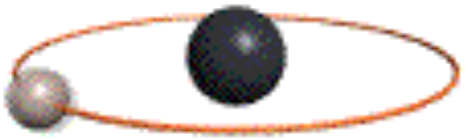
Atomic Theory:
Plum Pudding to Quantum Mechanics



Aristotle, Dalton, Thomson to Rutherford, Bohr and Schrödinger

The Atomic Timeline

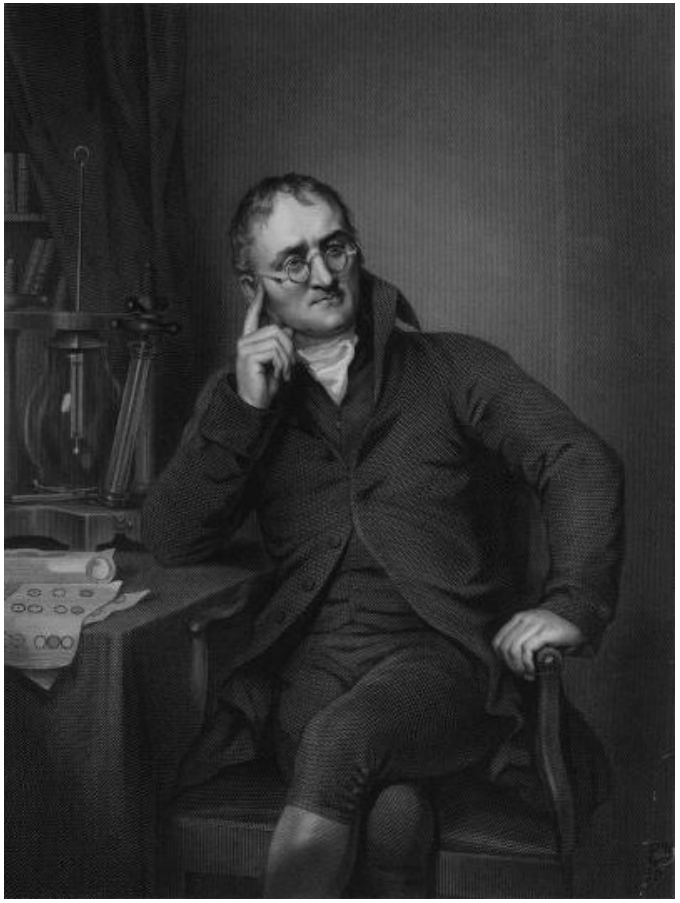
Aristotle – everything is made of 4 elements: earth, air, fire water **(~360 BC**)

This belief is held firm among scholars until the **17th century**.

Sir Isaac Newton is among the first "academic heavyweights" to subscribe to the *atom* theory.

The Atomic Timeline

John Dalton – offers the first real evidence and science for the existence of **atoms (1803)**

