Electrons

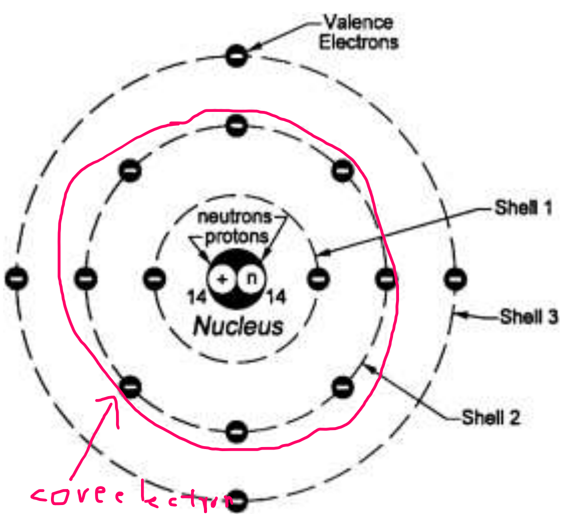
A negatively charged subatomic particle, they exist in spherical shells

Those shells represent energy level, the larger the shell, the higher the energy contained in the atom

The charge of an atom is **equal** but **opposite** to the charge of a proton

We symbolize the electron charge with **e** or 1.60 x 10^{-19} C

We symbolize the electron mass with **me** or 9.11 x 10^{-30} Kg



Valence electrons are electrons on the outermost energy level, they determine the valence of the element, and they are the electrons involved in chemical reactions

Commented [SD1]: تكافؤ

Core electrons are electrons that are in the inner energy levels

before the outermost energy level in the atom.

Nucleus

It’s the positively charged center of an atom containing protons and neutrons

Proton: A proton is a positively charged subatomic particle

charge = +1.

Neutron: The neutron is the particle in the atomic nucleus with

a **mass = 1 and charge = 0.**

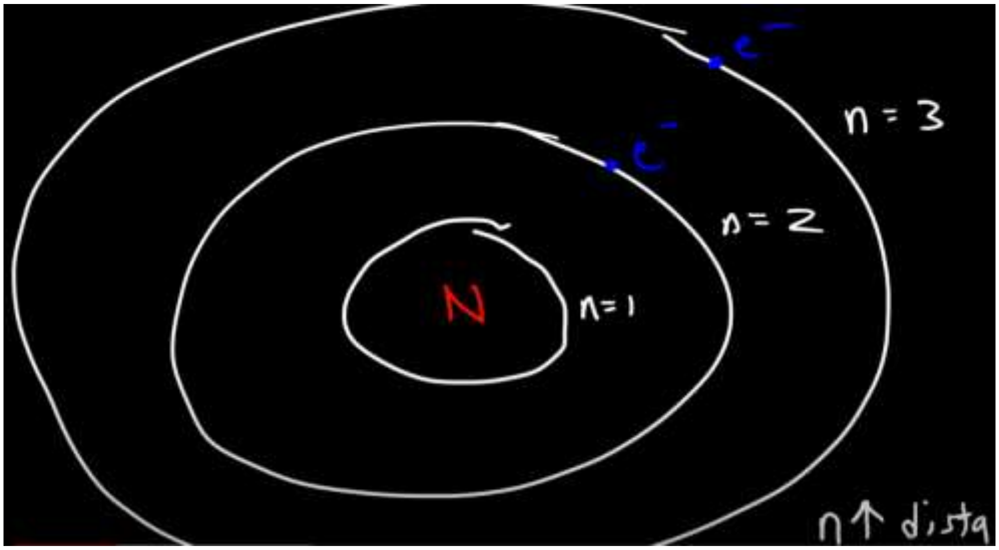
Quantum numbers

They tell you the address of an electron inside an atom, each electron has a unique set of 4 quantum numbers

N (principal quantum numbers) (energy level definer)

It is describes the energy level of an electron inside an atom, it fundimantly describes the size and energy of an atom

The principal quantum number can take on any positive integer value, starting from 1. The higher the value of **n**, the larger and higher-energy the orbital.



Principle energy levels are the main 7 energy levels

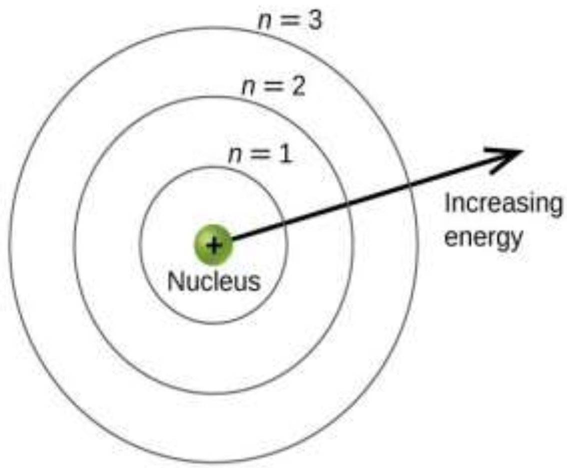
- **K -> (1)** it contains 1 sub-level
- **L -> (2)** it contains 2 sub-level
- **M -> (3)** it contains 3 sub-level
- **N -> (4)** it contains 4 sub-level
- **O -> (5)** it contains 4 sub-level
- **P -> (6)** it contains 4 sub-level
- **Q -> (7)** it contains 4 sub-level

They were discovered by Arnold Sommerfeld in 1916. Sommerfeld extended the Bohr model of the atom by introducing the concept of sublevels and orbital angular momentum. He realized that the electrons in the same energy level could have different amounts of angular momentum, and that this was responsible for the splitting of the energy levels into sublevels.

Sommerfeld also proposed that the seven main energy levels could be labeled with the letters K, L, M, N, O, P, and Q. This labeling system is still used today, and it is a convenient way to refer to the different energy levels of atoms.

The reason there are seven main energy levels is because the electrons in an atom can only have certain discrete values of energy. These energy levels are determined by the Schrödinger equation, which is a mathematical equation that describes the behavior of electrons in atoms.

The Schrödinger equation shows that the energy levels of an atom are quantized, meaning that they can only take on certain discrete values. The lowest energy level is the K shell, followed by the L shell, the M shell, and so on.



Here are some additional facts about the main energy levels KLMNOPQ:

- The K shell can hold up to 2 electrons.
- The L shell can hold up to 8 electrons.
- The M shell can hold up to 18 electrons.
- The N shell can hold up to 32 electrons.

