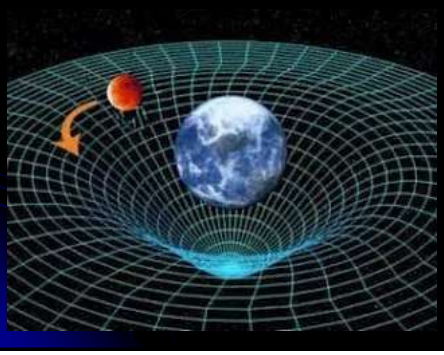
What holds an atom together?

Fundamental Forces in Nature

- Gravity- universal attraction of all objects to one another
- Electromagnetism- Attraction or repulsion based on charge or poles
- Strong Nuclear Force- Force holding the nucleus of an atom together
- Weak Nuclear Force- Force causing subatomic particles to change into one another (causing nuclear radiation)

Gravity



Quantum Forces

- Gravity is described by Einstein's general relativity.
- General relativity and quantum mechanics contradict each other.
- Normally general relativity is used for larger bodies (a baseball) and quantum mechanics is used for smaller objects (electrons)

Quantum Mechanics

- Quantum mechanics describe how forces and motion work at an atomic level.
- The word quantum is from the root "quanta-" meaning how much (quantity)
- Energy only comes out of an atom in *discrete amounts* (specific numerical amounts- little *chunks*) ~it works like getting $ change
- Say someone owes you $3.25
- The only money you can get from them come in the *discrete* amounts of $1, 50¢, 25¢, 10¢, 5¢, or 1¢

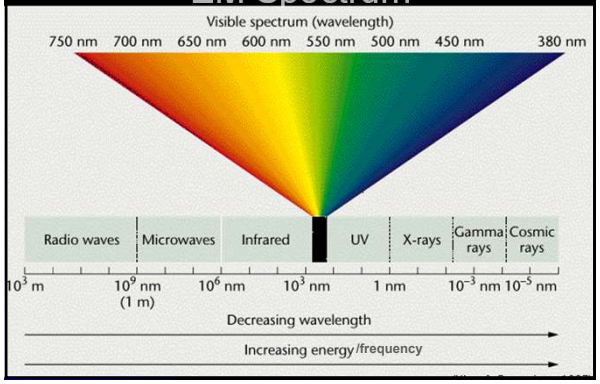
How atoms release energy

- atoms can absorb energy causing electrons to "*jump*" to a state of higher energy.
- This is called an *excited state*
- Electrons will leave ground configuration (electron configurations we have been drawing), and move to higher energy positions
- When electrons return to ground state they release energy in discrete amounts.

How do we know

- When atoms “drop” from an excited state back to ground they emit energy as light.
- *Light* refers to all of the electromagnetic spectrum, not just the colors we can see.
- Infrared, ultraviolet, radio waves, and microwaves are all types of light like Red, Orange, Yellow, Green, Blue, (Indigo) and Violet.
- All travel at c (the speed of light 3 x10^8 m/s)
- The difference between these is their frequency, wavelength, and energy.

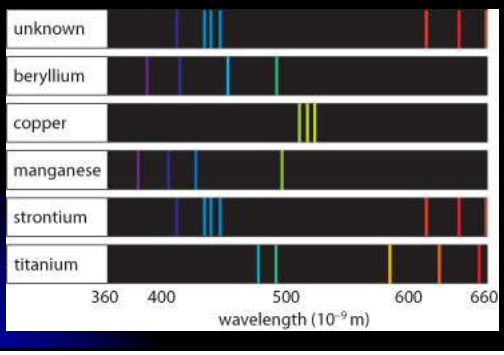
EM Spectrum



Neils Bohr

- Bohr saw, when he dispersed (put it through a prism to separate it) light from a hydrogen light bulb, distinct bands of colors instead of a smooth transition.

A few atomic specta



Hydrogen light bulb

- A hydrogen light bulb works like a neon light.
- Electricity goes through the gas. All the atoms jump to an excited state. When they fall back to ground state, they give off energy as light.
- Since we only see bands of light (when dispersed), we know energy is coming out in discrete amounts, not a steady flow.

Energy Levels

- From this, Bohr determined electrons were at certain energy levels from the nucleus.
- Excited e^-’s jump to higher energy levels, then fall back to ground.
- Since the distance it “falls” back is always the same, energy always comes out of an atom in *discrete amounts*.
- The energy level are the numbers on the left column

What keeps electrons near?

- electromagnetic force
- like charges repel, opposite charges attract
- The e^- are attracted to the positive nucleus but repelled by every other e^-.
- This is why we have to fill all up arrows before pairing electrons up (they don't want to be next to each other).
- Pauli Exclusion Principle ~ You can not have more than two electrons in one orbital (on the same line) because of this repulsion.

Orbitals instead of orbits

- With simple orbits electrons would be pulled into the nucleus.
- An orbital is just the area with the highest *probability* of finding an electron.
- The high energy of the electrons keeps them moving around (somehow).
- We do NOT know how an electron moves!
- Heisenberg's Uncertainty Principle ~ we can never know exactly where an electron is and where it is going at the same time.
- Orbitals are represented by the lines you place the arrows on

Orbitals take on different shapes

- The easiest (lowest energy level) shape an orbital can take is called s (sphere).
- The first energy level can hold 1 s orbital only.
- The second energy level can hold 1 s orbital and 3 p orbitals (p orbital is a higher energy shape than s)
- The third can hold 1 s orbital 3 p orbitals and 5 d orbitals.
- http://orbitals.com/orb/

More protons

- The more positive the nucleus the closer the electrons can be pulled in.
- This is why we have to skip d and f (only a larger nucleus can squeeze all those orbitals into one energy level).
- Aufbau principle- electrons will occupy the lowest energy orbital available.
- If electrons were forced to be in the same orbital, it is assumed they would spin in opposite directions (to avoid contact). This is represented by either an up or a down arrow.

What holds a nucleus together?

- Strong Nuclear Force- holds the nucleus together
- EM forces want to blow the nucleus apart
- Neutrons lessen this effect
- Without enough neutrons the atom will break apart.
- This process is called radioactive decay
- For some isotopes this happens very quickly (radioactive stuff) but for most it doesn't.

Going from atoms (microscopic) to useable amounts (macroscopic) of substances

- chemists do not talk about the number of atoms in a reaction because atoms are so small.
- Instead they refer to moles of atoms.
- 1 mole = 6.022×10^{23} particles
- This is Avogadro's number