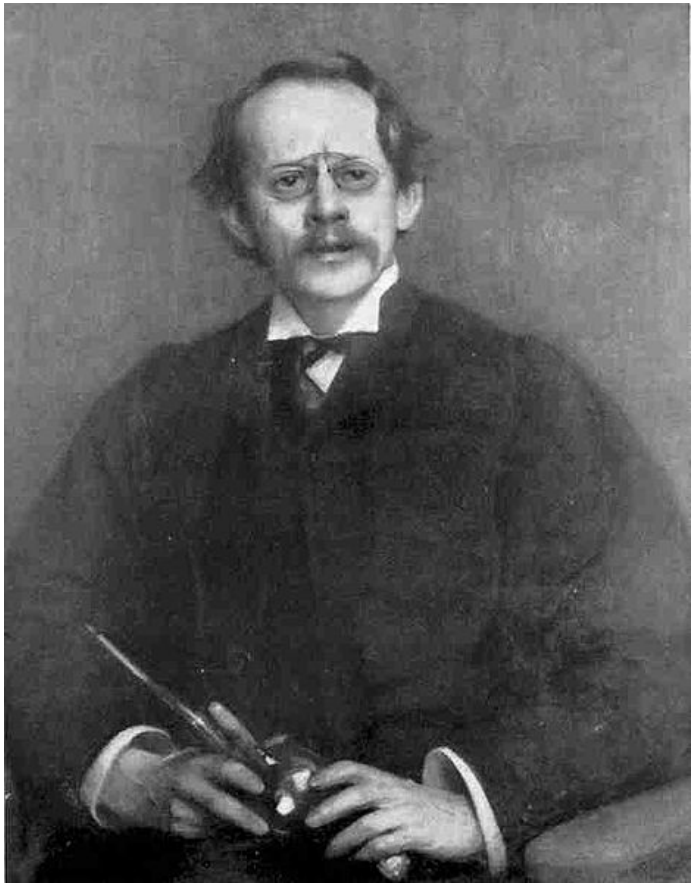


He laid down 5 key postulates:

1) All matter is composed of tiny indivisible particles called atoms
2) Atoms are indestructible*
   (Law of Conservation of Mass)
3) Atoms of an element have identical chemical and physical properties
4) Atoms of different elements have different properties
5) Atoms of two or more different elements can combine in constant ratios to make new substances

The Atomic Timeline

J. J. Thomson – used a cathode ray tube to prove that atoms were made up of positive and negative *sub-atomic* particles (**1897**)



By manipulating the magnetic field surrounding the CRT, he found he could "bend" the stream of negatively changed particles.

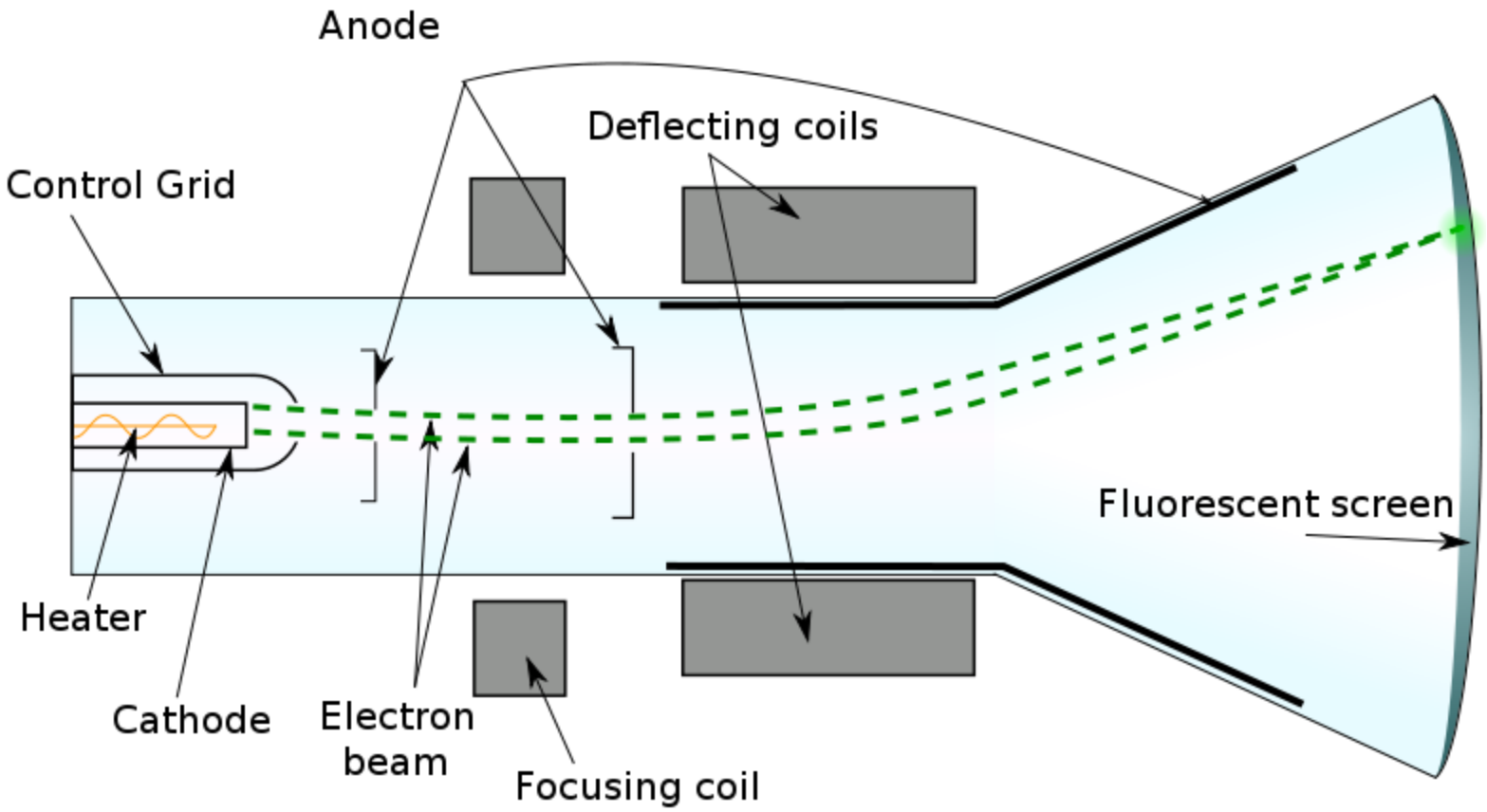
The particles are named **electrons** and are assigned the charge of -1.

