| 34. | John Dalton's Atomic Theory |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 35. Dalton imagined his atom to look like a | |

36. Around 1897 J. J. Thomson discovers the ________________________ (and later gets a Nobel Prize).

37. Thomson did experiments, using what's called a ______________________________________________

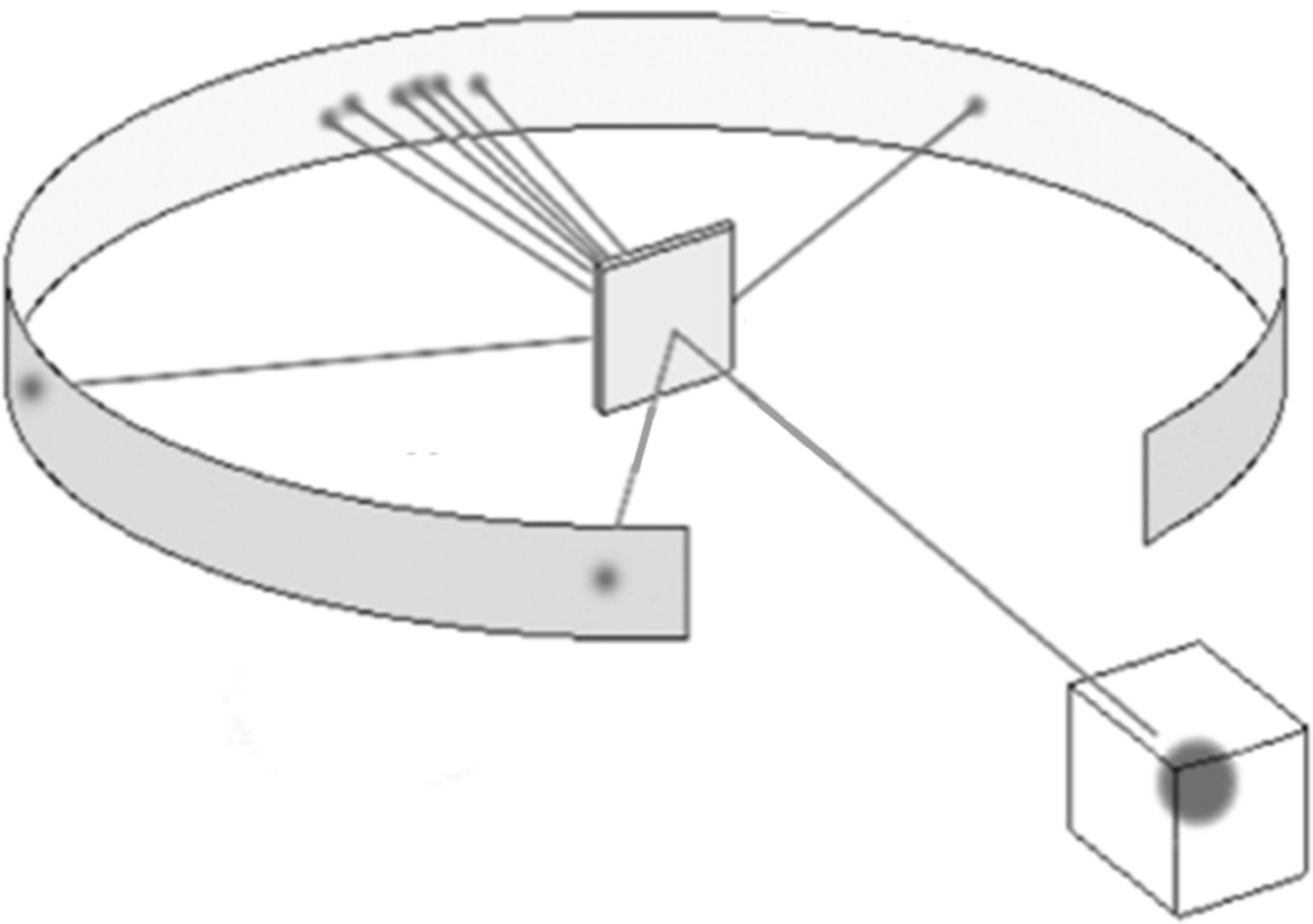
This first subatomic particle, the electron, was ___________________________________ charged.

38. Thomson describes the model of the atom as ______________ ___________________________!

In 1908, my chemical hero, Ernest J. Rutherford discovers the nucleus! He gets the Nobel Prize as well.

39. Rutherford's _________________________________________________________ Experiment
helps him discover the nucleus, and figure out the basic structure of the atom.

40. Listen first, then draw. This drawing is online, you can add details later if you need to.



There is a cool power point on arbuiso.com to watch: Gold Foil Experiment Explained Well

| 41. What does the Gold Foil Experiment prove? | |
|---|---|
| Atoms are mostly | |
| Atoms are neutral, so the nucleus must be | |
| Neutral atoms must have negatively charged electrons | |

42. The Rutherford Model is named the ________________________________________.
He perceives the electrons to be flying around the atom's nucleus like the

_____________________________________________________________________.

## 43. Problems with Rutherford's theory…

How can atoms be mostly __________________________________? How can they be mostly "not" there?

How can these negative electrons fly around a positive center, but

________________________________________________________? Why not?

How do they just keep flying without ever running out of energy?
Why don't they fly off, away from the nucleus?

If they do fly around, do they just fly willy-nilly, or _____________________________________ to them?

Rutherford could not provide solid answers to these questions.

44. _____________________________________ is able to do some very funky math, and he proves the Rutherford model of the atom is correct. He too wins a Nobel Prize.

45. The Bohr Model - _____________________________________________________________________.

He expands on the simple planetary model of Rutherford, and put the electrons into

______________________________________ or _____________________________________________.

46. Bohr proves that for hydrogen, if the electron flies at the right speed, and the right distance, it will

mathematically ______________________________________________________________________________ and stay in orbit forever around the nucleus.

47. The math that proves electrons never run out of energy only works for ___________________________ with a single electron.

48. Draw a Bohr Model for the atom of Nitrogen

49. Niels Bohr further determines that electrons could gain a _____________________________________

an amount he called a _________________________________________________________________.

This enables an electron to "jump" up to a higher-than-normal energy level

into what is known as the __________________________________________________________.

