

Atomic Theory

Democritus to the Planetary Model

Democritus

- * Greek philosopher (460 - 370 BCE)
- * Believed in the philosophy of materialism
- * With Leucippus, they thought that matter can not be divided infinitely.
- * Proposed the existence of indestructible, indivisible particles called atoms.

John Dalton

- * British chemist, physicist, meteorologist
- * Proposed the first “modern” atomic theory in 1803
- * Dalton’s atomic model: **Billiard Ball Model**

5 Points of Dalton's Atomic Theory:

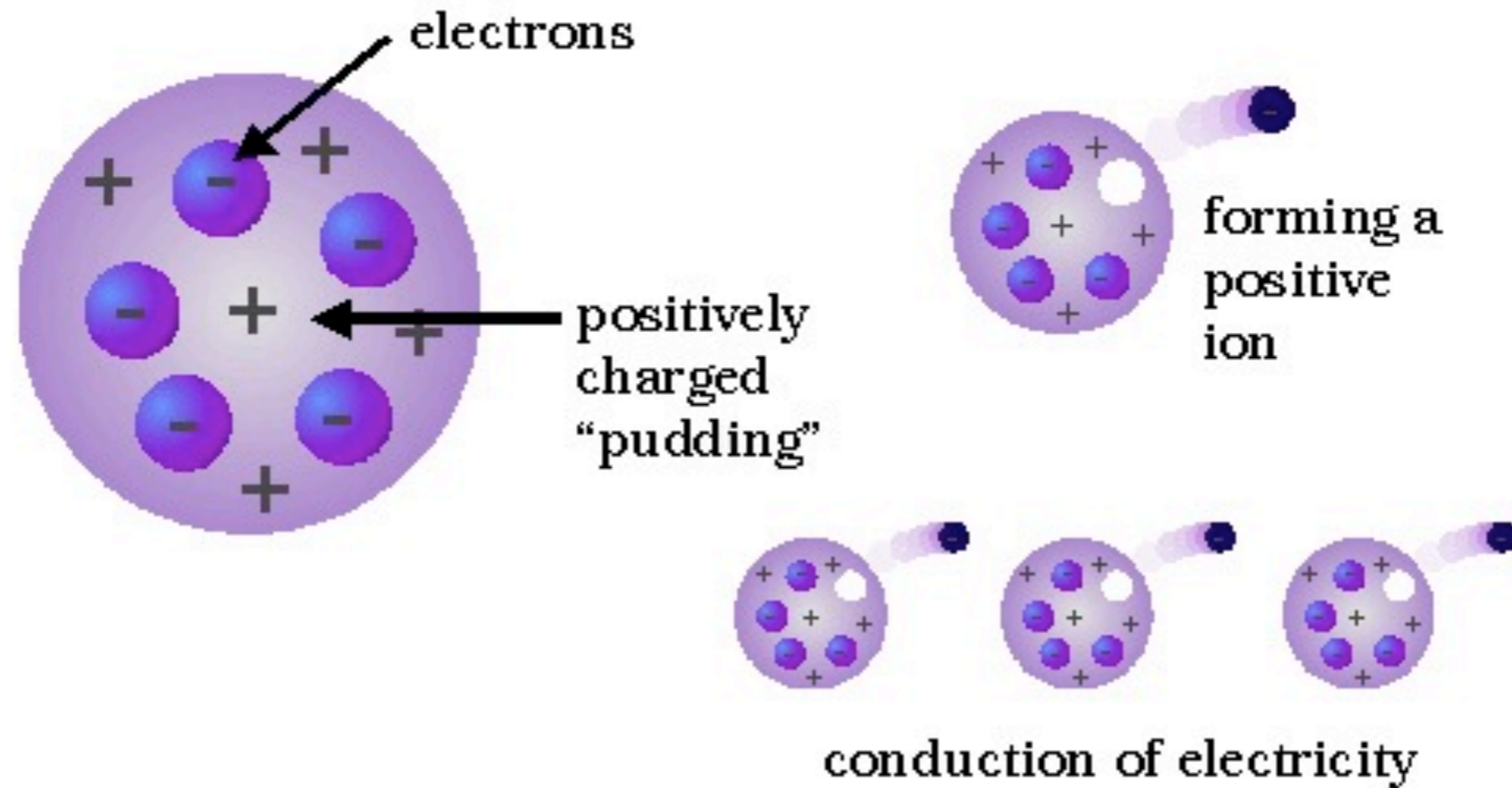
- * All matter is made of tiny indivisible particles called atoms.
- * Atoms cannot be created or destroyed.
- * All atoms of a particular element are identical.
- * Compounds are formed through the combination of elements.
- * Chemical reactions involve atoms recombining to form new substances.