Knowing that all substances were inherently neutral he surmised that there must be a particle with a charge equal in magnitude yet opposite in polarity.

The **proton**, assigned as +1 was discovered later by Goldstien.

The Atomic Timeline

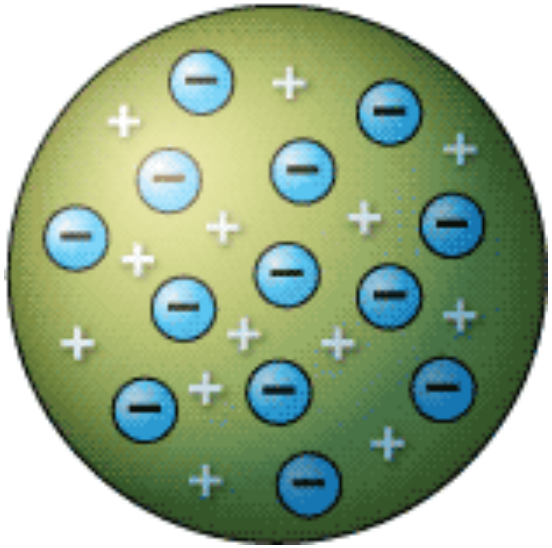
Thomson's Cathode Ray Tube (CRT) Experiment



The Atomic Timeline

Thomson's *Plum Pudding* model of the atom.

The positive and negative charges were evenly spaced throughout the atom like the raisins and fruits in a . . . plum pudding.



The Atomic Timeline

Ernest Rutherford – puts the plum pudding model to the test and makes a very unexpected discovery (**1914**)

Initially famous for the discovery of 3 types of radioactive emissions:

a particle (we now know is a He nucleus)

b particle (an electron)

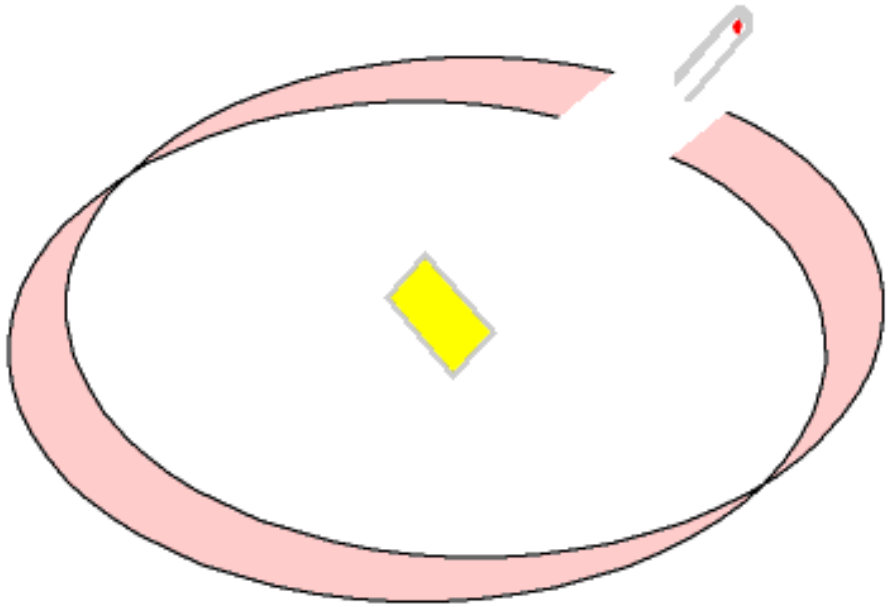
g ray (no charge, high energy)

Lots of this work was done was done while a member of the faculty at McGill University in Montreal.