- The O shell can hold up to 50 electrons.
- The P shell can hold up to 72 electrons.
- The Q shell can hold up to 98 electrons.

L (angular momentum quantum numbers) (the shape definer)

It determines the shape of the sub-level (sub-shell) within an energy level (energy shell)

Relative energies are **s < p < d < f**

Angular Momentum Quantum Number, l	Name of Subshell	Shape	
0	s	Sphere	
1	p	Dumbbell	
2	d	Complex/double dumbbell	
3	f	More complex/ multiple lobes	

as you can see, the angular quantum number becomes larger with the subshells

The sub energy levels s, p, d, and f were discovered by Walter Grotrian in 1925. Grotrian was studying the atomic spectra of different elements, and he noticed that the spectral lines could be grouped into four series, which he labeled s, p, d, and f.

Grotrian realized that these four series corresponded to four different types of electron orbitals. The s orbitals are the simplest type of orbital, and they are spherical in shape. The p orbitals are more complex, and they are dumbbell-shaped. The d orbitals are even more complex, and they have five different shapes. The f orbitals are the most complex type of orbital, and they have seven different shapes.

The reason there are four sub energy levels is because of the fourth quantum number, which is called the orbital angular momentum quantum number, l. The orbital angular momentum quantum number can take on four different values: 0, 1, 2, and 3.

the relationship between N and L

max L <= n – 1

This means

If n = 1, then L can be only 0 **S**

If n = 2, then L can be 0 **S**, or 1 **P**

If n = 3, then L can be 0 **S**, 1 **P**, 2 **D**

If n = 4, then L can be 0 **S**, 1 **P**, 2 **D**, 3 **F**

NOW NOTICE

There is no 1p where 1 is the energy level **(N)**

There is no 2D

There can be 3D

There is no 3F, but there is 4F

EXERCISE

1- Let's say we have a 3D electron

The N value = 3

And the L value = 2

2- Let's say we have a 4F electron

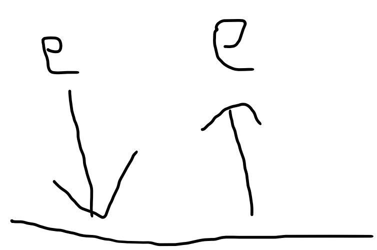
The N value = 4

And the L value = 3

What is an orbit?

It's a region in space where the probability of finding an electron is very high "**it is an area that likely has an electron**"

In an orbital, an electron can have an up spin or a down spin, that's why an orbital can only carry 2 electrons



M_L (magnetic quantum numbers) (orbit definer)

It describes a particular orbit inside the sub level, its value is 1 and -1 including 0, and it makes zero as it's median

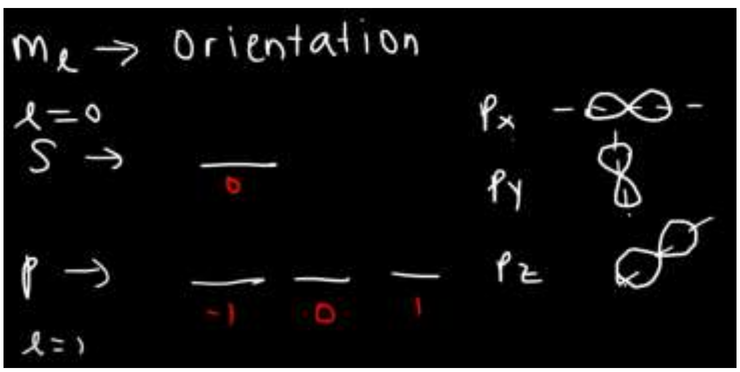
It describes the orientation

So let's say S has 1 orbital, we would indicate that orbital with **(0)**

P has 3 orbitals, then it is **(-1, 0, 1)**

D has 5 orbitals, then it is **(-2, -1, 0, 1, 2)**

F has 7 orbitals, then it is **(-3, -2, -1, 0, 1, 2, 3)**



The relation between L and M_L

L is the angular momentum quantum number

ML is the magnetic quantum number

When we have L as 0 or S sub-level, then ML must be 0

When we have L as 1 or P sub-level, then ML must be (-1, 0, 1)

-L <= ML <= L

MS (spin quantum numbers) (spin direction definer)

It defines the spin of the electron inside 1 orbital, it may be positive or negative **($+\frac{1}{2}$, $-\frac{1}{2}$)**

\+ —

As we said, in an orbital, an electron can be going up or down

Note: K (1) have the s orbital only, L (2) have the s and p orbitals only, M (3) have the s, p and d orbitals only. N, O, P and Q have all the 4 orbitals (s, p, d and f).

EXERCISE

Let's say you have a $3D^8$ value or 8 electrons in 3D

The N (energy level) = 3 or M

The L (sub-level count) = 2 because D = 2

And because D has 5 orbitals

Then ML of the 8 electrons can be in any item of this list [-2, -1, 0, 1, 2]

The location will tell us the ML and the MS

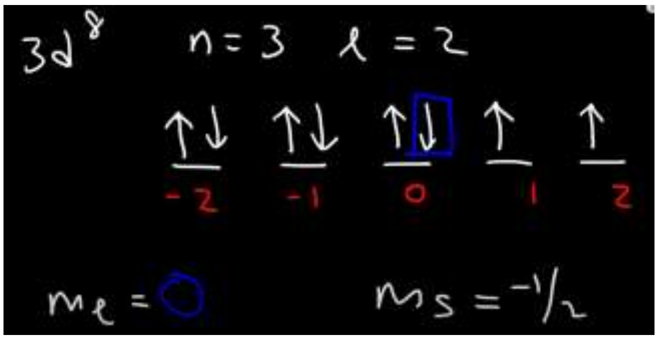
(a) Start with up arrow

For the [-2, 2] list, you begin adding an up arrow for each, you have added 5 up/positive spin electrons, you have 3 left

Now you add the other 3 down/negative spin electrons and you end at 0

So ML = 0

And MS = -1/2 because you ended on a down arrow



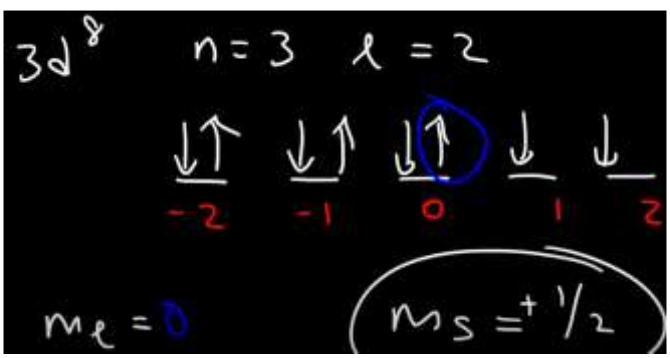
(a)Start with down arrow

For the [-2, 2] list, you begin adding an down arrow for each, you have added 5 down/negative spin electrons, you have 3 left