Neon in the ground state has an electron configuration of ________________________

Neon on the excited state has an electron configuration of ________________________

50. The excited state is __________________________, and the electron will soon move back to the lower energy, more stable ground state. To do that it must release that exact amount of energy, the same quantum of energy it absorbed to get excited.

51. This amount of energy is released as _______________________________________ which we can see!

52. This light we call __________________________________. An example is an electric neon light that emits that characteristic orange light. That orange light is its spectra, unique to neon.

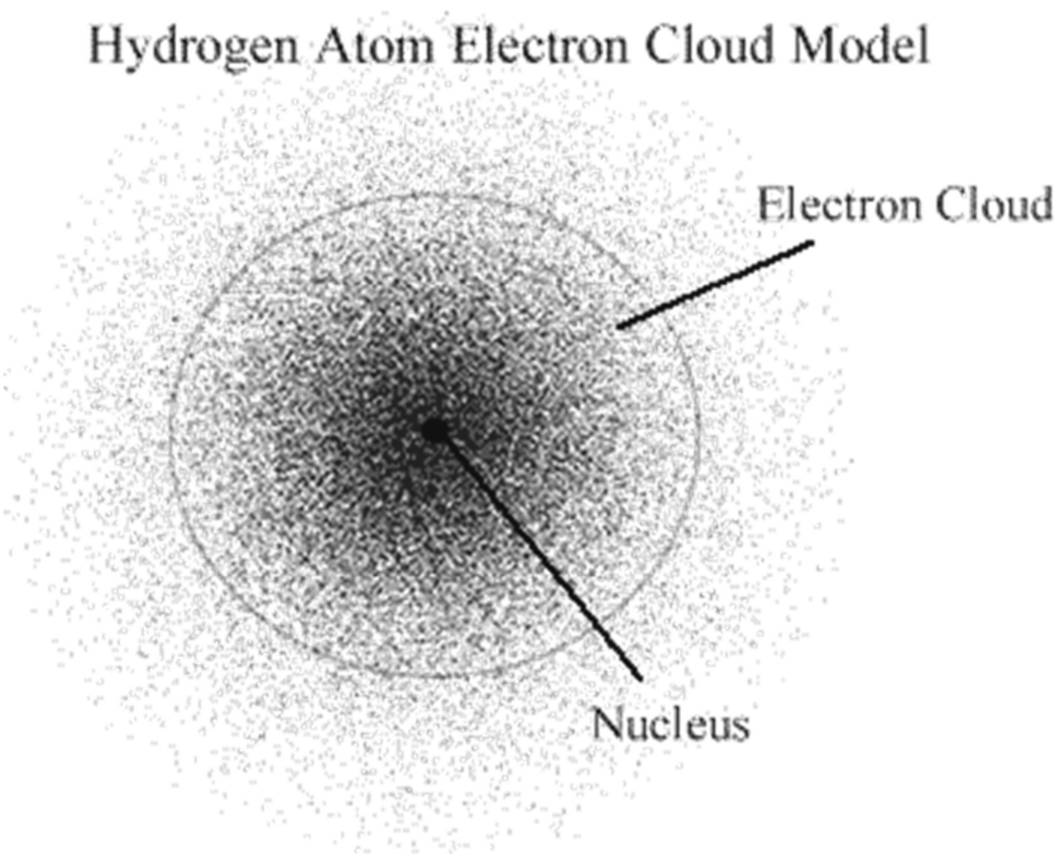
# The final model of the atom—the “Modern Model”

53

54. It’s called the ______________________________________________________ Model.
The electrons sometimes act like waves of energy, and sometimes like little bits of mechanical matter with negative charge.

55. This model is more about the ____________________________________________________
of finding an electron’s location MOST OF THE TIME, not always.

56. Electrons are like _____________________________________________, they are where they should be most of the time, but not always.



| | Symbol | Name | Ground State | *Possible* Excited State |
|---|---|---|---|---|
| 57 | Li | | | |
| 58 | Na | | | |
| 59 | Mg | | | |
| 60 | Ca | | | |
| 61 | He | | | |
| 62 | Ne | | | |
| 63 | Ar | | | |

64. Ground + Excited State electron configurations have the _______________ number of electrons,

the electrons are just in _______________________________ places.

65. How do electrons get excited? They absorb _____________________amounts of ____________________,

called a __________________________________________________.
A quantum means a specific amount.

66. Spectra is produced when this unique quantum of energy is ...

67. The color of light, or the SPECTRA that we see, is a ______________________________ of many colors of light that our eyes blur together.

68. A refractive lens can break up this mixture of colors into a unique

_________________________________________________________________
This can be measured (even by you, in lab)

In the Neon light tube orange light is the ____________________________

That orange light is many colors, which we can separate with

_______________________________lenses into this spectrograph
(like a fingerprint for neon.

69. We will do _________________________________________________________ too, where fire will change colors.

The ___________________________________________ we see when we heat up

copper salts is ___________.

The spectrograph (or spectra emission lines) is too hard to see because the flame is jumping around like mad and we can't follow that bounce with our heads!

Stop here.

Atomic Class #4

70. ______________________________________ once said that all atoms of an element are identical.

71. He should have said that:

72. All atoms of an element are chemically identical. They can have ________________________________

because the _______________________________________________________ in any element is not set.

All iron atoms have 26 protons, all have 26 electrons.
Some iron atoms have the "normal" amount of 30 neutrons. Some iron atoms have less, some more.

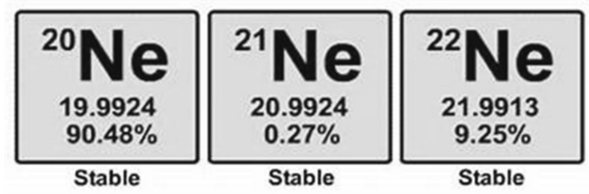
73. These different iron atoms are called _______________________________________ of iron.

There are 118 elements, but there are about 1500 different isotopes.

74. Each kind of atom comes in a variety of masses, every one of them is an ________________________ of that element.

| 75. Fill in this table. | | |
|---|---|---|
| H-1 | has | |
| H-2 | has | |
| H-3 | has | |

| | ISOTOPE | K-39 | K-40 | K-41 |
|---|---|---|---|---|
| | MASS in amu | 38.9637 | 39.963 | 40.9618 |
| 76 | # protons | | | |
| 77 | # electrons | | | |
| 78 | # neutrons | | | |




79. These 3 different ISOTOPES of neon are all ___________________________ identical. They have the same number of protons and the same number of electrons, but different numbers of __________________.

