Applied Science Summer work

Atomic Theory Timeline

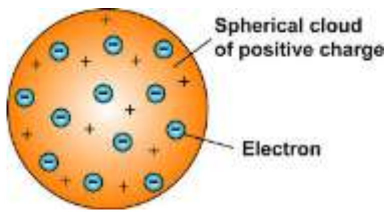
Before scientists, Greek philosophers pondered about the universe. Ancient Greeks thought that the entire universe (or the universe they knew of at the time) was made from five elements: earth, water, air, fire, and aether. Ancient Greeks thought that each of these "elements" had their natural place in the order of things: earth liked to be on the bottom, then water, then air, then fire, with aether floating on the very top. They used this idea to explain why a stone (earth) sinks in water and why fire reaches upwards in air. Democritus, a Greek philosopher, disagreed—and rightly so! Democritus proposed that matter could not be divided into smaller pieces forever; matter was made from small, hard particles that he called "atoms" from a Greek word meaning "indivisible".

Fast forward over two millennia to 1785. Charles Augustin de Coulomb published his work on electrostatic forces, saying that opposite charges attract and the force that the charges feel is related to the amount of charge and the distance between them. His mathematical equation describing the interaction between charges is now known as "Coulomb's law". While this did not immediately change the idea of the atom, this did help other scientists change the atomic model.

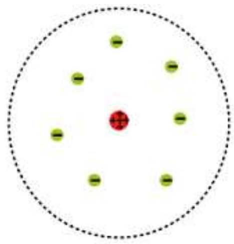
In 1808 a scientist, John Dalton, confirmed Democritus' views. He stated that atoms are tiny, solid balls, like billiard balls. While he also didn't change the idea of the atom, he introduced the first atomic theory. His theory stated:

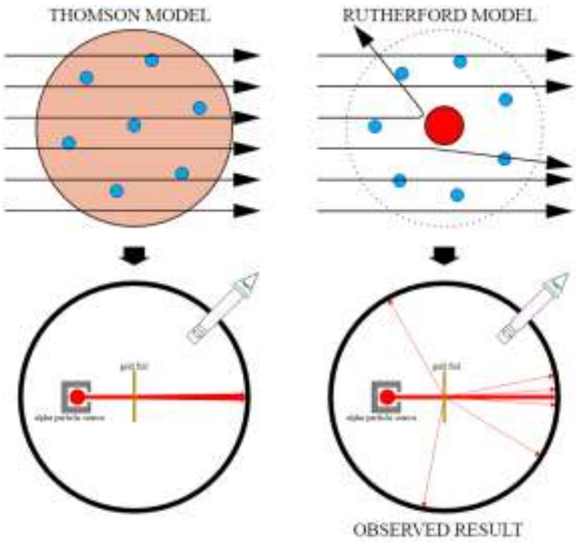
1. Atoms are tiny, invisible particles.
2. Atoms of one element are all the same.
3. Atoms of different elements are different.
4. Compounds are formed by combining atoms.

Nearly a century later, in 1897, J. J. Thomson discovered electrons with cathode rays. He was the first scientist to show that the atom is made of even smaller things. So much for atoms being indivisible! This knowledge changed the atomic model to the "plum pudding model". Thomson thought of the electrons as raisins inside a sphere of positively charged pudding.