The Atomic Timeline

Rutherford - if in fact the positive charge of an atom was spread out evenly, then when a positively charge particle was "fired" at an atom it should pass though with minimal interference.

The Rutherford gold foil experiment used an alpha particle gun.



The result:

- An atom is essentially all empty space

- The positive charge is localized in the centre of the atom

-The negative charge exists in a surrounding "cloud"

The Atomic Timeline

The result of the work by Dalton (atoms), Thompson (electrons), Goldstein (protons), Rutherford (atomic arrangement) and Chadwick (neutrons) is the spatial model of the atom that we essentially know today.

The electronic arrangement is another story*.

Particle	**Location**	**Mass (u)**	**Mass (g)**	**Charge**
electron (e^-)	orbitals*	5.435×10^{-4}	9.11×10^{-28}	-1
proton (p^+)	nucleus	1	1.67×10^{-24}	+1
neutron (n^0)	nucleus	1	1.67×10^{-24}	0

Atomic Food for Thought

If an atom were a football stadium, then the nucleus would be a **pea** at the centre of the 50 yard line.

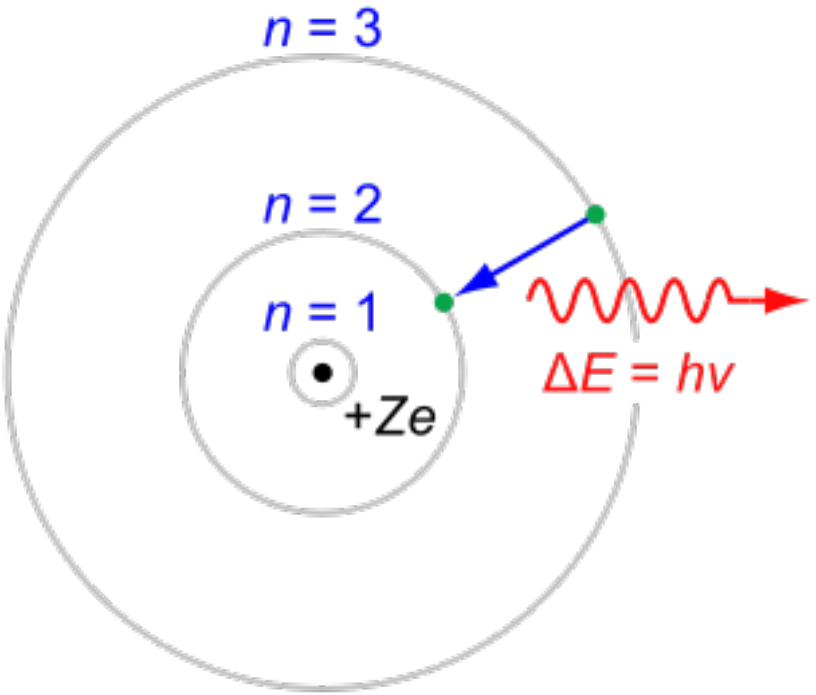
The traditional unit for atomic radius/length is the Angstrom, Å, (10^{-11})

We now use pm (10^{-12}) with the metric system.

The Bohr Model

Niels Bohr – discovers that the energy from electrons is *quantized*; meaning it can only exist at certain discrete levels, not between (**1913**)

This notion, that the electrons in an atom are localized into different energy levels leads to the birth of Quantum Mechanics and the *Bohr Model of the Atom*.




$1s^2$
$2s^2p^6$
$3s^2p^6d^{10}$
THIS LESSON IS REALLY BOHRING.