80. Isotopes have different _________________ but the same ______________________________________.

81. The masses of all the______________________________________________________________________ make up 100% of all the average atomic mass of neon

82. Adding 20 + 21 + 22 = 63 then divide by 3 for an average gives us an average mass of ______________.

83. That's not how we do average weighted atomic mass.

The Periodic Table says neon's atomic mass is ________________________________________AMU

84. Average weighted atomic mass has you multiply the exact mass X exact proportion of this isotope, then do that for all isotopes, then add up the totals to get your correct answer. COPY THE MATH…

85. ___________________________________________________________ is the mass listed on our periodic tables. These use the mass of each naturally occurring isotope and the proportions of those isotopes make up of all that element.

86. Scientists measure these ________________________________________________ proportions regularly, sometimes the proportions of an isotope are measured better (and change) which causes a slight adjustment to the mass numbers on the Periodic Table (wow).

87. A new element named Arbuiso is discovered (A). It has two isotopes, A-58 and A-59.
82.08% of all this Arbuiso metal has mass of 57.96 amu, while the rest has mass of 58.98 amu.
What is the weighted average atomic mass of this cool new metallic element? (DO THE MATH)

88. A new element X has 3 isotopes; the details are in this data table.
Calculate the average weighted atomic mass of element X.

| Isotope Symbol | Isotope mass (amu) | Proportion of element X |
|---|---|---|
| X-23 | 22.8995 | 84.25% |
| X-24 | 23.9105 | 8.82% |
| X-26 | 25.9068 | ?? |
| | | |

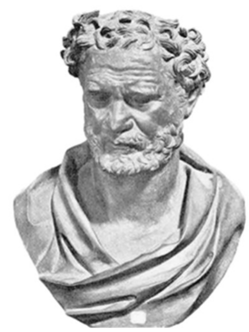
There are no more notes, but there are some more review slides in the "slideshow" on arbuiso.com

# Atomic Basics

These are our atomic theory objectives
1. Models and theories of the atom
2. Subatomic particles: protons, neutrons, and electrons as well as their masses, their charges, and locations
3. The Gold Foil experiment by Ernest Rutherford
4. Determining numbers of protons, neutrons and electrons in an atom using the Periodic Table of Elements
5. Isotopes & calculating the average atomic mass as shown on the Periodic Table
6. Spectra, how and why they are produced with electron movement
7. Ground state vs. excited state for electrons, electron shells/energy levels

## *The modern model of the atom has evolved over a long period of time, through the work of many scientists.*

Here are some of the highlights of atomic models through history.

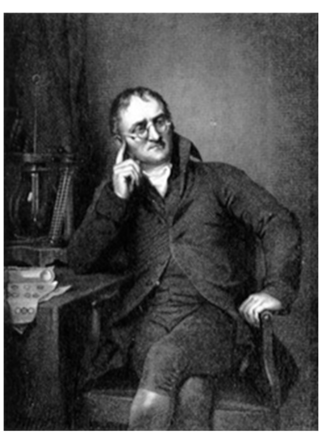


**Democritus** was a philosopher in ancient Greece who "thought" about things, and came up with his ideas. His idea was that all kinds of matter were unique and that you could cut it in half over and over until you reached some tiny part that was too small to be cut in half anymore.

That tiny particle he called "atomos", which meant indivisible. Not too bad considering science was not even invented yet. His nickname of "atom" has stuck.

Unfortunately, this meant you could have an "atom of fish" or an "atom of wood"! Still, he did come up with the name to that ultimately small particle.

**John Dalton** was a farmer who examined atoms, and "invented" modern chemistry. He noticed all atoms of an element has unique mass. He decided that ALL properties of elements were due to this difference in mass. That was not the reason really. He imagined atoms to be like BILLIARD Balls, which are like pool balls on a pool table, small, hard, spheres of different mass.



He published his Atomic Theory which said:

A. all matter is made up of extremely small particles called atoms
B. elements are made up of only one kind of atom, each identical to the others in properties and mass
C. two or more atoms can combine in small, whole number ratios, to form compounds
D. in a chemical reaction, atoms are re-arranged (combined or separated) - but not destroyed

Much of Dalton's theory was correct, but we now know that atoms are made up of sub-atomic particles called neutrons, protons, and electrons. Although every element is made up of atoms that are chemically identical, they are not identical, scientists know that isotopes of every atom exist. (more on those later). Still, he was clearly on the right track.

**JJ Thompson** was the person who discovered the electron. He used a device called the cathode ray tube and was able to find electrons.

He had no knowledge of protons or neutrons, or real atomic structure, so he imagined these electrons "stuck" into a sort of positively charged atomic stuff. He called it his “plum pudding” model of an atom.

Try to imagine that electrons are the chips in a chocolate chip cookie, and the rest of the atom (the cookie part) is all positively charged, enough to cancel out the negatively charged electrons. Plum pudding is ripped up bread, with chopped up bits of plum, mixed with egg and lots of sugar, baked together and formed into a sweet loaf of bready dessert. It’s heavy, but served warm with cream on top, it’s quite tasty, but a silly model for an atom!

It was a small oops, but hey, he discovered the electron and that was a great achievement!

Ernest Rutherford is my scientific hero; he furthered atomic theory along with an amazing experiment called the GOLD FOIL experiment. He proved that the electrons were flying around at a good distance from the nucleus of the atom which meant atoms were mostly empty space. He determined that the nucleus was positively charged, and because atoms were neutral, he put the electrons flying around it.

Although he did not understand shells for the electrons, this was a grand development in the model of the atom.

Unfortunately, he had some big problem he could not explain: How were the negatively charged electrons not just collapsing into the positive charged nucleus? They should. Additionally, why didn’t the electrons didn’t fly off, or ever run out of energy to keep flying around the nucleus?

Rutherford's Gold Foil experiment is one of the most important experiments in the history of science, it’s really that important. Here’s what he did:

He knew he could pound gold super thin; it’s the most MALLEABLE metal of them all. He pounded it so thin, approximately 1/1000th the thickness of a sheet of paper!