Now you add the other 3 up / positive spin electrons and you end at 0

So ML = 0

And MS = +1/2 because you ended on a up arrow



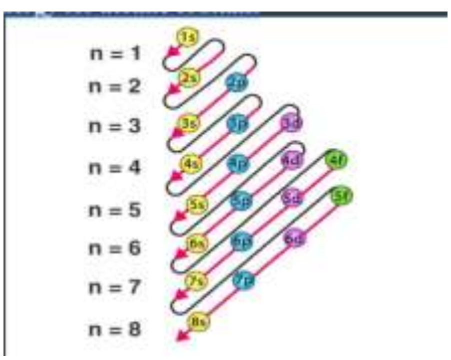
Bohr suggested the revolutionary idea that electrons “jump” between energy levels (orbits) in a quantum fashion. This means that they can never exist in an in-between level.

Thus, when an atom absorbs or gives off (emit) energy (as in light or heat), the electron jumps to higher or lower orbits. Electrons are the most stable when they are at lower energy levels closer to the nucleus.

Electronic Configuration

Any electron configuration of an atom describes the orbitals by electrons in the atom

Or it’s the order of increasing energy of the orbitals is shown by the order of these sublevels. This diagram predicts the following order of increasing energy for atomic orbitals.



Let’s say we have the element Nitrogen **N^{7}_{14}**

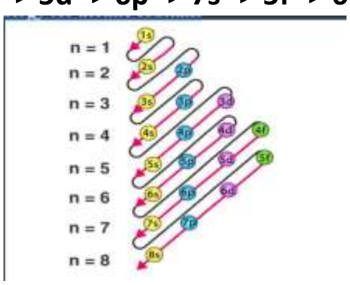
Atomic number = 7

Exercise -> get me the electronic configuration of nitrogen

(1) We need to know that
in the 1st level (**K**), you have only 1 sublevel (1s)
in the 2nd level (**L**), you have 2 sublevels (2s, 2p)
in the 3rd level (**M**), you have 3 sublevels (3s, 3p, 3d)
in the 4th level (**N**), you have 3 sublevels (4s, 4p, 4d, 4f)
in the 5th level (**O**), you have 3 sublevels (5s, 5p, 5d, 5f)
in the 6th level (**P**), you have 3 sublevels (6s, 6p, 6d, 6f)
in the 7th level (**Q**), you have 3 sublevels (7s, 7p, 7d, 7f)

(2) We need to know that
the s sub-level can hold 2 electrons because it has 1 orbital
the p sub-level can hold 6 electrons because it has 3 orbitals
the d sub-level can hold 10 electrons because it has 5 orbitals
the f sub-level can hold 14 electrons because it has 7 orbitals

(3) The order you choose sub levels would be
1s -> 2s -> 2p -> 3s -> 3p -> 4s -> 3d -> 4p -> 5s -> 4d -> 5p -> 6s -> 4f -> 5d -> 6p -> 7s -> 5f -> 6d -> 7p -> 8s, or you can use this thing

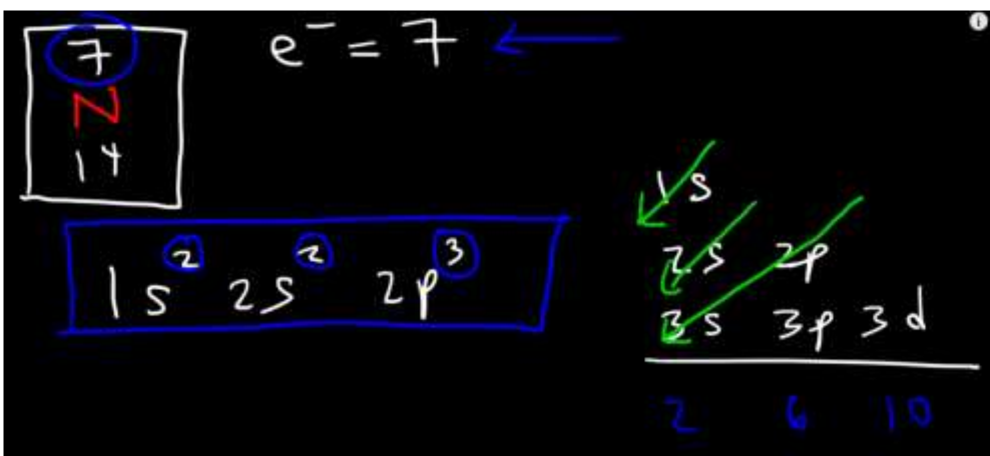


(4) Now we need to write the electron config, until you get a total of 7, why?

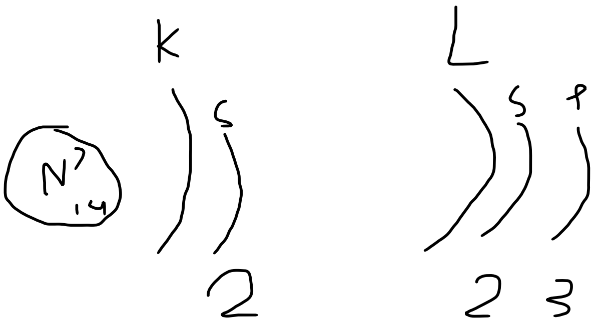
well because our nitrogen's atomic number is 7, it normally has 7 protons and 7 electrons, so we need to have an electron number of 7, it might change with ions, but currently we are working with stable elements

(5) Now you begin filling your electron count using the sub-levels

a. Firstly you do 1s2 where 1 is the level number, s is the sub-level, and 2 is the number of electrons in the sub level, which is the max count for s, now you have 5 electrons left
b. Then you add 2s2, now you have 3 electrons left
c. Then you add 2p3, now you have 3 electrons left
d. So the electron configuration is now 1s2 2s2 2p3