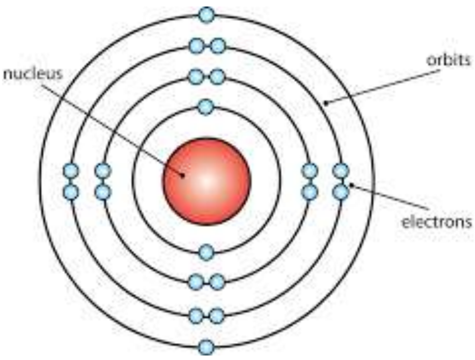


Fourteen years later, Ernest Rutherford published the results of his gold foil experiment (also known as "Rutherford's gold leaf experiment"). He sent a beam of alpha particles (which were known to be positive particles) at a thin piece of gold. Based on the plum pudding model, the alpha particles should have gone straight through the foil, at most deflecting by fractions of a degree. But what he found was very different! Most of the alpha particles did go straight through—as expected—though some were scattered by a few degrees (more than was expected) and some actually bounced backwards! Years later when commenting on this experiment, Rutherford said, "It was quite the most incredible event that has ever happened to me in my life. It was almost as incredible as if you fired a 15-inch shell [cannon ball] at a piece of tissue paper and it came back and hit you." Rutherford couldn't believe the results of his experiment, so he repeated it… over 100,000 times! From these experiments, Rutherford concluded that the atom must have a very dense, positive centre and most of the atom must be empty space. He called the dense centre the "nucleus" (from a Latin word meaning "little nut") and claimed it was made from positive particles he called "protons".

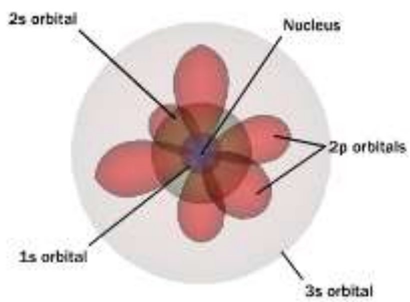


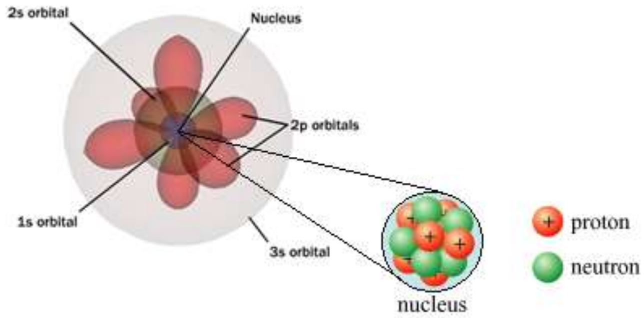


Rutherford's model of the atom was not without flaws. The negatively charged electrons would be attracted to the positively charged nucleus (remember Coulomb's work?). If the electrons were allowed to be anywhere on the outside of the nucleus, most of them would spiral into the centre of the atom, releasing energy as they did so. But atoms didn't release that energy. From thinking about the energy problems arising from Rutherford's model, Niels Bohr proposed that electrons move around in specific layers or "shells". In a 1913 publication he stated that every atom has a specific number of electron shells and thus the atomic model was modified once again to put the electrons in specific locations. This new model is sometimes referred to as the "Bohr model", in honour of Niels Bohr, and sometimes called the "Rutherford-Bohr model", to acknowledge both scientists' contributions.

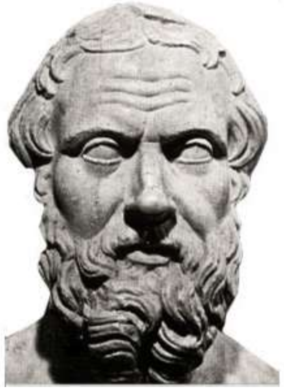
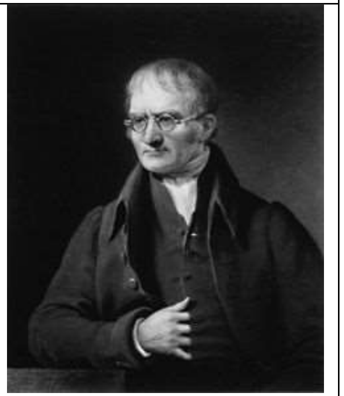
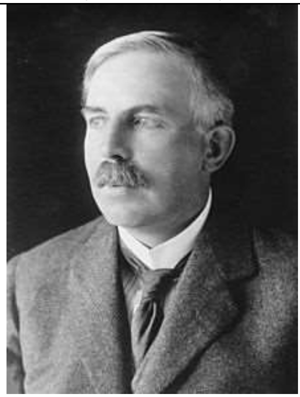