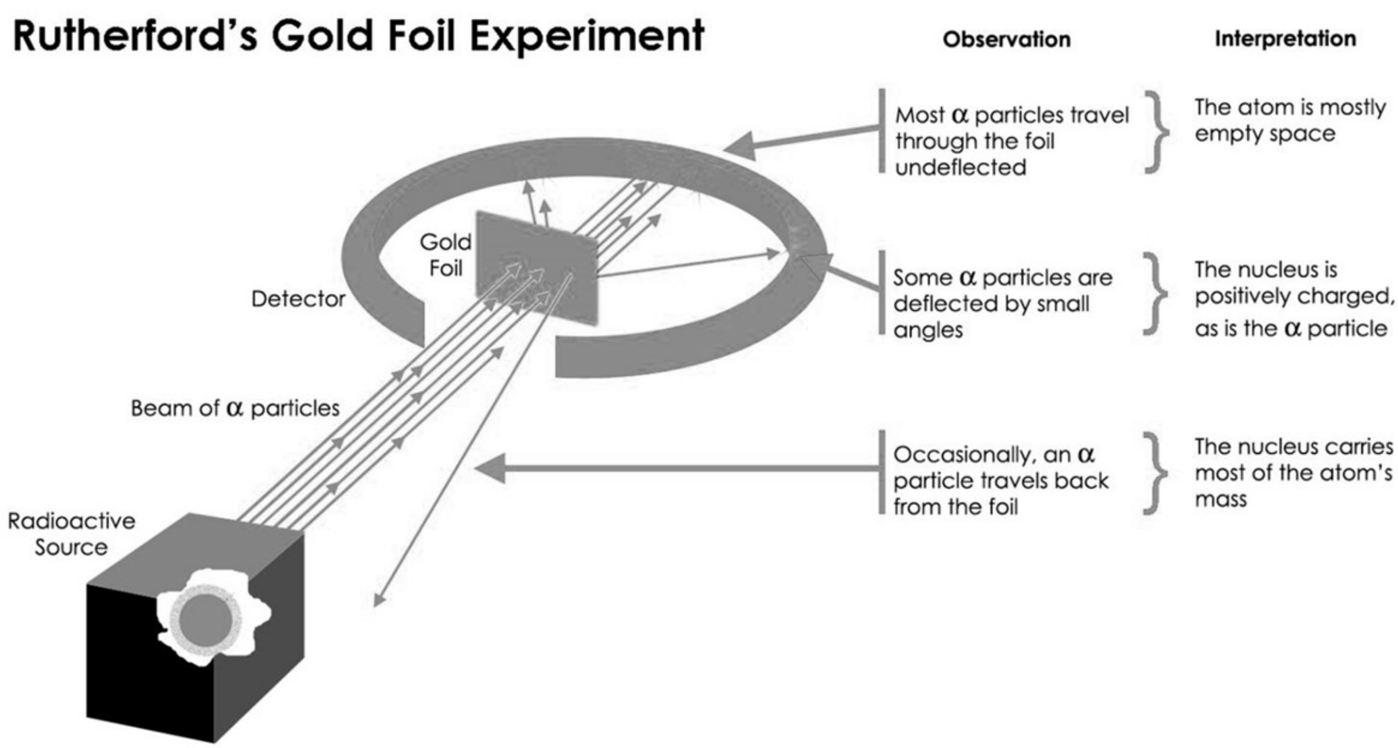
Marie Curie told him that radioactive polonium emitted radiation called ALPHA PARTICLES. She discovered that little and had a charge of +2. He could “shoot” this radiation at the gold and see what it did.

He put the polonium metal into a lead box (to keep the radiation from scattering) and drilled a small hole into the box so that the radiation came out only through this tiny hole. He could aim the radioactive alpha particles at the gold.

He surrounded his experiment with a zinc sulfide coated frame. It turns out whenever an alpha particle hits this zinc sulfide screen, a small flash of light can be seen (and counted).

When he shot the alpha particles at the gold foil, he was amazed by what he discovered.

Look hard at the diagram on the next page, you need to know it, be able to draw it, and explain it.




## Major Problems with the Rutherford model of the atom

A. How could atoms be 99% empty space? If so, why couldn't we just walk through, or see through walls?
B. Why did these flying negatively charged electrons never get tired (lose their kinetic energy) slow down, and get sucked into the nucleus with a positive charge?
C. Why did these electrons flying around so relatively far from the nucleus not just fly away?

Although Rutherford was correct in his interpretation of what atoms looked like, it was due to the Nobel Prize winning work of his student Niels Bohr who saved the Rutherford model.

## Niels Bohr and the Planetary Model of the Atom

Bohr was a physicist (explaining his missing mustache!). He wanted to study the structure of the atom. He knew it wasn't a billiard ball, or a plum pudding dessert. He understood the golf foil experiment, and was smart enough to do math to "explain" Rutherford's results.

Normal people can't always make sense of the math; it is counter intuitive. Atoms could be 99% "not there" and still be there.

Electrons could fly around the nucleus and never lose energy, never fly off, nor collapse into the positively charged nucleus.

And, he could do the math the "prove" it. If normal people couldn't begin to understand the math (quantum theory) that was their problem, it was true!

Using hydrogen, which has just one proton and one electron, he was able to prove mathematically that electrons do not lose energy if it stay in a precise orbit around the nucleus. Each orbit is also an energy level. That meant the electrons could fly around their nuclei forever. Further, each electron lived in specific energy levels or in orbit (like planets orbiting the Sun), and each orbit had unique energy levels to it.

If an electron gained a specific amount of energy (a quantum of energy) the electron could "jump up" to a higher-than-normal orbit for a while, which he called the EXCITED STATE. This was unstable, and the excited electrons would then "jump back to the lower energy level, the normal or GROUND STATE. To return, they'd give off that unique quantum of energy, which we can see as visible light. Since each atom (or compound) requires unique energy to become excited, electrons return that quantum of energy as visible light. Each substance produces a unique visible light which we call spectra, and we'll see in lab.

His orbits are energy levels. The closer to the nucleus, the smaller the orbit, and the lower energy they are. The further an orbit is from the nucleus the higher the energy levels the electrons in them have.