The Bohr Model

The Bohr Model of the Atom says:

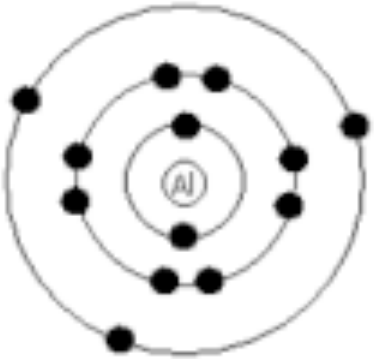
- electrons exist in distinct energy levels called **orbits**

- no electron can exist between orbits (*think of a ladder, you can't stop mid-step*)

- if an electron is excited and moves between two orbits there will be a release of energy

It also begins to explain the so-called "**octet rule**" where all atoms seek to have a filled outer shell consisting of 8 electrons.

The only problem with the Bohr model is that it doesn't work for anything except Hydrogen!



Aluminum will shed it's 3 outermost electrons to have a complete octet. It's easier to lose three than gain 5.

Where do we go from here?

Let's recap . . .

Dalton – matter is made up of atoms

Thompson – atoms have electrons

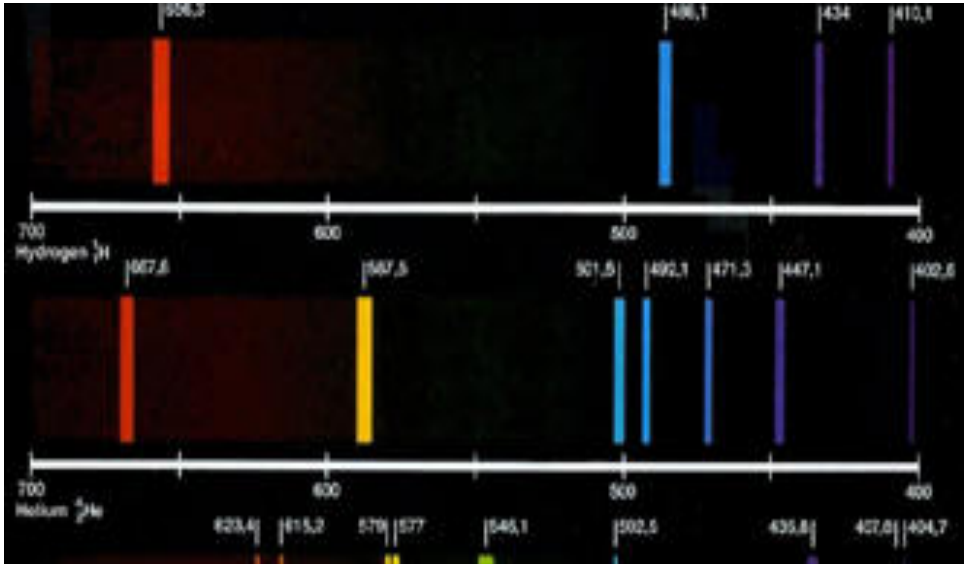
Goldstein and Chadwick – protons and neutrons (respectively)

Rutherford – atoms each have a nucleus containing p^+ and n^0

Bohr – electrons exist in distinct energy levels called *quanta*

According to Bohr's theory the electrons in Hydrogen and Helium should be identical and therefore have the same quantum properties.

The only problem is, they don't.



Schrödinger's Rise

In the 1920's Austrian physicist **Erwin Schrödinger** derives the equation that changes physics and chemistry forever.

Schrödinger develops the equation that now bears his name.

It allows physicists and chemists to use quantum mechanics to accurately describe the position of every electron in an atom.

In Schrödinger's model, every electron has a different set of quantum numbers that describe it.

A set of quantum numbers is to an electron as GPS coordinates would be to you if lost in the woods.