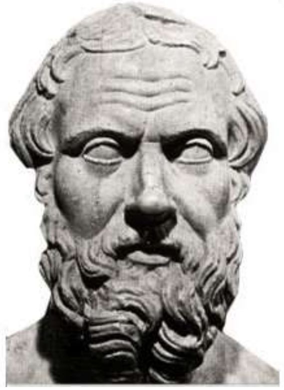
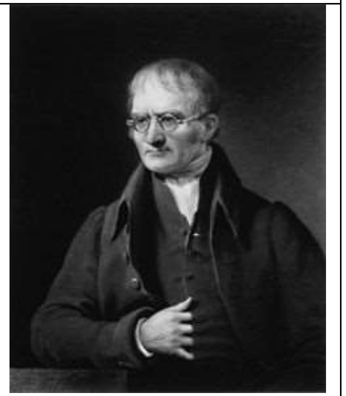
The next decades were a very exciting time to be involved in physics research, especially atomic theory and quantum mechanics. In 1926, Erwin Schrödinger published his work on the quantum wave equation, which treated electrons in atoms as waves instead of the classic billiard ball-like particles. The following year Werner Heisenberg published the "uncertainty principle". One of the uncertainty principle's forms states that you can never simultaneously know the exact location and energy of an electron. The combination of these publications lead to the idea of electron "clouds"; locations where the electrons have a high probability of being.





But there was still a problem with the model; most atomic nuclei had twice the mass they were theoretically supposed to have (based on the number of protons). Some scientists proposed that the extra mass was proton-electron pairs located in the nucleus. However, maths shows that to hold electrons in the nucleus would take way more energy than Coulomb's law could account for. Around the same time, other scientists discovered a type of radiation that was neutral, but it was inconsistent with gamma rays (the only then-known neutral radiation). James Chadwick showed that this radiation could be explained by a neutral particle. He performed numerous experiments, bombarding nitrogen, oxygen, helium, and argon with these neutral particles. From these experiments and momentum and energy laws, he was able to measure the mass of this neutral particle. In his 1932 publication, James Chadwick calls this particle the "neutron" and states that they are found in the nucleus with the protons. Since then, scientists have discovered that protons and neutrons are made up of even smaller things—quarks! But that is another story.

 **J. J. Thomson** (1856-1940)	 **Niels Bohr** (1885-1962)	 **Democritus** (470-380 BC)
 **Werner Heisenberg** (1901-1976)	 **Erwin Schrödinger** (1887-1961)	 **John Dalton** (1766-1844)
 **Charles-Augustin de Coulomb** (1736-1806)	 **James Chadwick** (1891-1974)	 **Ernest Rutherford** (1871-1937)

 **J. J. Thomson** (1856-1940)	 **Niels Bohr** (1885-1962)	 **Democritus** (470-380 BC)
 **Werner Heisenberg** (1901-1976)	 **Erwin Schrödinger** (1887-1961)	 **John Dalton** (1766-1844)
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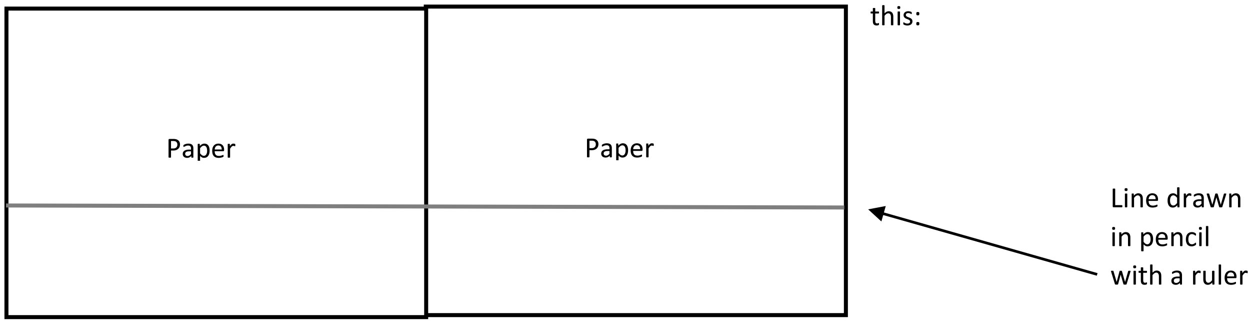
Instructions