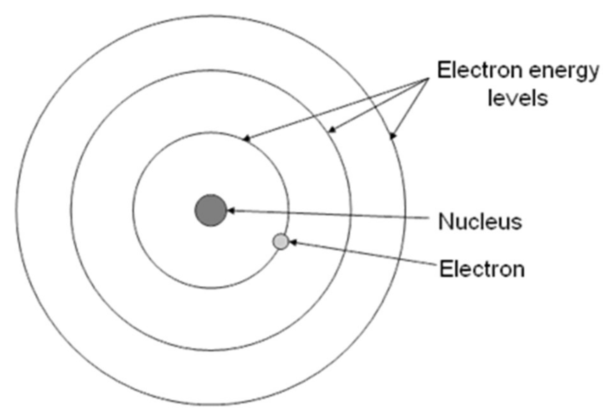
Bohr's math works great for the atom hydrogen with a single electron to cope with, but as soon as it's applied to He, with just 2 electrons, or any other atoms, the math is way too hard, even for him. Still, his ideas stand, and the electrons are drawn into nice little planetary diagrams, with the electrons filling up these orbits from the "lowest" energy orbit to the higher energy orbits. Below is the "Bohr Model".

The 1st orbit can fit just 2 electrons.

The 2nd orbit holds up to 8 more electrons.

The 3rd orbit can fill up with 8 electrons,

or it can STRETCH to hold up to 18
(that's tricky).




To remember how many electrons fill up any shell, just look at Group 18 on your Periodic Table.
Those noble gases always have ONLY COMPLETE electron orbits or ENERGY LEVELS.

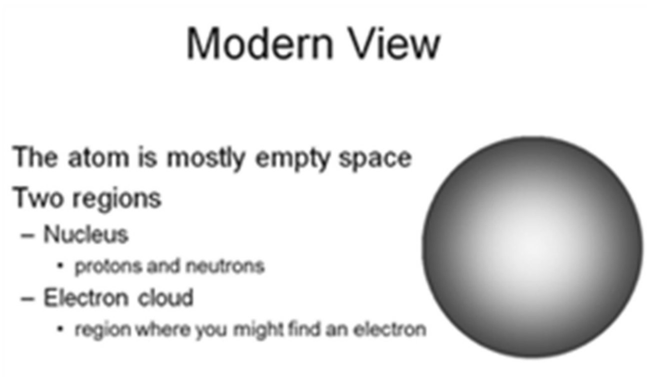
# The Modern Model or the Wave-Mechanical Model

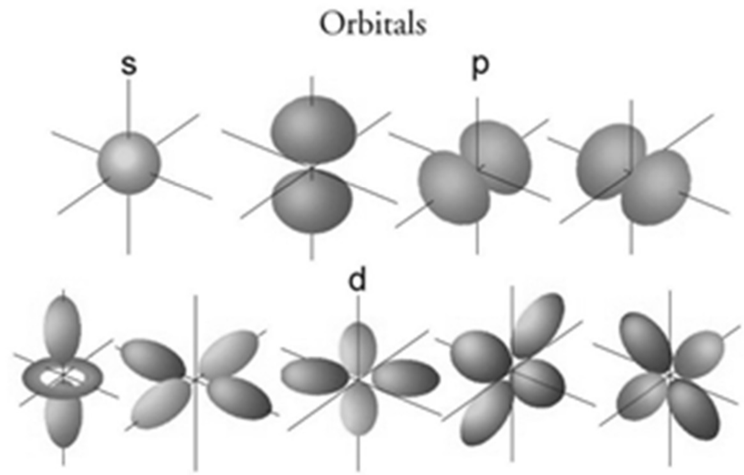
Finally, in the early part of the 20th century, as math gets fancier and quantum theory becomes the rage, the atom is again reconfigured. The modern model, or the wave-mechanical model, we find the nucleus still central, neutrons are already discovered, the charges of the neutrons is zero.

Protons are still positive and exactly balanced by the negative charges of the electrons flying about.
All atoms are still neutral, but the electrons no longer follow in neat little circles like in Bohr's time. Now these electrons are moving about in a sort of statistical cloud, a zone, called an SHELL.

Orbits were simple radial paths, but now the radius of any electron is a bit fuzzy, and more difficult to pin down. It seems that they are not as easy to grasp as the planetary model, but that is just how it is.
Electrons can act like particles, and sometimes they act as waves of energy. They are pretty funky and weird.
You can never determine both the speed of an electron and its location at the same.

SHELLS are more like "zones" that electrons live in, and they have remarkably complex shapes. Atoms cannot just have energy, rather they can only have certain amounts of energy, in precise "quanta" amounts.
For our class, it's all about the shells, don't sweat the shapes of shells or the fancy equations, that is not for us.
As you study more chemistry you will learn that the shells contain sub-orbitals as well.




# The Three Sub-Atomic Particles:

As far as sub-atomic particles are concerned, we need to know 3: protons, neutrons & electrons.

Protons have a +1 charge, they have a mass of 1 amu, they are in the nucleus only.

Neutrons have no charge, they too have a mass of 1 amu, and they are in the nucleus only as well.

Electrons have a -1 charge, and they fly around the nucleus in specific shells, or energy levels.

In our high school chemistry class, the electron mass is SO SMALL, we consider it to be zero, but it is in fact about $9.1066 \times 10^{-28}$ grams, which is, 0.00000000000000000000000000091066 grams
which we all accept as pretty close to nothing in high school. They are only about 1/1836th of an amu.

We will never ever do any math with this $10^{-28}$ exponent number. We'll round this mass away, don't forget.

# Determining numbers of $p^+$, n° and $e^-$ in an atom using our periodic tables.

All atoms are listed in ascending atomic number. The atomic numbers equal the number of protons and also the number of electrons in an atom. ALL ATOMS ARE NEUTRAL, the number of electrons = the number of protons found in the nucleus. The negative charges balance out the positive charges in a 1:1 ratio.

The atomic mass of an atom = the mass of the nucleus, or the protons plus neutrons only (remember in our class the electrons have no mass). So for this concept, we round off the atomic mass number on the periodic table to the nearest whole number. The total mass of an atom is the protons plus the neutrons. If you know this mass, and can subtract off the atomic number, or number of protons, the left over mass is made up of only neutrons. This method will work for all atoms. YOU NEED TO GRASP the concepts below concerning average atomic masses.

Titanium is shown at right. It's mass is rounded to 48 amu.
That is 48 is the total number of titanium's protons plus neutrons.