The Result

Electrons in an atom exist in distinct energy levels . . . just more levels than Bohr thought

Electrons cannot exist between energy levels

Electrons can move between energy levels only with an energy change

Every electron in an atom has a distinct set of quantum numbers (think GPS coordinates)

Electrons exist as both a wave and a particle → they exist over a region of space

Each region of space is called an **orbital**

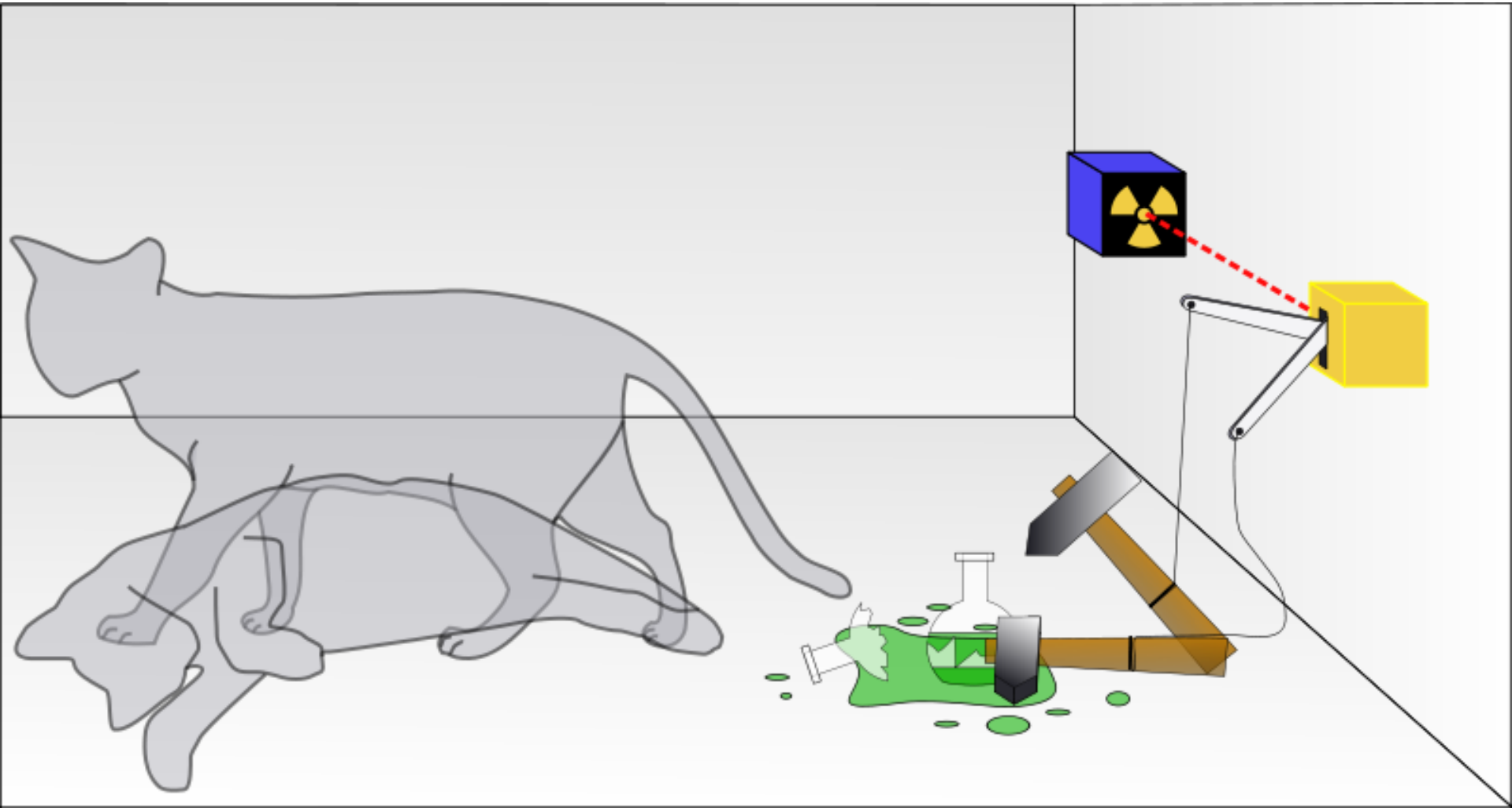
Each orbital can hold a maximum of 2 electrons

Each non-valence energy level can hold a maximum of $2n^2$ electrons (e^-)