J.J. Thomson

- * Studied behaviour of strange beams in evacuated glass cathode ray tubes (CRT) in 1897
- * When high voltage is applied across a CRT tube, fluorescence is produced from an invisible beam striking a ZnS coating

- * He concluded that cathode rays consist of tiny “particles”
- * These charged particles were much smaller than the tiniest atom and came from within the atoms of the metal electrode
- * These “subatomic” particles were called electrons and led to the Plum Pudding Model

Thomson's Plum Pudding Atom

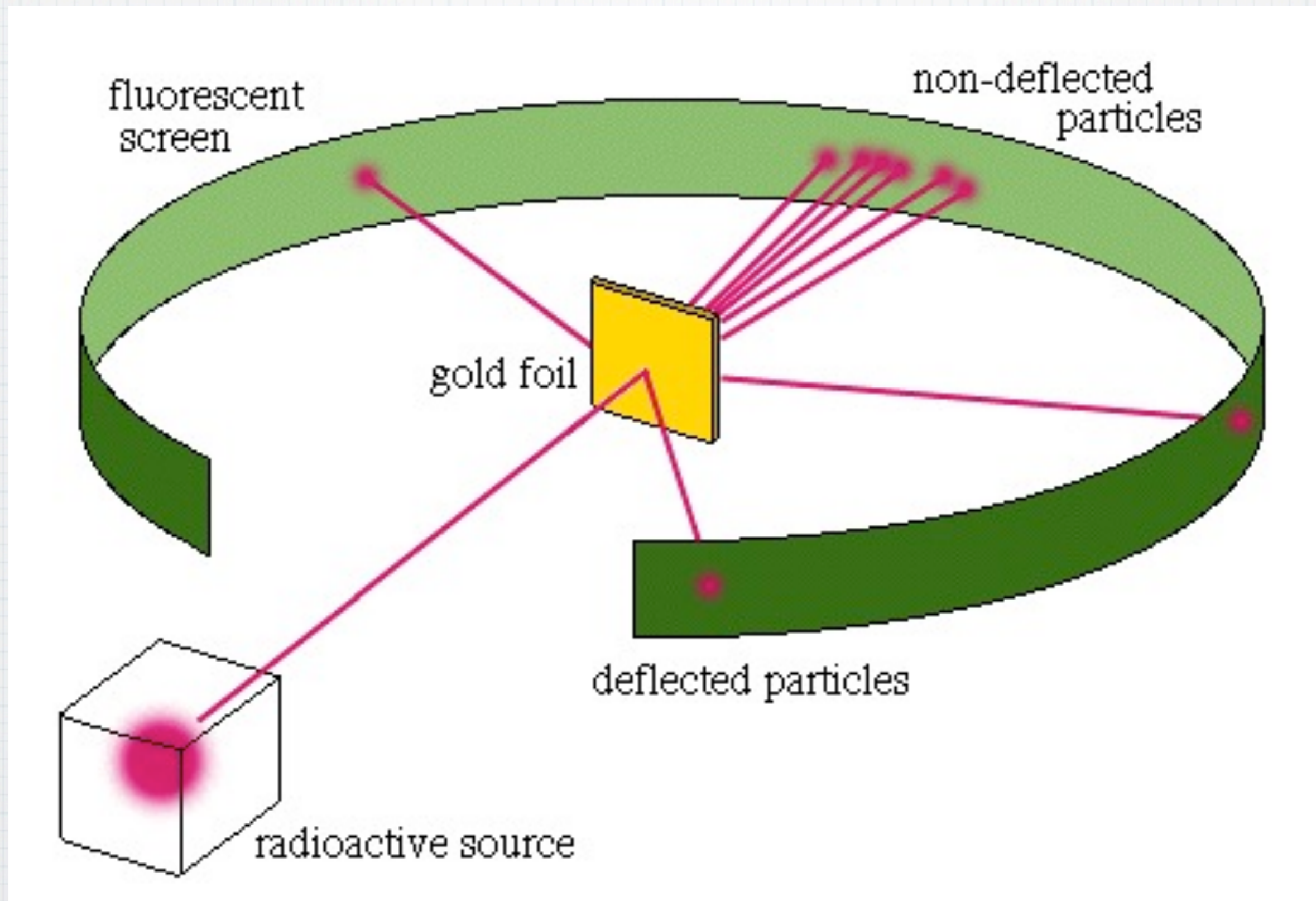


Rutherford and the Nuclear Atom

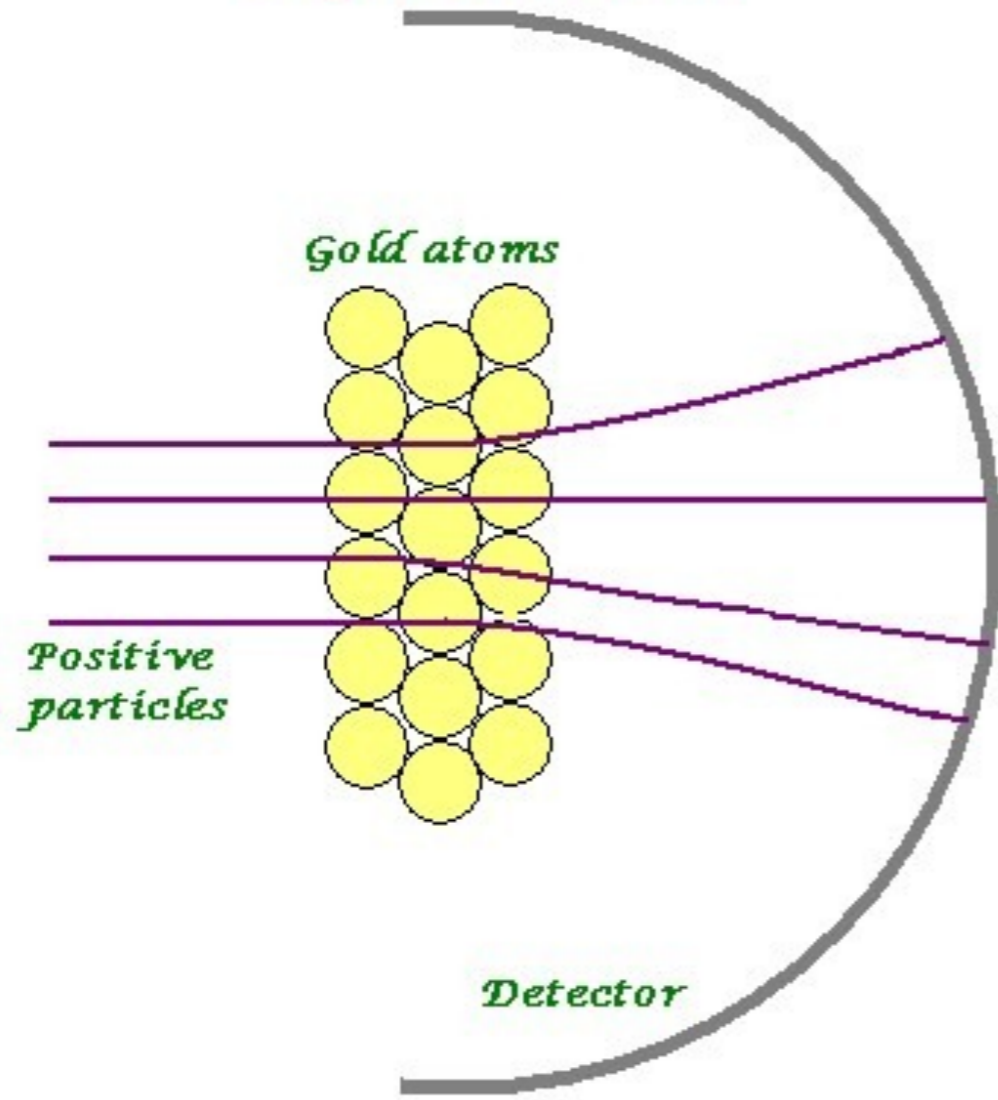
- * Work by the Curies and Bequerel led to the discovery of strange beams called radiation
- * Lead Block Experiment: Rutherford discovered radiation came in 3 forms: alpha (+), beta (-) and gamma rays
- * This radiation came from the spontaneous disintegration of unstable atoms called "radioisotopes" (e.g. radium, uranium)

Gold Foil Experiment (1909)

