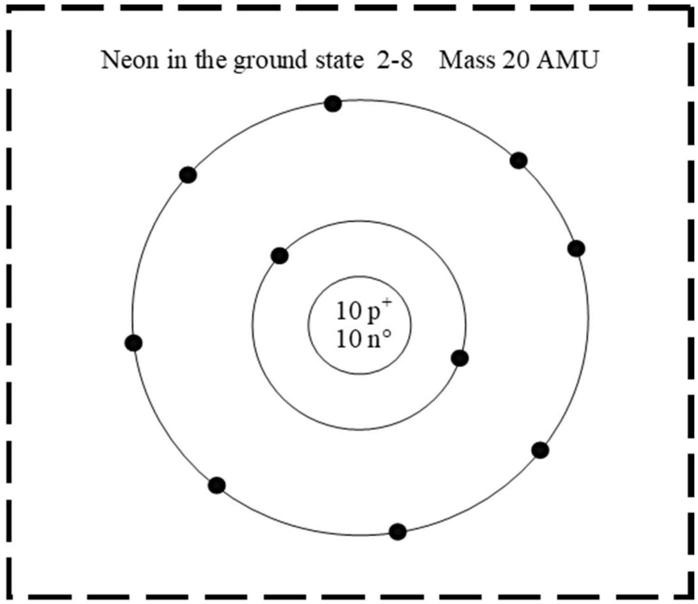
ELECTRONS LAB

80/1200 name: ______________________

Objective: To use flame tests + bright line spectra to identify elements and compounds.

As it turns out, Niels Bohr figured out a lot about electrons and the "orbits" that they exist in. We know now that the electrons live in shells.
These shells have sub-orbitals that we don't learn about in high school, but you will in college.



Bohr imagined the electrons moving in orbits, circling the nucleus, much like the planets that orbit the Sun. Science moved ahead, and although orbits are not correct, much of Bohr's work is still correct. His "orbits" were also energy levels, and electrons do exist in these energy levels, but now they are called shells.

In the first shell only 2 electrons can fit. That is the lowest energy level of all electrons. In the 2nd shell or orbital, up to 8 electrons can fit. This atom of neon shows this simplified 2-8 electron configuration.

College electron configuration would be $1s^2 2s^2 2p^6$ That shows 2 electrons in shell 1, and 2 + 6 electrons in shell 2.

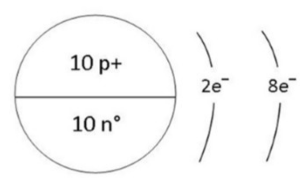
The 3rd electron shell is weird. It can be full with 8 electrons, or it can stretch, and hold up to 18 electrons. That's because of the hidden sub-orbitals that we do not need to worry about in high school.

Shells 3, 4, 5, 6 and 7 can all stretch by using their sub-orbitals, and that's cool.

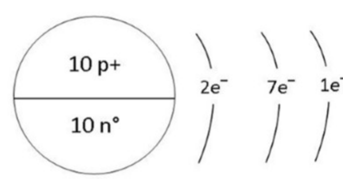
Bohr told us that electrons are normally found in the lowest energy levels possible, or the GROUND STATE. The electron configurations on the periodic table are all ground state configurations. In our class, when an electron gains energy from outside of itself (by heat or electricity or even radiation) this electron moves to a higher orbital than normal. We will be able to show only a *possible* excited state. We will not be able to know *exactly* what sub-orbitals the electrons are now in. For us it is more conceptual than detailed.

If we run energy into one type of atoms, like neon gas, or one type of compound, like CO_2 gas, the electrons will absorb only the specific amount of necessary energy to become EXCITED. This amount is unique for each substance because each atom and each compound has a unique number of protons and its own electron configuration. To push an electron to a higher than normal level requires a specific amount of energy.

We generalize that as a QUANTUM of energy. All electrons need their own "quantum of energy" to get elevated into their excited state. The electrons can absorb energy and if they hold this energy, they can stay in the higher energy excited state, in orbitals further from the nucleus.