Or in the traditional way



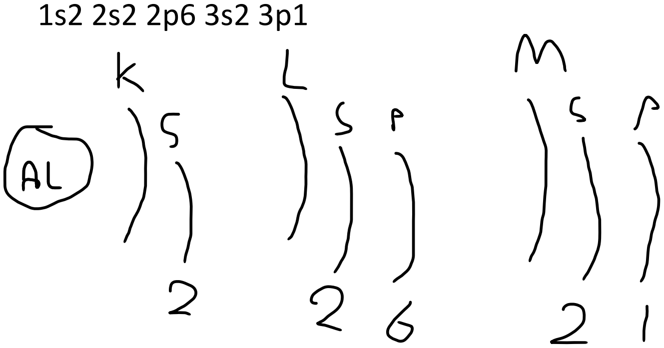
Let’s say we have the element Aluminum **Al^{13}_{27}**

Electron number = 13

So using our knowledge of levels and sub levels

The electronic config would be

1s2 2s2 2p6 3s2 3p1



This is the **ground-state** configuration of an aluminum atom

Exercise -> getting the electron configuration of an Ion

Let’s say we have the Ion **Fe^{+2}**

We know that Fe has an **atomic number** of **26** and **average atomic mass** of **55.85**

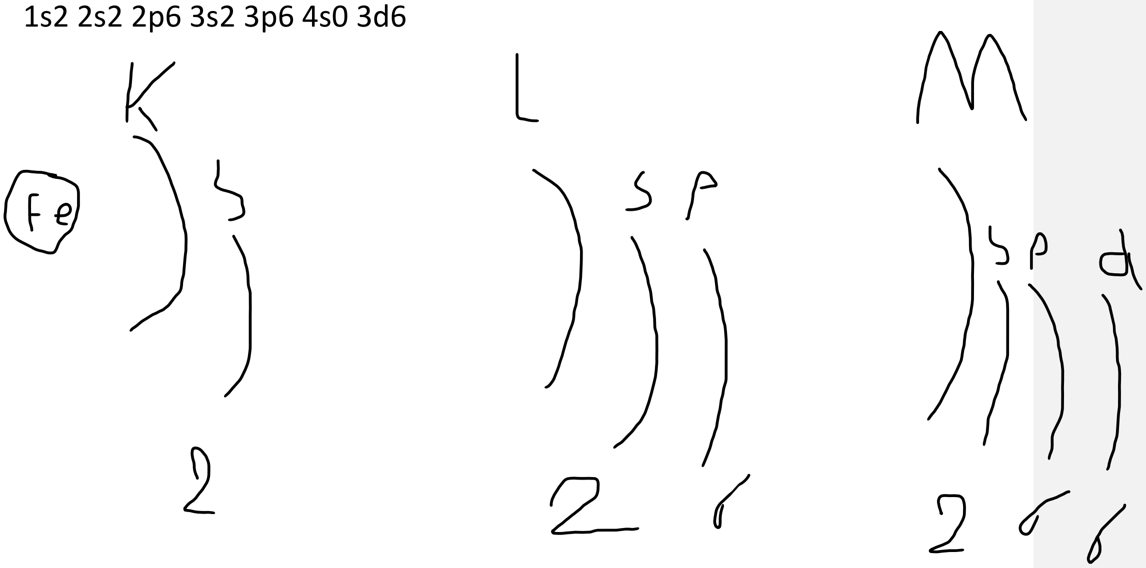
In Ions

- **+** equals that we need to subtract from the proton count to get the electron count, so Fe^{+2} would mean that we need to subtract 2 from the atomic number to get the electron count
- **-** equals that we need to add to the proton count to get the electron count, so Fe^{-2} would mean that we need to add 2 from the atomic number to get the electron count

Electron number = 26 – 2 = 24

Now we do the electron config normally

1s2 2s2 2p6 3s2 3p6 4s0 3d6



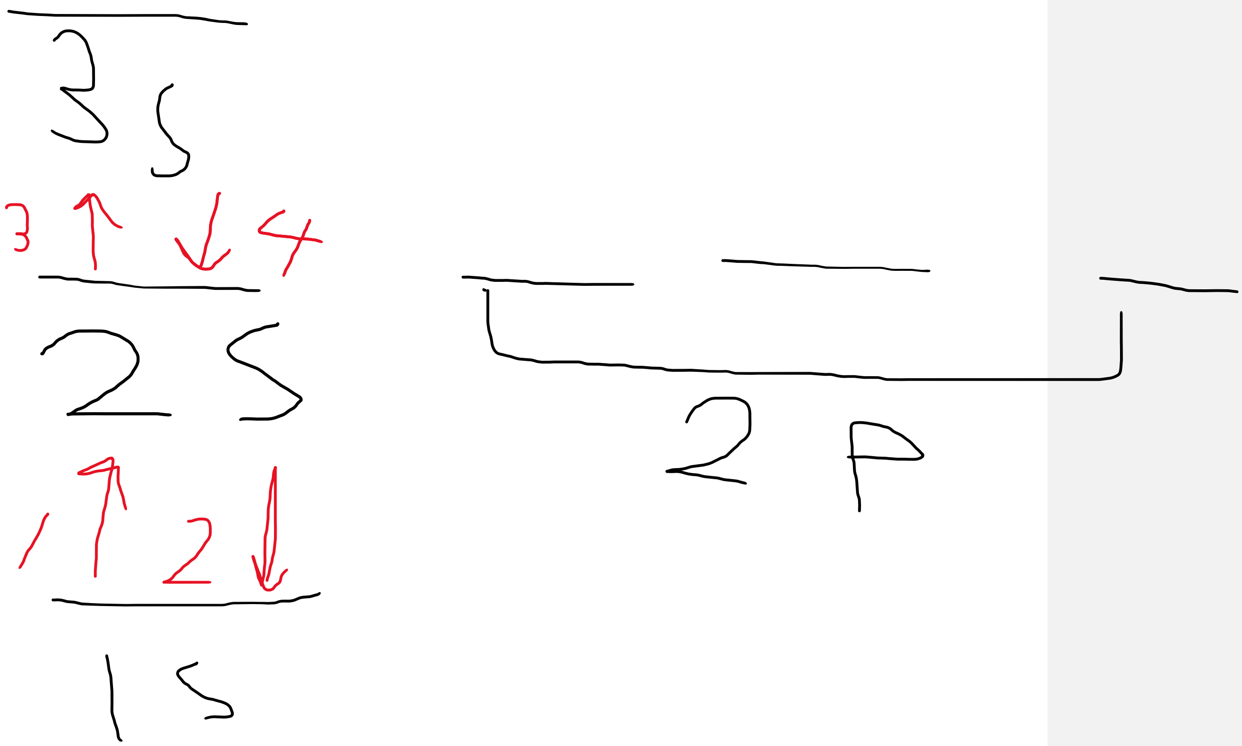
Observation : why did we do it 4s0 3d6 instead of 4s2 3d4

Well, because atoms get lost from the highest energy level first, which in our case, is 4

There are some principles we have to follow

Aufbau's Principle

Consider the orbital diagram we have



Aufbau says, when electrons are added into an atom, they go to the lowest energy level, then the higher ones

So you add on 1S, then 2S, then 2P, then 3S, etc.