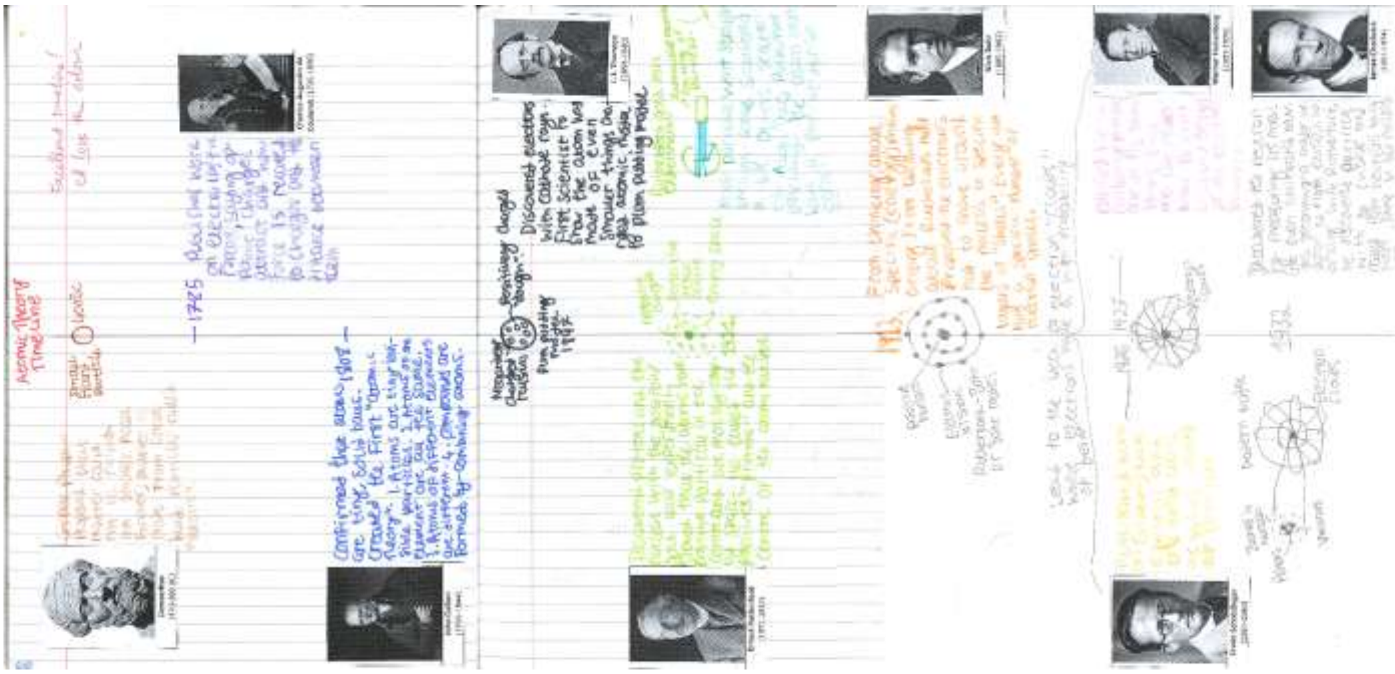
1. Get 2 pieces of plain paper and tape them together.
2. Overlap the pieces of paper just enough to ensure they can be taped together.
3. Draw a horizontal line in pencil across the middle of your paper. Afterwards, your paper should look like this:

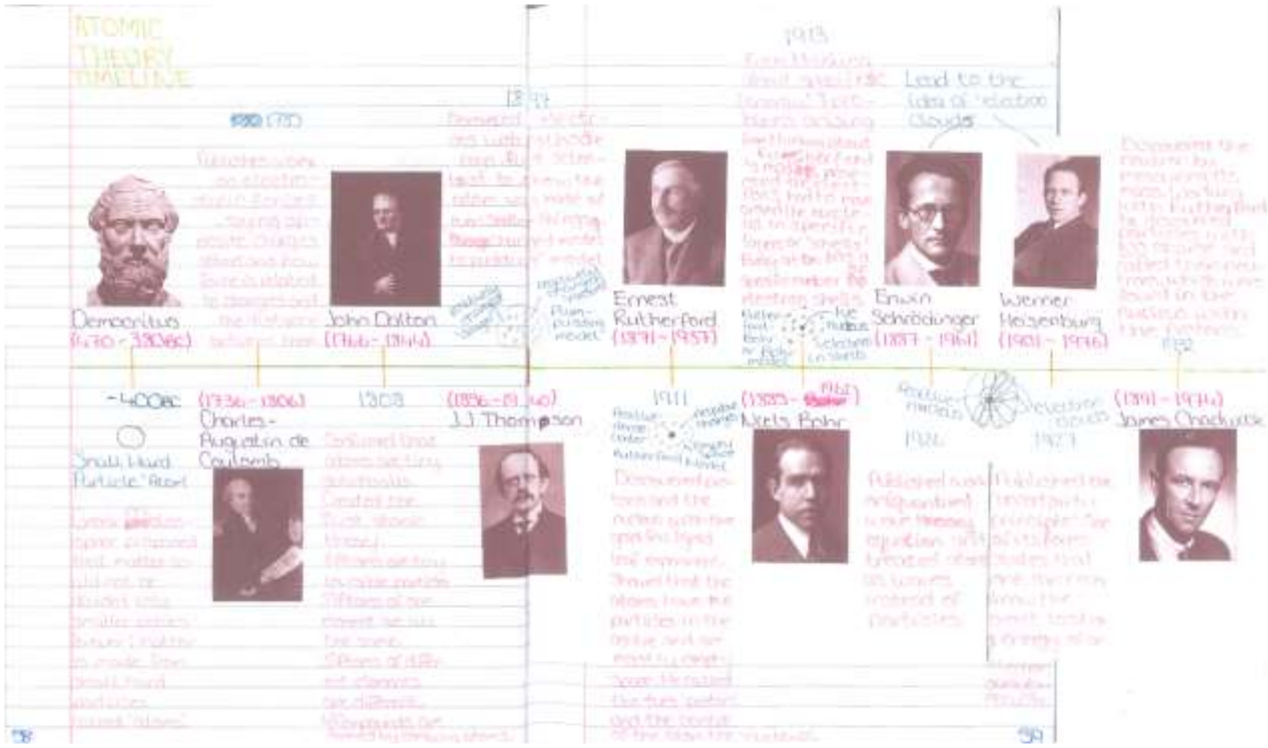


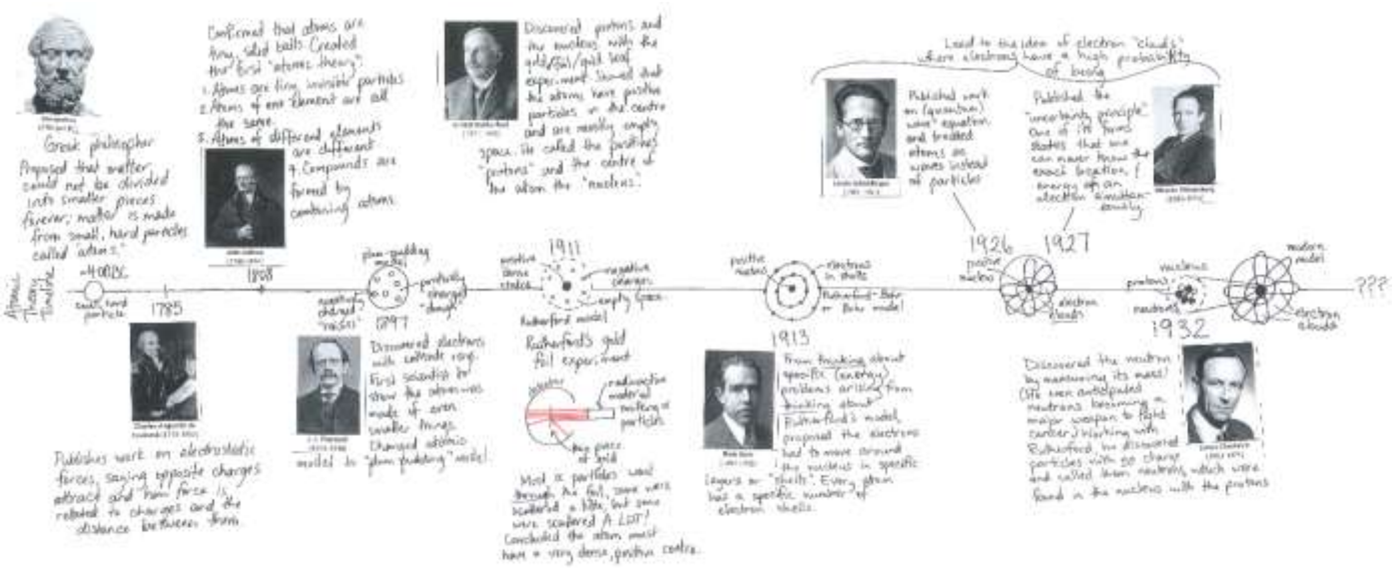
4. Make the timeline: On the pencil line, draw and label the atomic model. Label the year of the model change (or publication leading to the model change) close to the line. The reason you drew this line in pencil is so that you can rub it out if it is going through your model. Above and below your pencil line, include information such as:
    - what the discovery was;