These excited electrons HOLD this energy temporarily. This excited state is unstable. When these excited electrons return to the ground state, they EMIT that exact QUANTUM of energy it took to excite them in the first place. This released quantum of energy is emitted as visible colored light we see as one color, and we call it SPECTRA.



Both of these Bohr models of neon, the ground state (top) and in the excited state (below) have 10 electrons. The "top" ground state neon has the 2-8 normal configuration. If electrons were to be excited (say in a gas tube with electricity) the electrons would take a higher-than-normal position temporarily due to this absorbed quantum of energy. Neon changes from the ground state configuration of Ne 2-8 to the excited Ne 2-7-1 configuration.

In our class a different "excited state" of 1-8-1 is possible, so is 2-6-2. We don't know the exact excited state of any atom in high school, but we see that in an excited state that 1 or 2 electrons are at higher-than-normal orbitals than the configuration on the periodic tables.

The excited state is unstable and temporary. When the excited electrons emit this unique amount of energy that they gained, it gives off visible light called spectra. We can see it, a neon light emits a bright orange light that looks like every OPEN sign you have ever seen (spectra at work!).

Heat, electricity, or even radiation energy can be absorbed, but energy is emitted as visible light called spectra.

As it releases this energy as visible light, the neon electrons can return to the ground state again. This can happen many times per second, to millions of atoms in a tube, so our eyes see a constant flow of orange light.

Since a unique amount of energy is required to excite each kind of atom or substance, that same amount of energy is released as a unique spectrum we see with our eyes. That means each spectrum is unique. For neon, this visible light released is orange. Neon lights only emit an orange-colored light. If you see a "blue neon light", or a "white neon light", those lights DO NOT contain neon gas. Neon only emits an orange light when excited electrons return to the ground state. Other gases release other colors of light.

The orange color (spectrum) we see with our eyes is a mixture of colors that our eyes register as orange.

This VISIBLE COLORED LIGHT is called the SPECTRA. We see this energy as a ONE COLOR with our eyes. If we use the REFRACTIVE LENS GLASSES, we can break that mixture of light into the individual colors of light, at the specific wavelengths, and see the SPECTRA EMISSION LINES or SPECTROGRAPH that is truly unique to that element or compound. The refractive lenses allow us to see this easily.
The spectra-graph is like a fingerprint for each substance. It is a physical constant for that pure substance.

Spectra are measurable, and they are unique. Spectra can be used to help a scientist determine what an unknown substances might be. Scientists compare the spectra they can see to the spectrographs that they KNOW already and seek a match. They can look through a telescope at a distant planet or start and by <u>comparing</u> the spectrographs we know to the mix of spectra in the telescope, they can determine what substances are there without having be there. It is measurable even at a great distance.

If a scientist discovers a spectrum that is unknown, that scientist has discovered a new substance. Spectra for any substance is unique and the same everywhere in the Universe. Spectra are EMITTED, not absorbed.

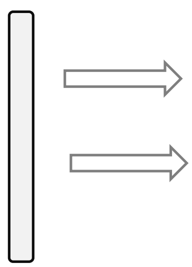
The most common mistake students make is this: Grasping exactly when is spectra produced.

Spectra IS NOT produced when electrons get excited by absorbing energy. The energy absorbed is used to move and keep electrons in higher energy levels and to hold them there. This is unstable; when electrons release that absorbed energy, and they can move back to the ground state, the released energy that IS THE VISIBLE SPECTRA.

Spectra can be seen with our eyes as colored lamp light, or as colored flames.

We can see the spectrographs or the spectra emission lines using the lamps, but not the flames. The color flames have spectrographs, but because the fire is literally jumping around, your eyes can't track the lines of the spectrograph with the refractive lenses. Lamp color and flame color are both spectra, but the lamps emit a steady light, where the fires are too wiggly to see the spectrographs.

