



# Structure of the Atom

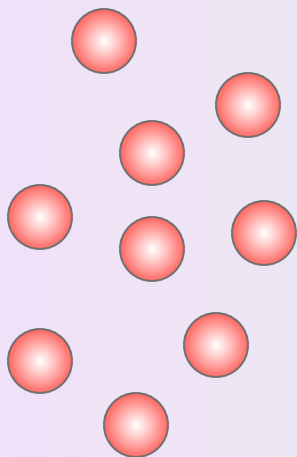
# Chemistry Timeline

**Democritus** — Fifth century B.C.

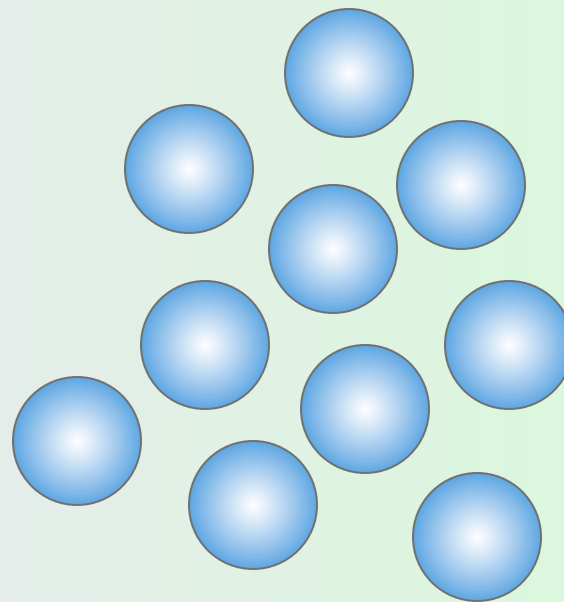
- Matter is composed of individual particles called “atomos”

# Dalton's Atomic Theory—1808

1. Elements are composed of extremely small particles called atoms. All atoms of a given element are identical, having the same size, mass and chemical properties. The atoms of one element are different from the atoms of all other elements.



**Atoms of Element X**



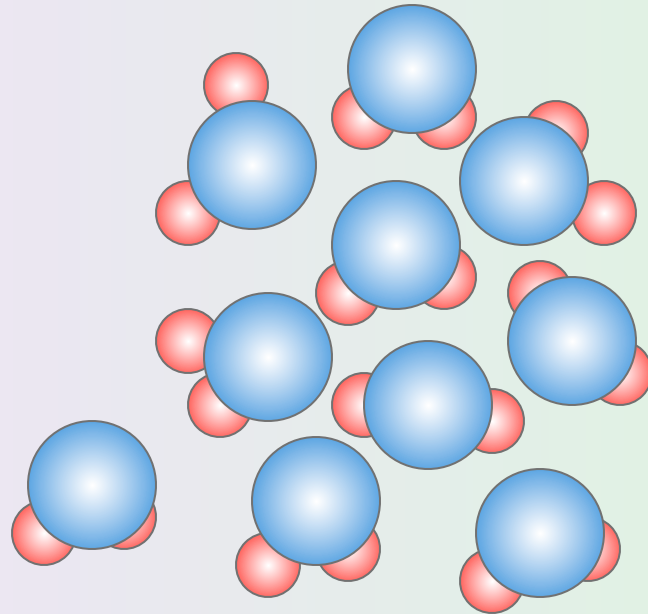
**Atoms of Element Y**

According to Dalton's atomic theory, atoms of the same element are identical, but atoms of one element are different from atoms of other elements.

# Dalton's Atomic Theory—1808

1. Elements are composed of extremely small particles called atoms. All atoms of a given element are identical, having the same size, mass and chemical properties. The atoms of one element are different from the atoms of all other elements.

2. Compounds are composed of atoms of more than one element. In any compound, the ratio of the numbers of atoms of any two of the elements present is either an integer or a simple fraction.



## Compound of Elements **X** and **Y**

In this example, the ratio of the atoms from element X to the atoms from element Y is 2:1.