It does not tell us about how many of each, but we will figure that out now.
Titanium's atomic number of 22 tells us that it has 22 protons (and 22 $e^-$)

48 = protons plus neutrons
- 22 = minus the protons (atomic number)
26 = neutrons

| 47.88 |
|---|
| **Ti** |
| **22** |
| 2-8-10-2 |

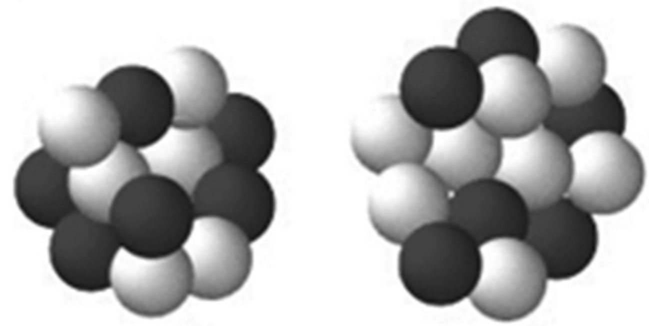
| | |
|---|---|
| 63.546<br>**Cu**<br>**29**<br>2-8-18-1 | Copper….<br>Mass = 64 (The protons plus the neutrons)<br>Minus - 29 (the atomic number or # protons)<br>35 = (the number of neutrons) |

## Two more examples…

Tungsten - W mass 183.64 amu. Atomic number 74 184 - 74 = 110 neutrons 74 protons & 74 electrons

Iron – Fe mass 55.845 amu. Atomic number 26 56 - 26 = 30 neutrons 26 protons & 26 electrons

# Isotopes




Not all atoms of one element are identical, John Dalton said they were but he was incorrect.

It turns out that all atoms of one element are CHEMICALLY IDENTICAL because they have the same numbers of protons and electrons, but they have DIFFERENT numbers of neutrons.

He didn't know about protons, neutrons or electrons. Neutrons do not affect the chemistry of the atoms, just the mass.

The number of neutrons can vary, and each isotope of an element has a different number of neutrons, and therefore a different mass. They all bond and react identically, but the neutron number is different.
At right are the nuclei of the 2 isotopes of carbon. Carbon-12 isotope has 6 dark colored protons and six white neutrons (6 + 6 = 12 amu)

The Carbon-14 isotope on the right has 6 dark colored protons and EIGHT white neutrons (6 + 8 = 14 amu) Both have six electrons. They are chemically the same, but they have different masses (12 amu vs. 14 amu).

# Isotopes and average atomic masses

The atomic masses on the Periodic Table are mostly decimal measures while we know each atom has a whole number of protons and neutrons making up this mass. The reason for this decimal is because isotopes exist in nature and they need to be taken account of.

Out of the 118 types of elements, there are almost 1500 different kinds of isotopes. Every atom has at least 2 isotopes, some have up to 15 or more isotopes. Why do these exist? No one really knows, but scientists like to measure everything, so we will learn this too.

For example, CARBON has 3 naturally occurring isotopes. They are C-12 which are the most common isotope of carbon. Also, Carbon-14 which is radioactive. There is also some Carbon-13 which is stable but uncommon.

Each has a whole number mass in high school chem, 12 amu, 13 amu, or 14 amu. It's the PROPORTIONS of them that are measured carefully, to many decimal places, that yields the decimals on the periodic table masses.

To calculate the average weighted atomic mass, on the Periodic table, scientists multiply the mass by their proportion, for each isotope, then sum the masses to get the weighted average of the atom's mass.

| Isotope | Mass (u) | Naturally occurring Proportion | Math (mass x proportion) = | Partial mass |
|---|---|---|---|---|
| C-12 | 12.000 u | 98.80% | (12.000 u)(.9880) = | 11.854 u |
| C-13 | 13.003 u | 1.100 % | (13.003 u)(.01100) = | 0.1430 u |
| C-14 | 14.003 u | 0.100 % | (14.003 u)(.00100) = | 0.01400 u |
| All | → | 100.0 % | Avg. Wt. At. Mass = 12.011 u | |

For an "unknown" element with just two isotopes, calculate the average weighted atomic mass.
When you are given real measurements for mass, don't use the casual isotope mass of "75 amu".
The mass of 74.86 u is correct, 75 amu is too fuzzy.
Atomic Mass Units (amu) are abbreviated by NYS as "u", which is in Table D in reference table D.

| Isotope | Mass | Approx. Proportion | math | Partial mass |
|---|---|---|---|---|
| X - 75 | 74.86 amu | 89.35 % | (74.86 amu)(.8935) = | 66.89 amu |
| X - 77 | 77.06 amu | 10.65 % | (77.06 amu)(.1065) = | 8.210 amu |
| All | | 100.0 % | Avg. Wt. At. Mass = 75.10 amu | |

It makes perfect sense that when we "round" the average weighted atomic mass to 75 amu, that the most common isotope of this element is X - 75. That always happens on the periodic table.

The most common isotope for mercury is 201 amu (atomic mass = 200.59 amu)
And the most common isotope for helium is 4 amu (atomic mass = 4.00260 amu)

# Electron Configurations

On the periodic table the electron configurations provided are always in the ground state, or lowest energy state. There are many sub-orbitals that we won't learn about, but this is a simplified design in our class. Electrons always fill up the shells of the lowest energy levels first, then fill in the higher shells.

In college you will learn the more complex sub-orbital system, and this will all make even more sense to you.

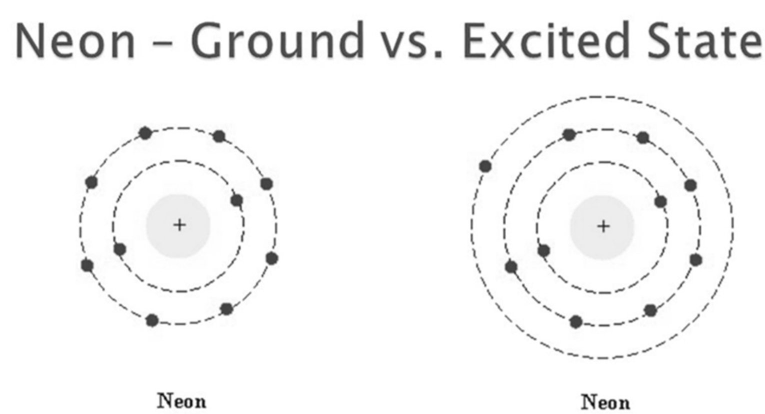
In the first shell only 2 electrons fit. In the second shell up to 8 electrons fit. The rest of the shells, are weirder. They can "fill up" with 8 electrons or stretch out and fill with more electrons. How will you ever remember all of this? Look at group 18 on the periodic table, the noble gases. They have ONLY full shells. So, you can see (example) argon has 3 full shells. Two in the first, eight in the second and eight more in the third shell. But krypton has a different pattern. 2 in the first shell, 8 in the second, 18 (!) in the third shell and finally 8 in the fourth shell.