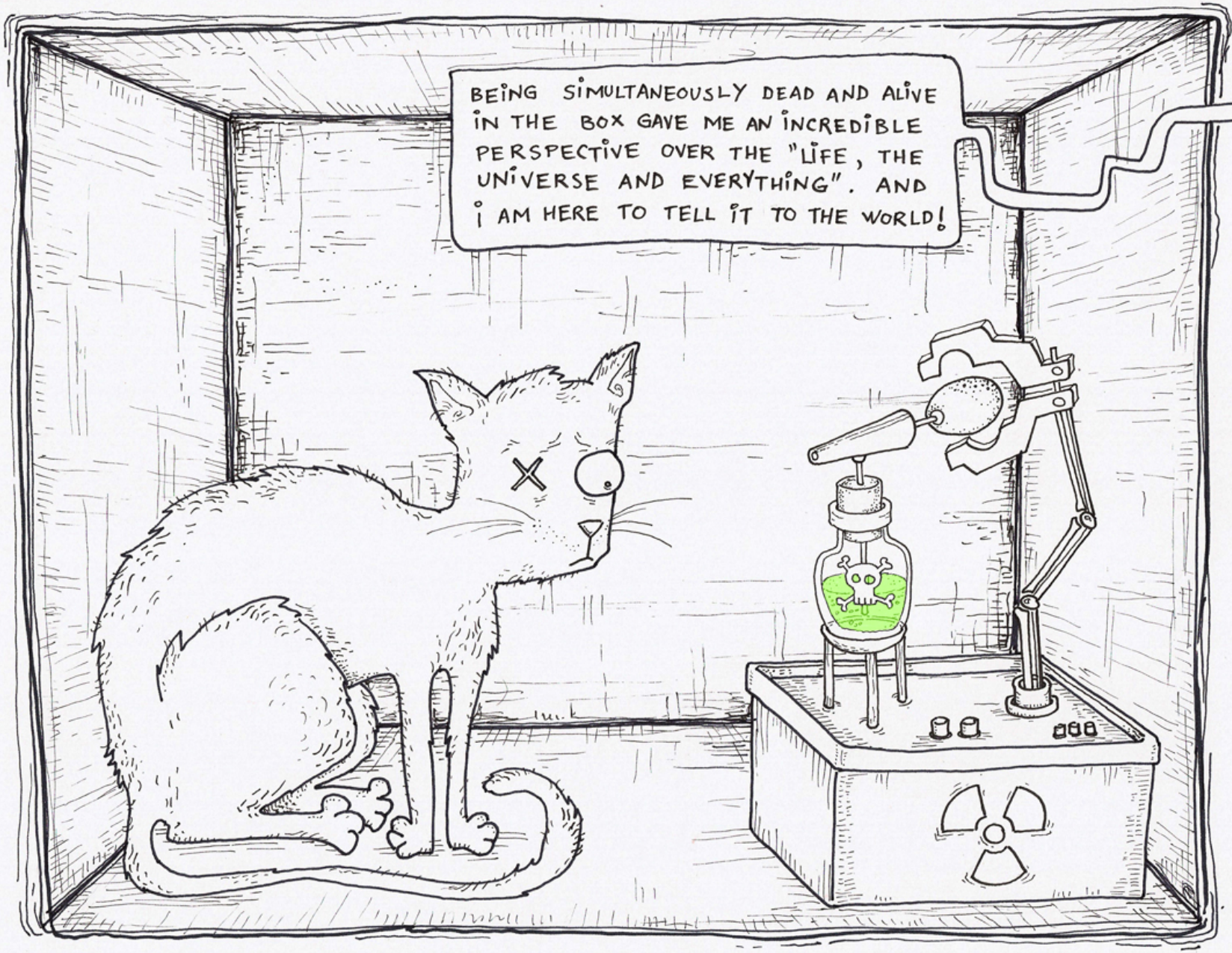
We call this the:

WAVE or QUANTUM MECHANICAL MODEL OF THE ATOM

Schrödinger's Cat



Schrodinger in Pop Culture


BEING SIMULTANEOUSLY DEAD AND ALIVE IN THE BOX GAVE ME AN INCREDIBLE PERSPECTIVE OVER THE "LIFE, THE UNIVERSE AND EVERYTHING". AND I AM HERE TO TELL IT TO THE WORLD!