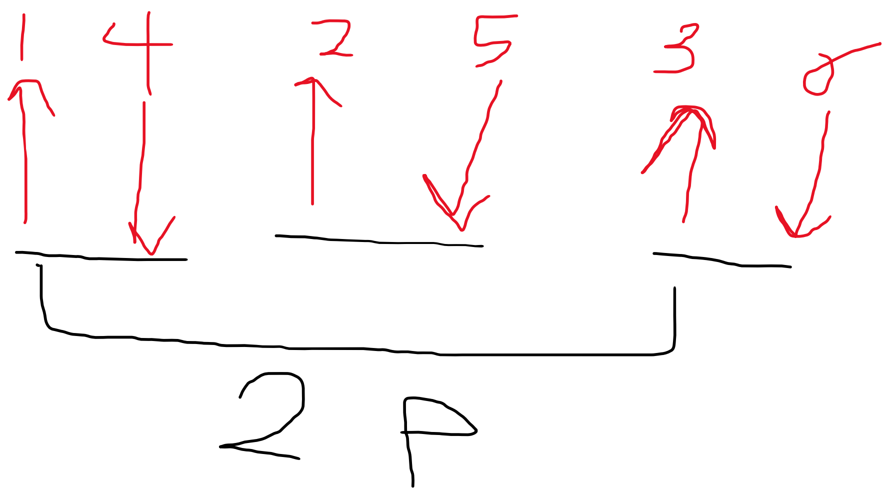
But, what happens when multiple orbitals are on the same sub-level?

Well, Hund's rule says

Whenever you have degenerate orbitals, you want to add the electrons one at a time with parallel spins

Commented [H2]: Orbitals in the same sub level

So you add up spins first until you fill all orbitals, if you still have electrons, then add them to the down spin



Pauli's Exclusion principle

No 2 electrons can have the same 4 sets of quantum numbers **N, L, ML, MS**

In our previous 2P set
the electron 1 has a quantum number set of (2 , 1 , -1, +1/2)

What we are saying is that there are no other electrons that are in level 2 with sub-level p that are on orbital -1 and have an up spin

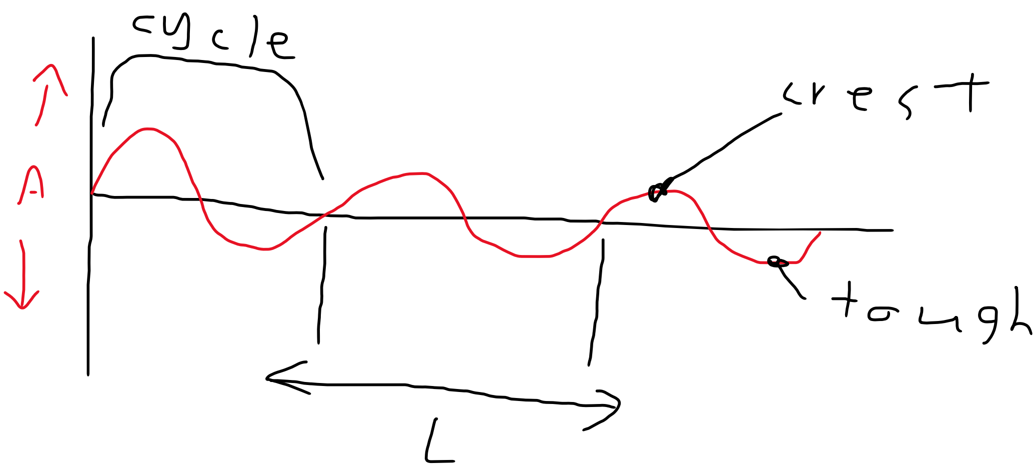
2 ADDITIONAL RULES

1. There is nothing called d4 and d9 in the real life, if it is the turn for them we take an electron from the s, as following: Cu which have an atomic number of 29, its electronic configuration will not be like this: 1s2 2s2 2p6 3s2 3p6 4s2 3d9. But like this, 1s2 2s2 2p6 3s2 3p6 4s1 3d10. Why is it like that? Because the atom always need to be stable and it achieve special stability by doing so, aka, you cant fill the higher level before filling the lower level
2. when we make the electronic configuration of a cation (positive ion) we take the electron it lost from the outermost energy subshell. Because this is what happen in nature, any electron an atom loses is always taken from its outermost.

THE ELECTRO MAGENTIC SPECTRUM

Firstly, let's talk about **electromagnetic waves**

They are **waves**, but what are **waves**?
a wave is a disturbance that can carry energy from one place to another



They have an **amplitude** **(A)**, a length **(λ)**, and a **frequency** **(F)**

Electromagnetic waves when in a vacuum move at a **speed of light ©**

This speed is equal to the **wave length * frequency**

C = LF

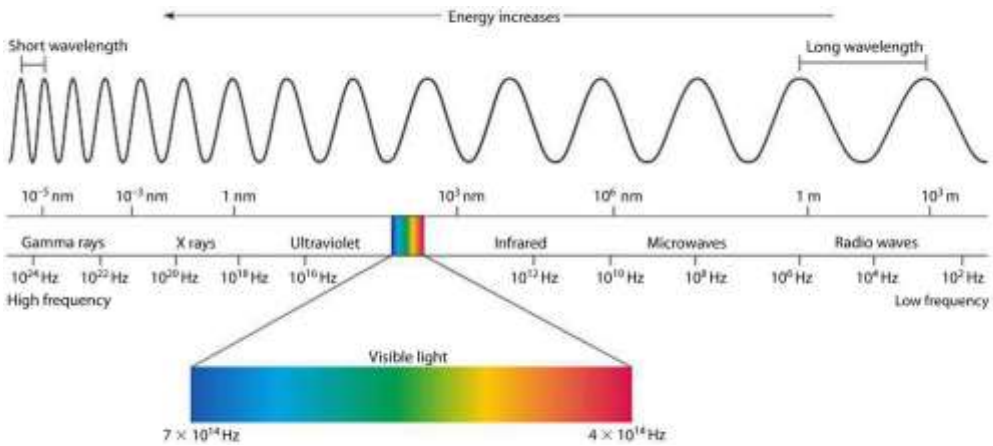
Because **C** is constant, L, and F always have to get the same result, meaning that if one **decreases**, another one **increases** to get the constant **C**