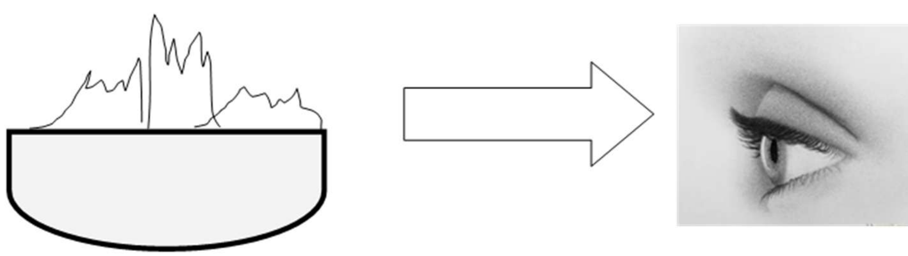
Neon filled lamp



Gas lamps emit light. Electricity (energy) is converted into visible light (spectra)

Our eyes see one color of spectra, the MIXTURE of colors that are emitted when the excited electrons return to the ground state electron configuration.

The refractive lenses break up the mixture of colors emitted into their specific colors at specific wave lengths, and we see the "spectrograph" or spectra emission lines, which are a digital fingerprint, and a unique physical property of elements and pure substances.



Evaporating dish with a "salt" inside, heated up with burning alcohol. Flames will be different colors. The flame is the spectra but we can't really use the refractive lenes to see the spectra emission lines because the fire is MOVING so much.

Our eyes see one color of spectra, one flame color which are the MIXTURE of colors that are emitted when the excited electrons return to the ground state electron configuration.

Each flame is a different color, but our eyes cannot always discern them. We can't use a refractive lens with the flames, the flames move too much, and so would the spectrographs they produce. Flame tests are not as accurate as measuring with a spectrograph, but they "work" the same way.

Flame Test Demonstration

You will see 6 evaporating dishes containing copper (II) chloride, potassium chloride, sodium chloride, strontium chloride, calcium chloride and lithium chloride. To each we will add some flammable methanol alcohol (poison) to use heat to excite some electrons. These excited electrons will return to the ground state and emit spectra, which we see as colored flames. LOOK and record some data. configurations. We will list the flame color names in this table. The color flame cannot be broken apart into a spectrograph, it is moving too much to see that way.

Chloride salts	Formulas	Flame color
Sodium chloride		
Potassium chloride		
Copper (II) chloride		
Calcium chloride		
Strontium chloride		
Lithium chloride		

Student FLAME TESTS

There are 3 aqueous salt solutions. Sample them one at a time with half a Q-Tip and see what color flame is emitted when you heat up this Q-Tip in the Bunsen burner flame. Attempt to match the flame's color to the colors recorded above. You should be able to determine which of the salts are in the solutions. Check your answers to the actual solution formulas.

The flame colors, and the lamps, both emit spectra. A different type of energy is put into the gases (electricity) and the salts (heat), but both release visible light as the spectra we see. The lamps are "steady" so it's easy to see the actual spectra emission lines. Flames are too bouncy - if we were to look at the flames with our refractive lenses, we'd get dizzy because the flame moves around so much. The spectra is there, we just can't see the spectrograph clearly. We only see the spectra as one color of flame.

Unknown Solution	Flame color	Likely salt solution
A		
B		
C		

Almost all spectra is known and easily measurable, even by you today.

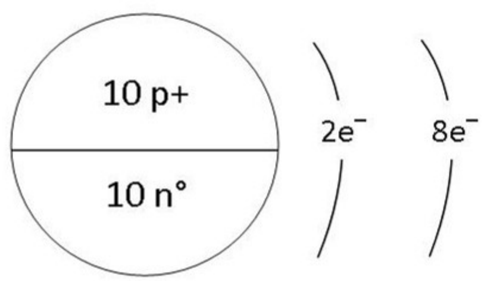
We will see several FLAME SPECTRAS. We will burn some methanol (a kind of alcohol)
on various salts, each will emit a colored flame. The flame color is the spectra color.

