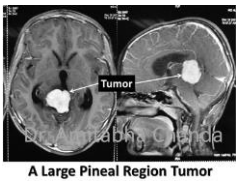
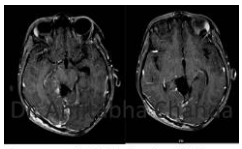
What have atoms done for you lately?

- The discovery and knowledge of atoms have brought us many things like MRI (Magnetic Resonance Imaging).



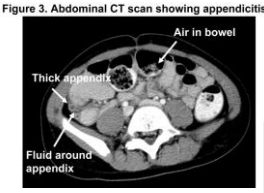
A Large Pineal Region Tumor

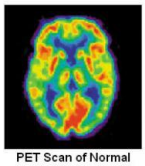


Postoperative MRI showing No Tumor

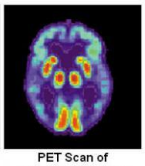
What have atoms done for you lately?

Figure 3. Abdominal CT scan showing appendicitis.





PET Scan of Normal Brain



PET Scan of Alzheimer's Disease Brain

A Day Without Chemistry

- https://www.youtube.com/watch?v=AbfW_CMMe48

Emission Spectra

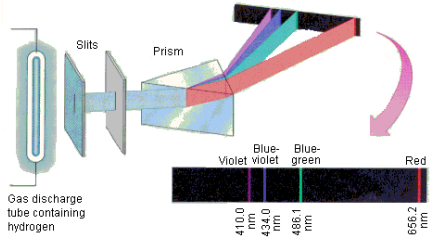
- Objects at high temperature emit a continuous spectrum of electromagnetic radiation when viewed through a diffraction grating.

Emission Spectra

- But when a pure sample of individual elements is heated and the emitted light passed through a diffraction grating, only a few narrow lines, called a line spectrum, are observed.

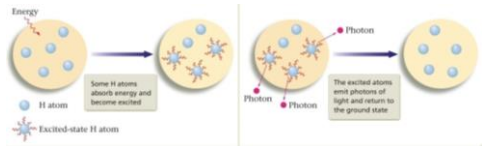
Emission Spectra

- Example: H_2 produces a line spectrum corresponding to four specific wavelengths.



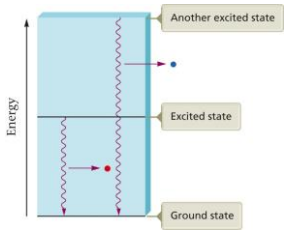
What Causes Emission Spectra?

- When electricity is run through a sample of H_2, H atoms gain energy and become excited.
- H atoms release this energy by emitting photons of varying energies.



Neils Bohr (1913)

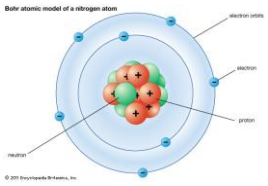
- Bohr believed that these photons were the result of energy being released as an electron moved from a higher energy level (or orbit) to a lower one.



Neils Bohr (1913)

Let's back up to Bohr's Model of the atom:

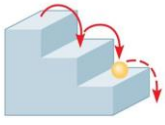
- neutrons and protons occupy the nucleus
- electrons orbit the nucleus much like planets orbiting the Sun



Neils Bohr (1913)

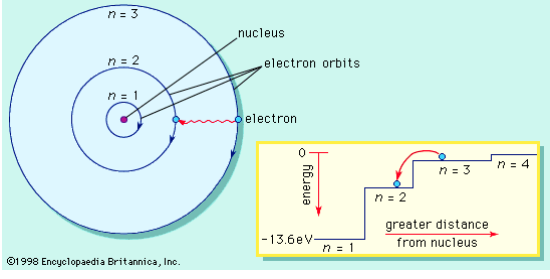
- In Bohr's model, electrons are located in energy levels, which can be thought of as steps on a staircase.
- Whether you are going up or down, you can only move in whole-step increments. Electrons cannot exist between energy levels, just like you can't stand between steps.