    - who made it (cut out and stick their picture on your timeline!);
    - how the discovery was made (e.g. a brief description of the experiment).

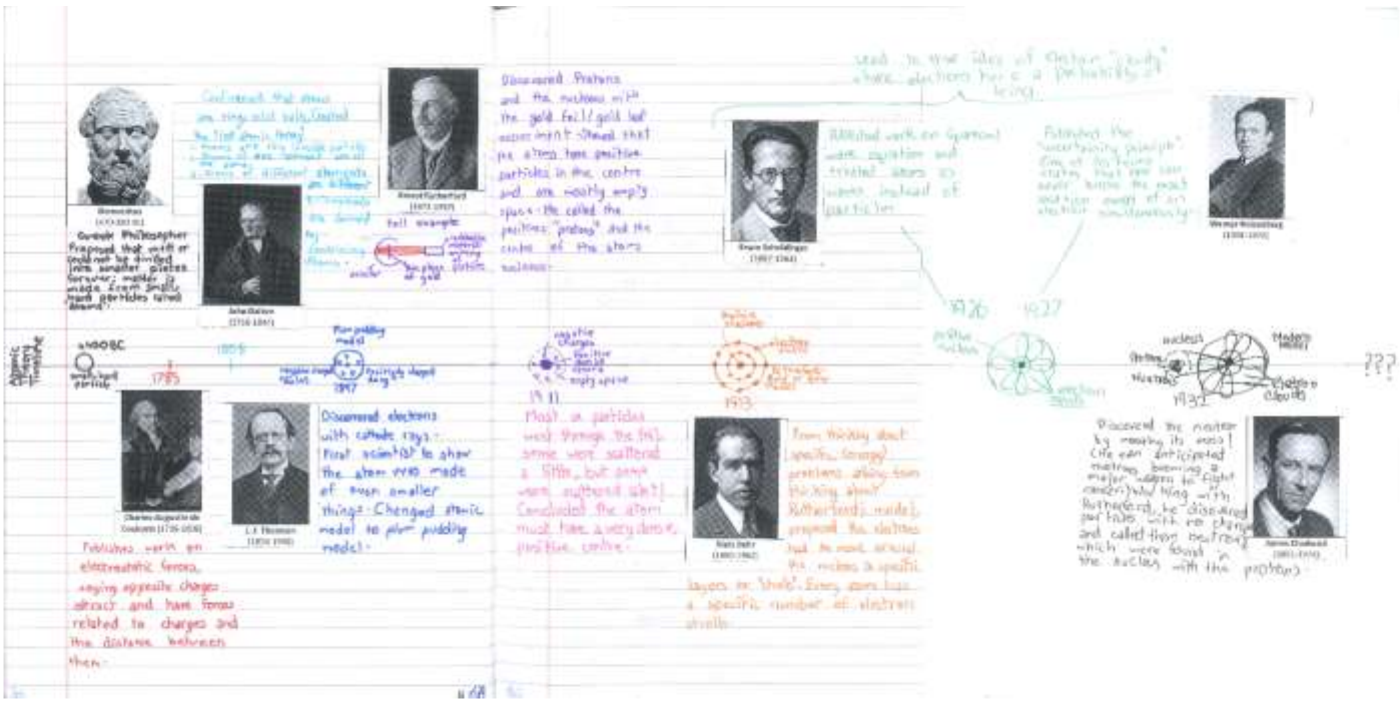
   This is not an exercise in writing tiny to include every bit of detail. Make sure to include the important points and get rid of the "fluff". Also ensure that your timeline is easy to read and appealing to study from—if you like looking at it, chances are you'll look at it (and study it) more.