Commented [H3]: Distance between crest and tough, the unit of it is Hertz (Hz) and the period is in seconds

Commented [H4]: Distance between crest and crest, or tough and tough

Commented [H5]: The number of cycles per second

Commented [H6]: The distances that light traverses in a second when in a vacuum, which is 3 x 10^8 meters/second



Radio Waves (RW)

have the lowest energy, but longest wave length

Micro Waves (MW)
Inferred Waves (IR)

Visible light [ROYGBV]

Ultraviolet Waves (UV)

X-rays

Gamma-rays

Cosmic radiation

we are going to go in order

As you go to the left, the wave length gets smaller, the frequency gets higher, and the energy gets higher

Opposite with the right

If you want energy then high frequency / low wave length

If you do not mind then low frequency / high wave length

ENERGY HAS A POSITVE CORRELATION WITH FREQUENCY

BUT HERE IS THE THING

We know that light can fracture, that is because the **Velocity (not speed)** of light changes with the medium it's traveling through this equation

$v = \frac{c}{n}$

Where **V** is the velocity of light inside a material

C is constant

N is the material index

Water has an index of 1.33

Diamond has an index of 2.4

The frequency is negatively related to the period of a wave (T)

$$\boldsymbol{F = \frac{1}{T}}$$

To get the energy of a wave / travelling photon

You would use this formula

E = hf

Where

- **E** is the energy
- H is the planck constant, it equals $6.626 \times 10^{-34}\, J.s$
- **F** is the frequency

EXERCISE

Let's say you have a wave with the length of 700 nm, calculate the frequency

Solution

- C = LF
- Firstly, you change the unit from nanometers to meters
  U can use this formula $\frac{value \times current\ multiplier}{target\ multiplier}$
- **L(m) =** $\mathbf{\frac{700 \times 10^{-9}}{1}}$ **= 7 x $\mathbf{10^{-7}}$**
- $3\text{x}10^{8}$ = **7 x $\mathbf{10^{-7}}$** * F
- F = 4.286 x 10^{14} Hz

Using this frequency, calculate the energy of the photon

Solution

- E = hF
- E = 6.626 x 10^{-34} * 4.286 x 10^{14} = 2.84 x 10^{-19} joules

That is cool and all but we want it in electron volts

To convert from joules to electron volts

The factor is 1.602 x 10^{-19} joules = 1 ev

So from joule to ev you divide by 1.602 x 10^{-19}

And from ev to joule you multiply by 1/1.602 x 10^{-19}

So E(ev) = $2.84 \times 10^{-19} \times 1.602 \times 10^{-19} = 1.773$ ev

So let's say you have a blue photon (480nm), how to get the photon energy directly

Let's combine both equations

F = C/L

E = hF

So E = $\frac{hC}{L}$ or energy = planck's constant x speed of light / wavelength

So E = $6.626 \times 10^{-34} \times 3.00 \times 10^{8} / (480 \times 10^{-9}) = 4.141 \times 10^{-19}$ joules

E (ev) = $4.141 \times 10^{-19} \times 1.602 \times 10^{-19} = 2.58$ ev

EXERCISE

E(J) = $7 \times 1.602 \times 10^{-19} = 1.1214 \times 10^{18}$ joules

E = hF

So $1.1214 \times 10^{-18} = 6.626 \times 10^{-34} \times F$

F = 1.692×10^{15} Hz

$1.692 \times 10^{15} = 3 \times 10^{8} / L$

L(m) = 1.773×10^{-7} m

L(nm) = $1.773 \times 10^{-7} \times 10^{9} = 177.3$ nm

There are two other equations which are

Rydberg equation

$1/L = rz^{2}(1/n^{2}final-1/n^{2}initial)$

But this equation based only on atoms which contain only 1 electron

Where:

R = Rydberg constant = $1.097*10^{7}$

Z=atomic no.

Bragle equation:

L = h/p

Where:

H is plank constant= $6.626*10^{-34}$

P is the momentum= mv

M is the mass of the object

V is the velocity

Photon: is the smallest piece of light a fixed packet of electromagnetic radiation that has a given amount of energy.

Max Planck, found that light comes in fixed packets called photons.

The energy of a photon could be calculated by this equation E (energy of the photon) = h (Planck's constant) x f (frequency)

Planck's constant (h) is 6.63×10^{-34} J.s (constant)

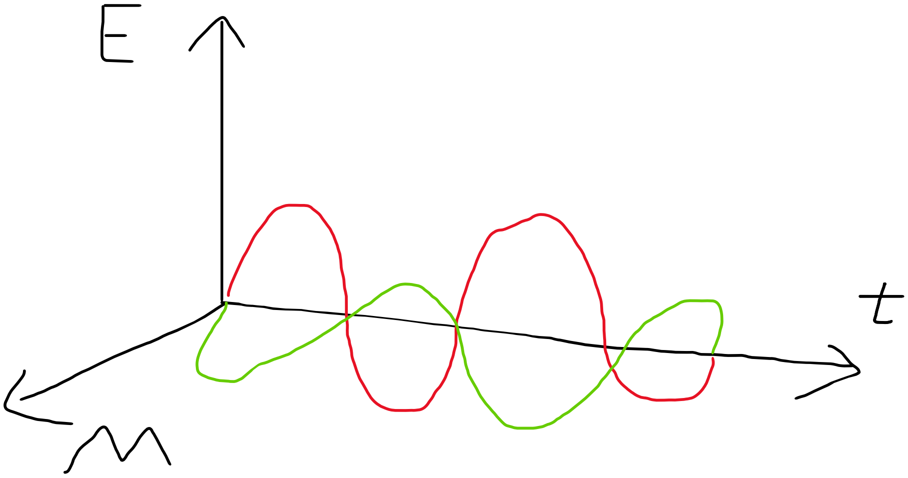
E (energy of the photon) in joule (j).