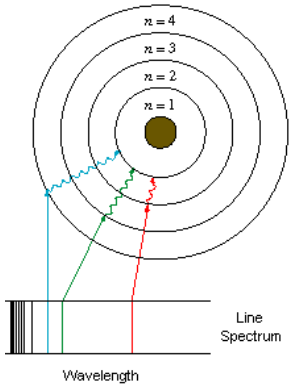
A ball bouncing down a flight of stairs provides an analogy for energy levels of electrons



Neils Bohr (1913)

- The lowest step is the lowest energy level, called ground state.
- As one moves up the steps, one gains potential energy. As one moves down, one loses energy.
- To move from one energy level to another, an electron must absorb or emit a photon of a particular energy.



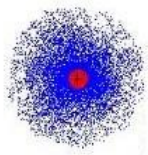


Electron Cloud

- Bohr's model was right in assigning energy levels to electrons…but wrong in assuming electrons moved like planets orbiting the sun
- Reality: electrons are much more unpredictable and are thus said to move in an electron cloud

Electron Cloud

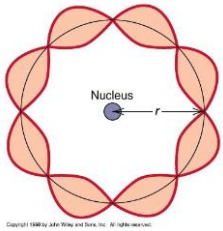
- An electron cloud is a visual model of the most likely locations for electrons in an atom.



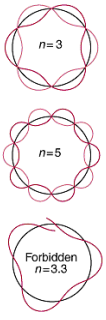
The blue area is the elctron cloud. The darker it is, the more likely the electron is there.

Louis de Broglie and Erwin Schrodinger (1926)

- de Broglie proposed that electrons, previously thought of as particles, must exhibit wave-like behaviour ("Wave Particle Duality")
- With Schrodinger, said that electrons behave like circular standing waves around the nucleus



Louis de Broglie and Erwin Schrodinger (1926)



- The circular standing wave consists of wavelengths that are multiples of whole numbers.
- Any other orbits are not allowed because they would cause the wave to collapse.
- This agrees with the idea that only certain electron energies exist.

Louis de Broglie and Erwin Schrodinger (1926)

- Schrodinger then created a wave function (equation) to calculate electron energy levels.
- If an electron has a definable energy, then it can be localized in an orbital, a region around the nucleus where there is a high probability of finding the electron.

Werner Heisenberg (1926)

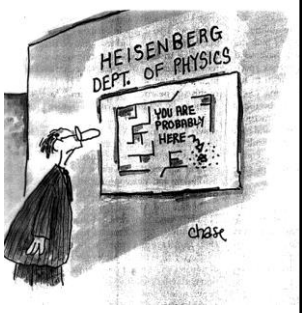
- Derived a statistical approach to locating an electron

Heisenberg's Uncertainty Principle:

- It is impossible to know the exact position and speed of an electron at a given time.

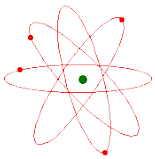
Werner Heisenberg (1926)

- The best we can do is describe the probability of finding an electron in a specific location.



Orbitals

- Thus, electrons are said to move in orbitals, regions of space where the electron is likely to be found, rather than in orbits.



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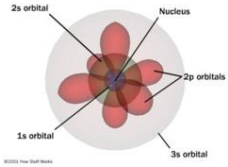
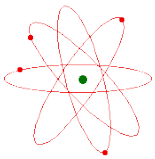


Orbitals

- An "orbital" is not a 2-D race track, it is a 3-D space that defines where an electron may be (like a rain drop in a cloud).



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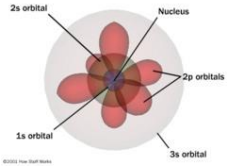

Quantum Mechanical Model

This is our current understanding:

- Electrons move around the nucleus in orbitals, as represented by a 3-D electron cloud.
- The electron cloud is based on wave functions and probability.
- Orbitals can overlap.
- Electrons can be in different orbitals by absorbing/emitting energy.