Some examples of other students' timelines (these are just a guide to point you in the right direction):




ATOMIC THEORY TIMELINE
Democritus
John Dalton
Ernest Rutherford
Erwin Schrödinger
Werner Heisenberg
-400BC
Charles-Augustin de Coulomb
1808
J.J. Thompson
1911
Neils Bohr
1926
1927
James Chadwick
Lead to the idea of 'electron clouds'
58
59


Atomic Theory Timeline
Greek philosopher
Proposed that matter could not be divided into smaller pieces forever; matter is made from small, hard particles called "atoms."
~400BC
small, hard particle
1785
Publishes work on electrostatic forces, saying opposite charges attract and how force is related to charges and the distance between them
Confirmed that atoms are tiny, solid balls. Created the first "atomic theory":
1. Atoms are tiny, invisible particles
2. Atoms of one element are all the same.
3. Atoms of different elements are different
4. Compounds are formed by combining atoms
1808
plum-pudding model
negatively charged "raisins"
positively charged "dough"
1897
Discovered electrons with cathode rays. First scientist to show the atom was made of even smaller things. Changed atomic model to "plum pudding" model.
Discovered protons and the nucleus with the gold foil/gold leaf experiment. Showed that the atoms have positive particles in the centre and are mostly empty space. He called the positives "protons" and the centre of the atom the "nucleus."
1911
positive dense centre
negative charges
empty space
Rutherford model
Rutherford's gold foil experiment
radioactive material
big piece of gold
Most α particles went through the foil, some were scattered a little, but some were scattered A LOT! Concluded the atom must have a very dense, positive centre.
positive nucleus
electrons in shells
Rutherford-Bohr or Bohr model
1913
From thinking about specific (energy) problems arising from thinking about Rutherford's model, proposed the electrons had to move around the nucleus in specific layers or "shells". Every atom has a specific number of electron shells.
Lead to the idea of electron "clouds" where electrons have a high probability of being
Published work on (quantum) "wave" equation and treated atoms as waves instead of particles
Published the "uncertainty principle". One of its forms states that one can never know the exact location & energy of an electron simultaneously.
1926
1927
positive nucleus
electron clouds
nucleus
protons
neutrons
modern model
electron clouds
1932
???
Discovered the neutron by measuring its mass! (He even anticipated neutrons becoming a major weapon to fight cancer.) Working with Rutherford, he discovered particles with no charge and called them neutrons, which were found in the nucleus with the protons


Atomic Theory Timeline
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