The third shell can be "full up" with 8 electrons, or with 18 electrons! All the atoms on the periodic table have their electrons in the ground state.

These are their lowest energy state.
This is normal.

But electrons can gain energy from electricity, or heat, or even by radiation. When they gain exactly enough energy, the electrons can "jump up" to higher-than-normal electron configurations.

This is called being in an excited state.




**Neon 2-8 (ground state electron configuration)** **Neon 2-7-1 (excited state electron configuration)**

# Ground vs. Excited state for $e^-$, then, Bright Line Emission Spectra

Carbon's electron configuration in the ground state is 2-4. A possible excited state is 2-3-1 where one electron in the second shell gains sufficient energy go move up to the new third shell.

Sodium's electron configuration in the ground state is 2-8-1. A possible excited state is 2-7-2.

Argon's electron configuration in the ground state is 2-8-8. A possible excited state is 2-8-7-1 *OR* 2-7-9. When electrons are in this excited state they are holding onto some extra energy. It takes a unique amount of energy for any atom to get excited, they each absorb their own "quanta" amount of energy.

The excited state is unstable, and the electrons would "rather" revert back to the ground state. They need to emit this exact quanta of energy do return to the ground state. This unique amount of energy can be seen by your eyes as visible light.

Energy can be absorbed as electrical, heat, or even radiation (not in our class though), but it is emitted as visible light which we call spectra.

In lab we will see that this energy gain, due to electricity or heat, is then emitted, and it is given off as visible light energy. This light creates colored flames in a flame test. It comes out as a single color of orange color in a neon lamp.

This "color" flame, or color lamp light is really a mixture of colors that our eyes register as one color. This mixture can be broken apart with special glasses or lenses called refractive lenses.

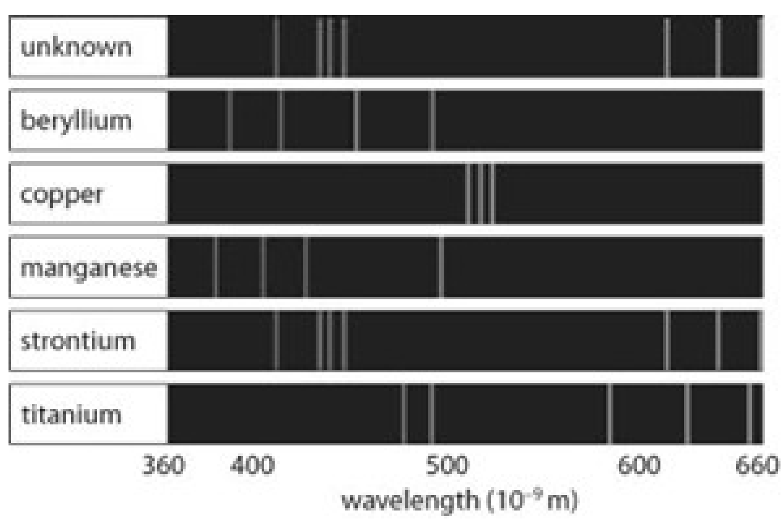
If you break up the mixture of light into component colors with a refractive lens, you see a unique pattern of bright color lines. These lines are the exact wavelengths of energy that is being emitted (looks like one color to the eyes) and can be measured. Each pattern, or spectra, is unique to the atom or molecule due to particular electron movements. The colors are due to the electrons moving from an excited state to the ground state. Each element or compound has unique spectra that can be broken into a color pattern that is unique for that particular substance.

These patterns show some spectra.

The top is the unknown spectra.

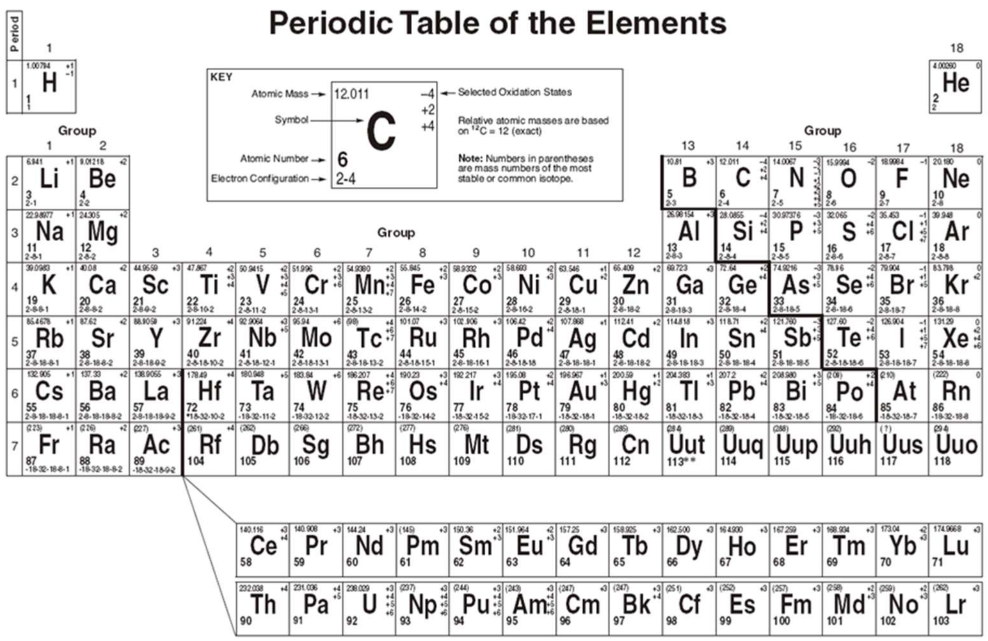
We will compare four known spectra to it.