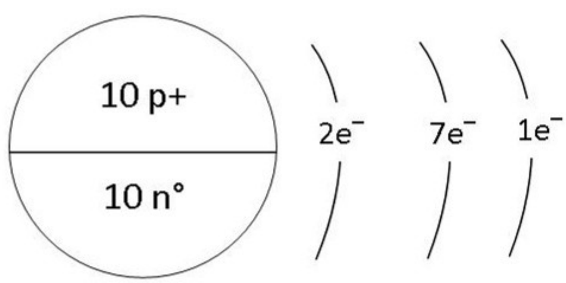
We won't be able to see the spectrographs because the flames are too bouncy to follow, but they do in fact emit unique spectrographs, but we can eyeball measure each of the different colors of spectra.

You will observe several lamps of gases, electrified while being held steady. The lamps emit different color spectra, but with the lamps you will draw the unique spectrographs (best you can).

Commercially, spectra can be used to make different color sparklers, fireworks, or flares, glo-sticks, and of course, all different color signs. Gases can be mixed as well, so they could give off mixtures of spectra which can provide many different colors of light.

This is NEON in the ground state with
"normal" electron configuration of 2-8





This is NEON in the excited state with electrons in a
"higher than normal" configuration of 2-7-1

Lamps Procedure The vertical line under the word “emission” is the lamp itself.

When viewing the lamps straight on, you will see, to each side, in mirror image, several lines, of various colors, that are the actual SPECTRA LINES which are the light that makes up the “mixture” of light you see without the lenses. Your job is to draw these SPECTRA LINES that you will see while wearing the refractive lenses on both sides, at approximately the same distance from the lamp. Only put in 4-6 matching lines on each side of the lamp for each. Use colored pencils. You will not be graded on your artwork.