Property	Electromagnetic Waves	Mechanical Waves
Medium	Do not require a medium	Require a medium to travel
Examples	Light, radio waves, X-rays, microwaves	Sound waves, water waves, seismic waves
Speed	Travel at the speed of light (300,000 km/s) in a vacuum	Travel at a speed that depends on the medium
Transverse or longitudinal	Can be transverse or longitudinal	Can be transverse or longitudinal
Polarization	Can be polarized	Cannot be polarized
Energy transfer	Transfer energy through the electric and magnetic fields	Transfer energy through the vibration of particles in the medium

Additional notes:

- Electromagnetic waves are created by the acceleration of charged particles, such as electrons.
- Mechanical waves are created by the vibration of matter.
- Electromagnetic waves can travel through a vacuum, but mechanical waves cannot.
- Electromagnetic waves can be polarized, but mechanical waves cannot.
- Electromagnetic waves transfer energy through the electric and magnetic fields, while mechanical waves transfer energy through the vibration of particles in the medium.

Let's draw an electromagnetic (EM) wave in 3D



E is the electric field

M is the magnetic field

T is the time

When the electric field is changing, it will create a magnetic field, and they both will affect each other

E = CM

Where E is the electric field, and C is the speed of light, and M is the magnetic field

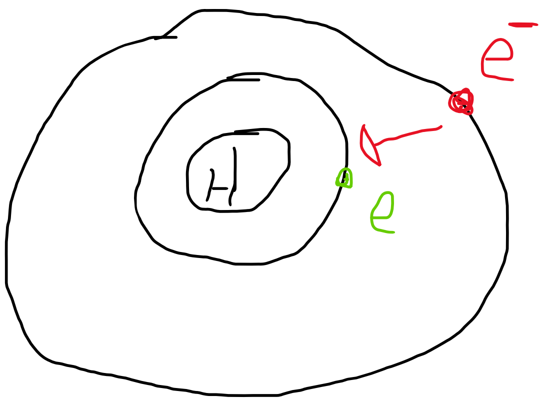
Electromagnetic waves can be created by any type of charged particles

Charged particle has an electric field

A moving charged particle can have a magnetic field

An accelerating charged particle can create an electromagnetic wave

Let's say we have a hydrogen atom



When an excited electron moves from a high energy level to a lower energy level, it can generate an electromagnetic wave, sometimes it can even emit a **photon** of light

You can get the energy of a photon using this

$$E = -2 \cdot 18 \times 10^{-18} J \left(\frac{1}{(n_f)^2} - \frac{1}{(n_I)^2} \right)$$

E is the energy of a photon

$-2.18x10^{-18}$J is a constant

N_f is the final energy level of an electron

N_I is the initial energy level of an electron

When an electron absorbs a photon, it can jump to a higher energy level, but when when it drops, it release a photon

Real world Example

When you heat up a metal, it will eventually go red hot and starts to glow, that means that the electrons are now releasing inferred radiation and red light as well, and the more you heat it up, the more color will change to yellow, then green, then blue
basically what im trying to teach you is, red is weaker, blue is stronger

Uses:

Radio waves: are used for sending TV and radio signals both short and long

distances really short wavelengths are used for very short distances and the

longer wavelength for longer distances as they can reflect off a layer of

charged particles in the atmosphere called ionosphere.

Microwaves: However, radio waves can't pass through the ionosphere so if we

want to communicate with satellites, we must use microwaves as they will easily pass through the ionosphere microwaves are also used in mobile phones

and certain wavelengths are absorbed strongly by water molecules and so

used to cook food. these are not the wavelengths however that are used in

mobile phones.

Infrared rays: infrared as we know carries heat and can be used in thermal

imaging and for grills for cooking and it is also used in communications as is

visible light both being sent down optical fibers so all these for lower energy

electromagnetic waves are used in communication.

But is there any danger in using them?

Well at the moment there is no scientific evidence that any of these parts of

the EM spectrum pose any danger whatsoever apart from maybe getting

burnt by infrared.

Ultraviolet rays: ultraviolet is used in sunbeds to help

you get a suntan and it's also used in special security inks because they

absorb ultraviolet and emit visible light.

X – rays: X-rays obviously are used to look for broken bones in hospitals.

Gamma rays: gamma rays are used to kill bacteria in food to keep it fresh

longer to sterilize surgical equipment and also to kill cancer cells in

radiotherapy.

Harms:

this is the high energy part of the spectrum so there are dangers with using

these as you know too much exposure to ultraviolet can cause skin cancer now

x-rays and gamma rays are even more dangerous as they have enough energy

to remove an electron from an atom creating an ion, we call this ionization

and this can really damage cells I can actually kill them or cause mutations in

them leading to cancer so exposure to high doses of

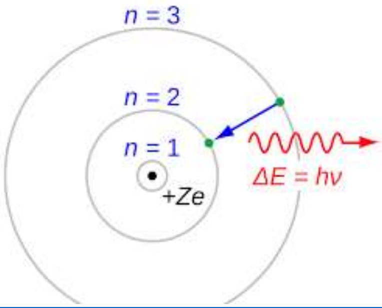
x rays and gamma rays really need to be minimized it's okay when you're just

going for one or two x-rays at the hospital but it's why the people working in

the hospitals need to take extra precautions to minimize their dose.

Bohr's experiments on the hydrogen atom

Bohr's experiments on the hydrogen atom were designed to test his Bohr model of the atom. He used a spectrometer to measure the wavelengths of light emitted by hydrogen atoms. He found that the wavelengths of light emitted were discrete, meaning that they could only take on certain values. This supported his model of the atom, which proposed that electrons can only exist in certain discrete energy levels.



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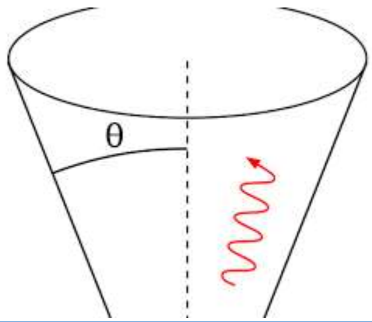
Heisenberg's gamma-ray microscope experiment

Heisenberg's gamma-ray microscope experiment was designed to test the uncertainty principle. He tried to use a gamma-ray microscope to measure the position of an electron. However, he found that the gamma rays interacted with the electron in such a way that it was impossible to measure its position with perfect accuracy. This supported his uncertainty principle, which states that it is impossible to know both the position and momentum of a particle with perfect accuracy.



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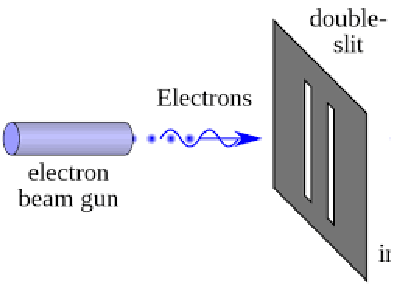
Double-slit experiment

The double-slit experiment is a famous experiment that demonstrates the wave-like nature of matter. In the experiment, light is passed through two slits and then onto a screen. The light forms a pattern on the screen that can be explained by the interference of waves.