What is the unknown substance (which of the known spectra matches to this unknown?)




It's strontium, of course.

Uses for this technique include determining what elements and compounds are found on distant planets and stars. Or discovering any unknown substance at hand, say from a crime scene, by comparing the spectra formed from what you have to the known spectra.




*denotes the presence of (2-8-) for elements 72 and above

**The systematic names and symbols for elements of atomic numbers 113 and above will be used until the approval of trivial names by IUPAC.

Source: *CRC Handbook of Chemistry and Physics*, 91st ed., 2010–2011, CRC Press

# The Periodic Table

The periodic table is organized into groups which go up and down, and need to be labeled 1-18.
The periods run left to right, and need to be labeled 1-7.

Group 1 are the alkali metals. Lithium to Francium.
Group 2 are called the alkaline earth metals. Beryllium to Radium.
Groups 3-12 and the “triangle” of metals from Al to Tl to Po, are the Transitional metals.
Group 17 are the halogens. Fluorine to Iodine (not At)
Group 18 are the noble gases, which are nearly inert. Helium to Radon (not Uuo)
The inner transitional metals are the two rows at the very bottom that fit into Group 3, under Yttrium. They include both La and Ac. In group 3, period 6 fit La to Lu. In group 3 period 7 fit Ac to Lr).

The staircase divides metals on the left, nonmetals on top right (hydrogen is the exception)

9 atoms touch the stairs, but only 7 are metalloids, they are B, Si, Ge, As, Sb, Te, and At.
Al and Po are the “dog food” exception. Aluminum and polonium are metals,
but they do touch the staircase. Al and Po remind your teacher of AlPo Dog Food!


A metalloid is a metal with some nonmetallic properties, and/or a nonmetal with some metallic properties. They sometimes are called semi-metals.

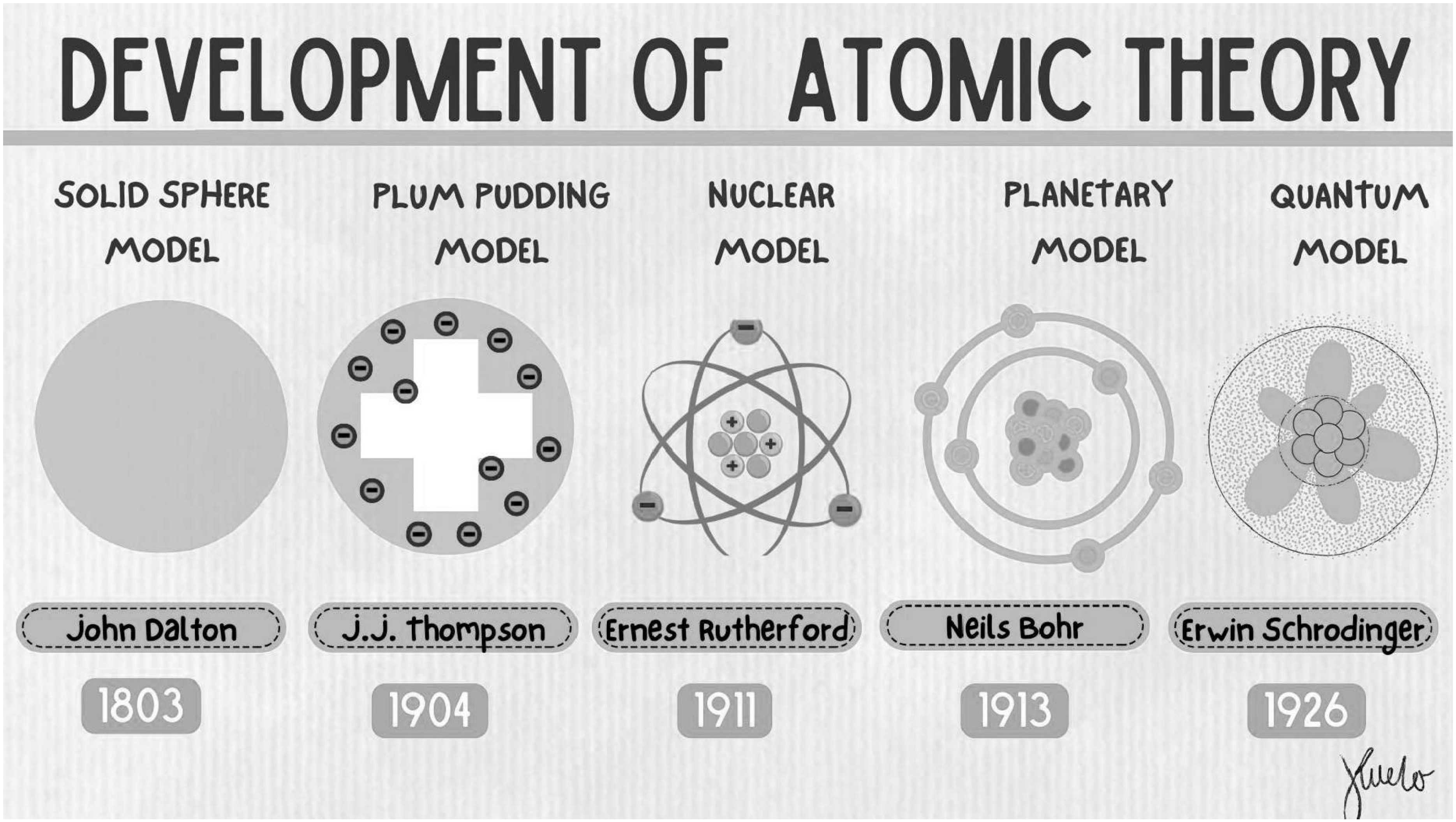
All metals are to the left and below the stairs, including the inner transitional metals

All nonmetals are to top right corner, to the right of the stairs.

Only hydrogen is “misplaced”, it is a nonmetal, but it is in group 1.

We’ll see why another day.

☺


DEVELOPMENT OF ATOMIC THEORY
SOLID SPHERE MODEL
PLUM PUDDING MODEL
NUCLEAR MODEL
PLANETARY MODEL
QUANTUM MODEL
John Dalton
J.J. Thompson
Ernest Rutherford
Neils Bohr
Erwin Schrodinger
1803
1904
1911
1913
1926