Names & symbols		Spectra emission lines	
1			
2			
3			
4			
5			
6			

Unknowns		Spectra emission lines	
A			
B			
C			

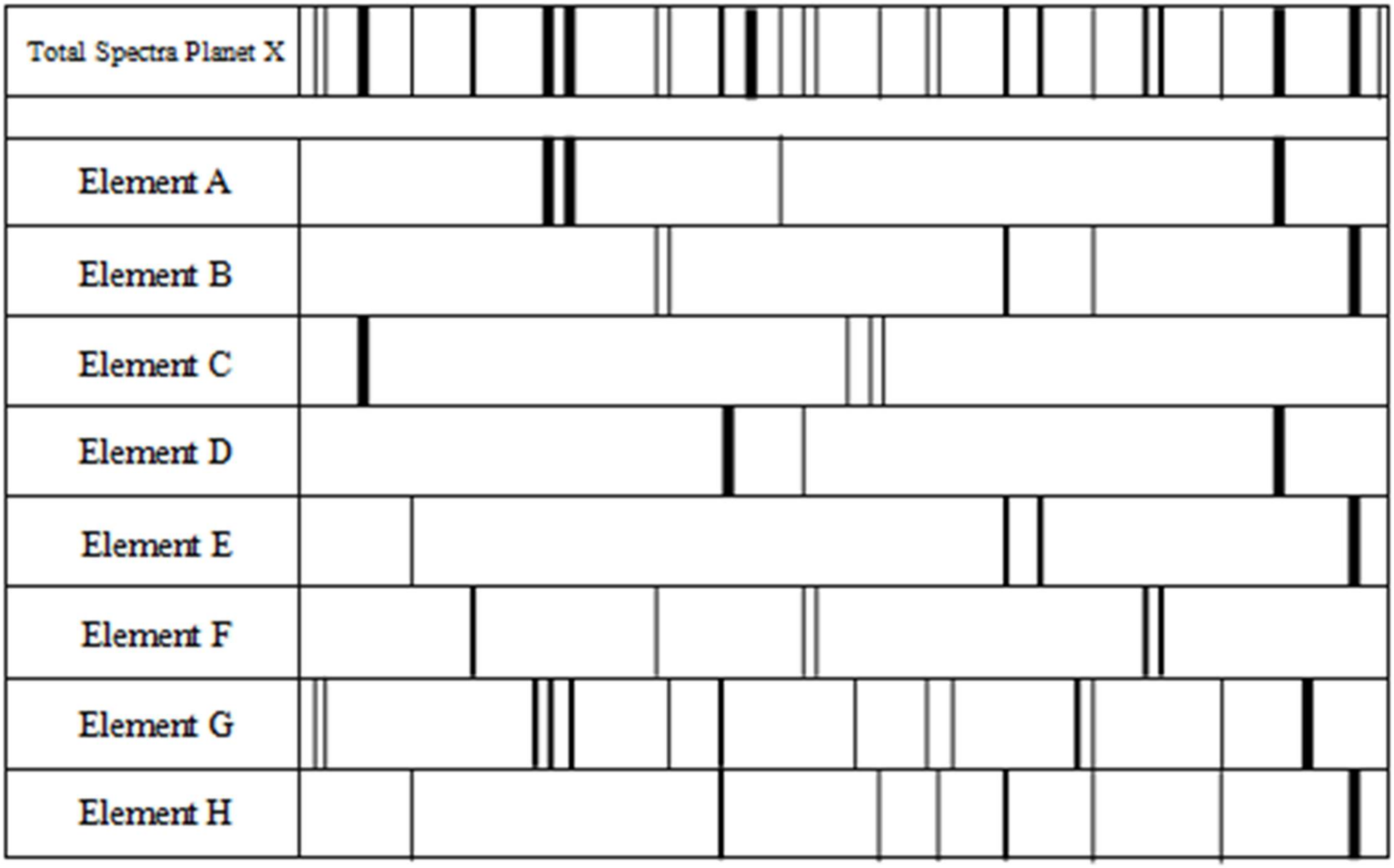
Lab Questions: Number 1 is worth 5 points, it's the MOST IMPORTANT question of all	
1	Explain why the neon and the helium lamps give off different color light. Be sure to use these words: electrons, ground state electron configuration, excited state electron configuration, mixture of color, refractive lenses, and spectra lines in your answer.
2	Draw two Bohr, or planetary orbit models (like the diagrams on the bottom of page 4 of the lab handout) of two magnesium atoms, one in the ground state, and one in the excited state.
3	Draw 2 more Bohr models of two phosphorous atoms, one in the ground state, and one in the excited state.
4	Explain how spectra is produced and EXACTLY when spectra gets produced.
5	How many protons are neutrons & electrons are in each of these isotopes of iron? Copy this chart (bigger) into your work.

	Fe—54	Fe—56	Fe—59
# protons			
# electrons			
# neutrons			

6	How many protons, neutrons and electrons are in each of these isotopes? Copy this chart (bigger) into your work.

	Au—198	Sc—44	Cu-65
# protons			
# electrons			
# neutrons			

7	Write the names and symbols of the six noble gases. What is special about their electron configurations as compared to all other atoms?
8	If an astronomer focuses her telescope on the distant Planet X, she could photograph all the spectra she sees through her refractive lens. Her photograph would contain many spectra at once, and all mixed together. To figure out what substances were on that planet, she would have to compare the spectra that she knows, to the spectra she sees in the mix. She could determine exactly what substances were on that planet or star without having to go there. ALL the spectra lines for a substance must match up with similar lines in the same place for her to know that element to be present on the distant planet. A substance is either ALL IN or not in at all. Planet X's total spectra are on the top line, and several known spectra are below. Which elements (A to H) are found on Planet X. (Match the elements with the Planet X total spectra on the next page.



Lab Report Rubric		
Cover page	Title, optional funny sub-title, a 2-3 sentence introduction as to why are we doing this lab?	2 points
Handout	The lab handout and the spectra drawings	5 points
Questions	Lab questions and charts.	5 + 8 points
Conclusion	SMALL conclusion: What you did in lab, then... clearly tell how and when spectra is produced and why each element and each substance has unique spectra.	5 points
Lab is due		25 points