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The double-slit experiment can also be performed with electrons. When electrons are passed through two slits, they also form an interference pattern on the screen. This shows that electrons, like light, can behave like waves.

The double-slit experiment was used to confirm Schrödinger's wave equation, which describes the wave-like nature of matter.

The Photoelectric effect

We always thought of light as an electromagnetic wave, it has a wave length and a frequency, but it couldn't explain the **photoelectric effect**

The photoelectric effect was an observation

Let's say you have a metal, and there is an electron inside the metal

What is keeping the electron in, is the electromagnetic force from the nucleus

Now this observation says, if you point a beam of light at this metal with just the right wave length and frequency, the light is going to eject the electron from the atom, now when they replicated the experiment, they found out that the intensity of the light did not matter, but the frequency did, drop under a certain frequency and you cannot eject the electron, a wave can not just do that, to move an electron, there needs to be collsion with another **particle**

Discovery of the photon

Albert einstien solved the problem by extending the concept by max planck

It says that energy is not continuos, meaning that energy in the void can not exist, energy has to be kept in something, and because of that, the transfer of energy is possible.

People thought that you can emit or absorb half energy or something like that, but plank said that energy can be gained or lost in whole-number multiplies of the quantity HV, where h is now called planck's constant

That is where the law **E = hv** was born, this exact amount of energy is called a **quantum**

Einstien said that even light or electromagnetic radiation needs to be made of **quantua** which he called **photons**

A photon is a particle of light, that transmits light energy
using this he extended planck's equation to

$\mathbf{E_{photon} = hF}$ **or** $\mathbf{hC/L}$

Back to our **photoelectric effect**

We would see that a photon particle with enough frequency or energy can eject an atom

We do not need an intese light, meaning we do not need to shoot multiple photons at the same point, but we just need 1 photon

This has lead to to a discovery that light obeys **wave-particle duality**

Particles have mass and a location in space

Waves are massless and delocalized

By knowing that increasing the frequency to a certain point will lead to the ejecting of the colliding photon using the equation E=hF

Well what if we increased the frequency even more, the electron will get ejected, but that happened with less energu before, we did this excess energy go, well

The remaining energy will be converted into kinetic energy given to the electron to make it move further

If the energy required to move the electron is E0 = hF0

Where the E0 is the ejecting energy

And hF0 is the required energy to move the electron

Then the

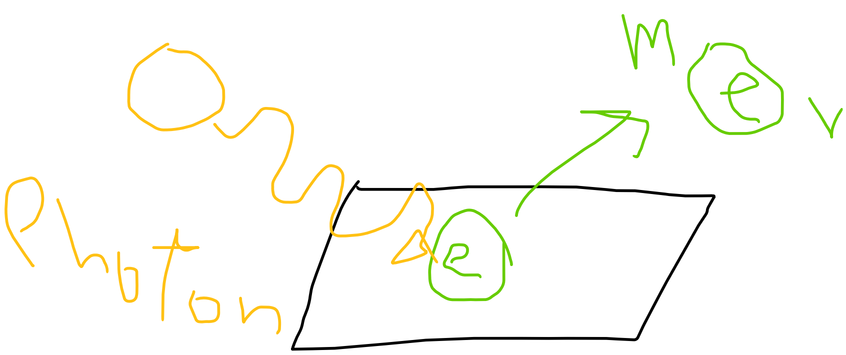
$K_{electron} = \frac{1}{2} mass \times velocity^2 = hF - hF0$

M = mass of electron

V = velocity of electron

hF = photon energy

hF0 = required energy to eject the electron



The Hydrogen emission spectrum

We took some hydrogen gas, shot it with high-energy rays

The H_2 particles absorb the energy causing some of the bonds to get broken, and because the hydsrogen atoms are exicted and have excess energy, they begin releasing the energy emitting light of various wavelengths to produce what we call a hydrogen emission spectrum

To understand what this means, we need firstly to learn about a **continuous spectrum**

When you pass light through a prism, all wavelengths are casted, the ones you can see and the ones you cant see

But if you pass the hydrogen emission spectrum through a prism, you see only a few lines, each of them corresponds with a different wave length, the hydrogen emission spectrum is called a **line spectrum** because it gets you specific lines of the spectrum

This helps us indicate that only certain energies will allow the atom to get ejected and it is not just the more the better, meanining that it is quantitized, which fits perfectly with the postulates of Max Planck

FLAME TESTS:

Flame tests basically depend on the emission process.

When we heat the metal, by heating or by applying an electrical field, their electrons are able to move from their ground state to higher energy levels. As they return to their ground state, they emit photons of very specific energy. This energy corresponds to particular wavelengths of light, and so produces particular colors of light.

Each element has a "fingerprint" in terms of its line emission spectrum.

Because each element has an exactly defined line emission spectrum, scientists are able to identify them by the color of flame they produce.

Flame tests are used to identify the presence of a relatively small number of metal ions in a compound.

Not all metal ions give flame colors.

	flame color
Li	red
Na	Golden yellow
Ca	orange-red
Ba	pale green
Cu	blue-green

Essential Question: How do fireworks create different colors?

Fireworks create different colors by using different metal salts. When these metal salts are heated, they emit photons of light with different energies. The energy of the photon determines the color of light that we see.

For example, strontium salts emit red light, barium salts emit green light, copper salts emit blue light, and sodium salts emit yellow light. By combining different metal salts in fireworks, different colors can be created.

Capstone Connection: Material properties of building materials (and paints and other surface treatments) impact how light energy is reflected or absorbed, impacting the thermal properties of the dwelling.

The material properties of building materials, paints, and other surface treatments can have a significant impact on the thermal properties of a dwelling. For example, light-colored materials reflect more sunlight than dark-colored materials, which can help to keep a building cool in the summer.

In addition, certain types of paint and surface treatments can be used to absorb specific wavelengths of light. For example, solar-reflective paint can be used to reflect infrared radiation away from a building, which can help to reduce cooling costs.

Example:

A dam is typically made of concrete, which is a light-colored material. This means that it will reflect more sunlight than a dark-colored material, which can help to keep the dam cool. In addition, the concrete surface can be treated with a solar-reflective coating to further reduce heat absorption.

This can help to improve the thermal performance of the dam and reduce cooling costs.