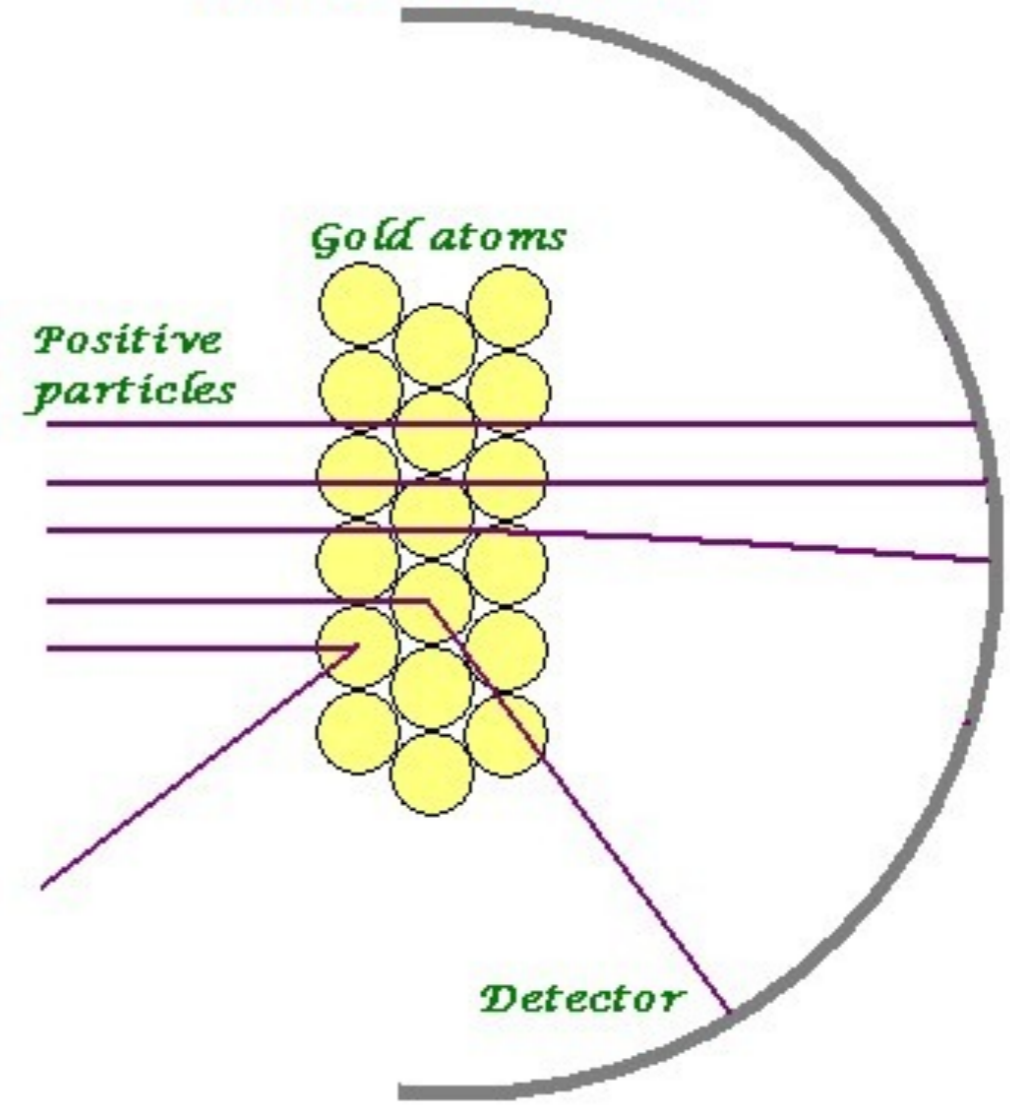
- * Rutherford proposed that a beam of alpha particles (He^{2+} ions) should have enough energy to pass through a thin gold foil and be detected on a ZnS screen behind the foil
- * The experiment initially seemed work, confirming Thomson's Plum Pudding Model of the atom with a diffuse positive sphere.



Expected result



Observed result



- Most alpha particles behaved as expected
- But 1 in 8000 deflected back (anomalies).

Rutherford's Conclusions

- * The positive charge is not distributed evenly but is in a very dense positive core.
- * Most of the atom is simply empty space occupied by tiny electrons.
- * Rutherford proposed a new model called the **Planetary Model** due to its resemblance to our solar system.

The Proton (1919)

- * Rutherford's nucleus was extremely tiny - only 1/10,000th the diameter of the entire atom!
- * Later, Rutherford proved that other atoms contain hydrogen nuclei
- * He concluded this is the simplest positively charged particle and named it the proton

The Mass Problem

- * Protons seemed to account for most of the mass of the atom
- * But evidence showed that atoms had only half the positive charge that was expected if the nucleus was composed only of protons
- * The answer to the problem came from another radioactive beam....

James Chadwick

- * In 1932, Chadwick experimented with a new type of radiation emitted from beryllium
- * The particle had no charge but almost the same mass as the proton; he called these particles neutrons

The Structure of the Atom

Particle	Symbol	Location	Charge	Mass (amu)
proton	p	nucleus	+ 1	1.007276
neutron	n	nucleus	0	1.008664
electron	e ⁻	outside nucleus	- 1	0.0005486

Overview

Democritus	Indestructible particles called atoms
Dalton	Billiard Ball Model
Thompson	Plum Pudding Model
Rutherford	Planetary Model, introduced proton
Chadwick	Neutrons

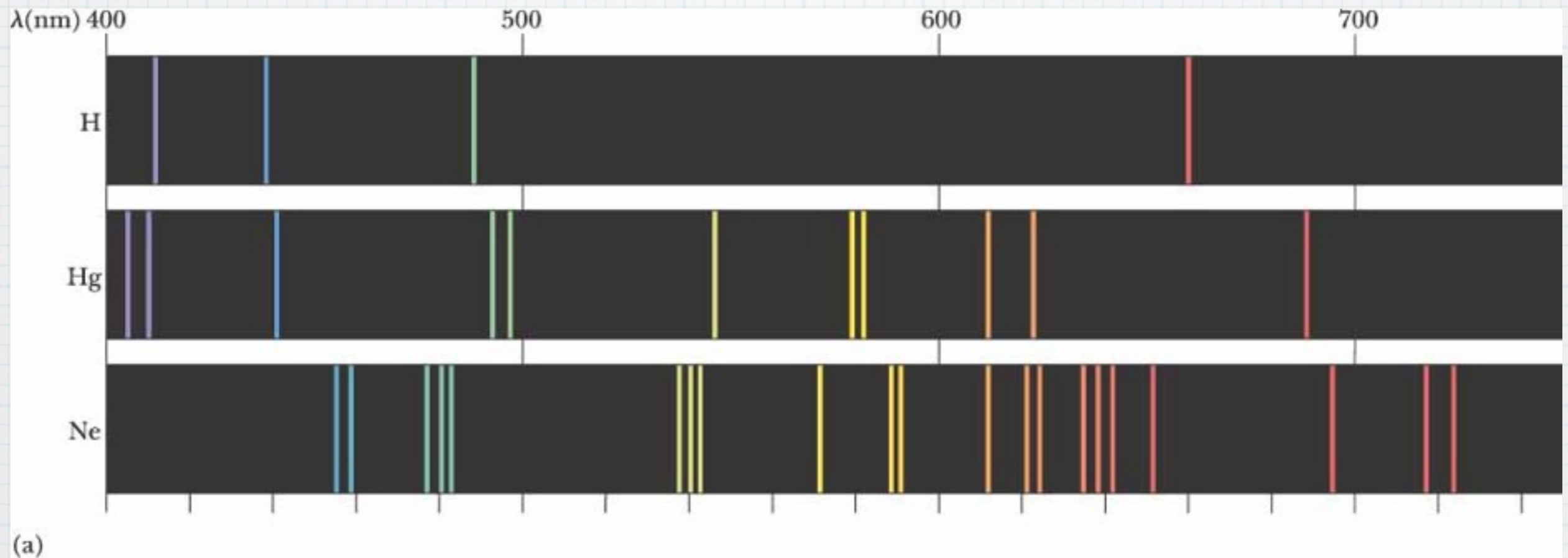
Atomic Theory

Bohr to Schrodinger

Problems with Rutherford

- * Two pieces of evidence could not be explained:
- * **The Stability of the Atom:** A charged electron orbiting a charged nucleus should lose energy as it orbits.
- * **The Line Spectra of Elements:** All elements create a unique signature colour when excited.

Each element has a unique series of lines



- * Bohr understood that the 4 visible (and other invisible) emission lines of hydrogen corresponded to specific jumps in energy levels.**
- * Electrons could only exist at specific orbits or “energy levels” around the nucleus.**

Bohr's Shell Model

- * 1. Electrons can only occupy certain discrete orbits or energy levels.
- * 2. Electrons can exist in an energy level without losing energy.
- * 3. Electrons absorb or release energy only when they change their energy levels.

The Bohr Model and Electron Arrangement

- * Bohr's orbits (energy levels) can only hold a certain number of electrons (2, 8, 8...)
- * When an inner orbit is filled, electrons occupy orbits further from the nucleus
- * Bohr's shell model finally explained the structure of the Periodic Table, which had been published in 1869!

Modern Atomic Theory: Schrodinger

- * Used Schrodinger wave equation to describe atoms in terms of energy.
- * Showed electrons don't orbit in fixed orbits but rather in clouds.
- * Electron "cloud" around nucleus.
- * Exact location of electron is not known.
- * Theory is known as 'Electron Cloud Model.'