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incorporates laws of definite proportions  
and multiple proportions

# Dalton's Atomic Theory—1808

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2. Compounds are composed of atoms of more than one element. In any compound, the ratio of the numbers of atoms of any two of the elements present is either an integer or a simple fraction.
3. A chemical reaction involves only the separation, combination or rearrangement of atoms; it does not result in their creation or destruction.



# Fundamental Chemical Laws

## **Law of Definite Proportions**

- different samples of the same compound always contain its constituent elements in the same proportions by mass

## **Law of Multiple Proportions**

- if two elements can combine to form more than one compound, the masses of one element that combine with a fixed mass of the other elements are in ratios of small whole numbers

## **Law of Conservation of Mass**

- matter can neither be created nor destroyed

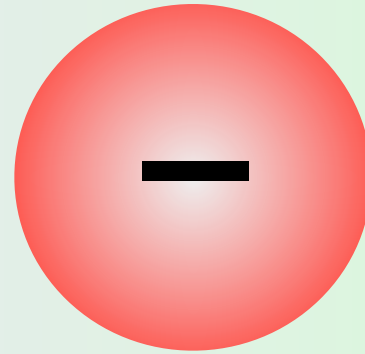
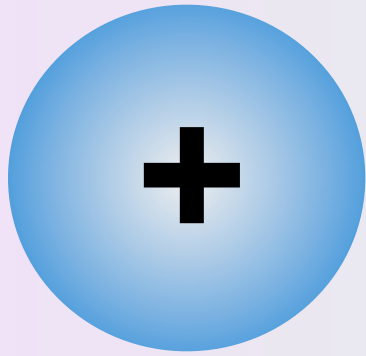
**On the basis of Dalton's Atomic Theory:**

**An atom is the basic unit of an element that can enter into chemical combination.**

# Three major differences between modern atomic theory and Dalton's atomic theory

1. Atoms are **NOT** indivisible. They are made up of smaller particles: electrons, protons and neutrons.
2. Atoms **CAN** be changed from one element to another, but **NOT** by chemical reactions.
3. Atoms of the same element are **NOT** exactly alike. They can have different masses.

# **Interactions Between Electric Charges**



## **positive and negative charges**

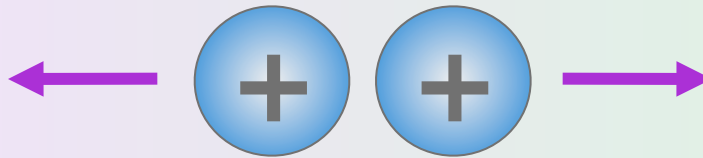
- **objects with an equal amount of positive and negative charge are said to be electrically neutral**

# Forces between charges

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## Electrostatic Force

- objects with like charge repel



# Forces between charges

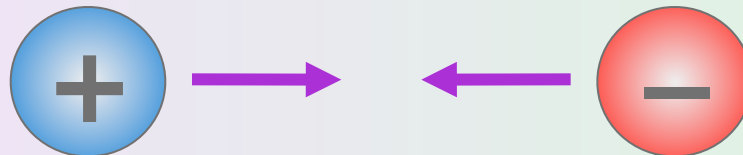
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## Electrostatic Force

- objects with like charge repel



- objects with opposite charge attract

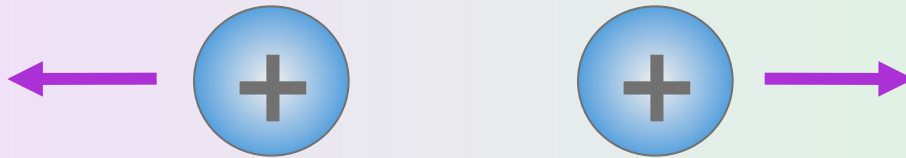


# Forces between charges

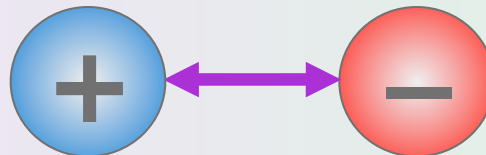
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## Electrostatic Force

- objects with like charge repel



- objects with opposite charge attract





# Forces between charges (cont...)

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- **electrostatic force becomes greater the more excess charge**
- **electrostatic force becomes smaller the greater the distance separating the charges**

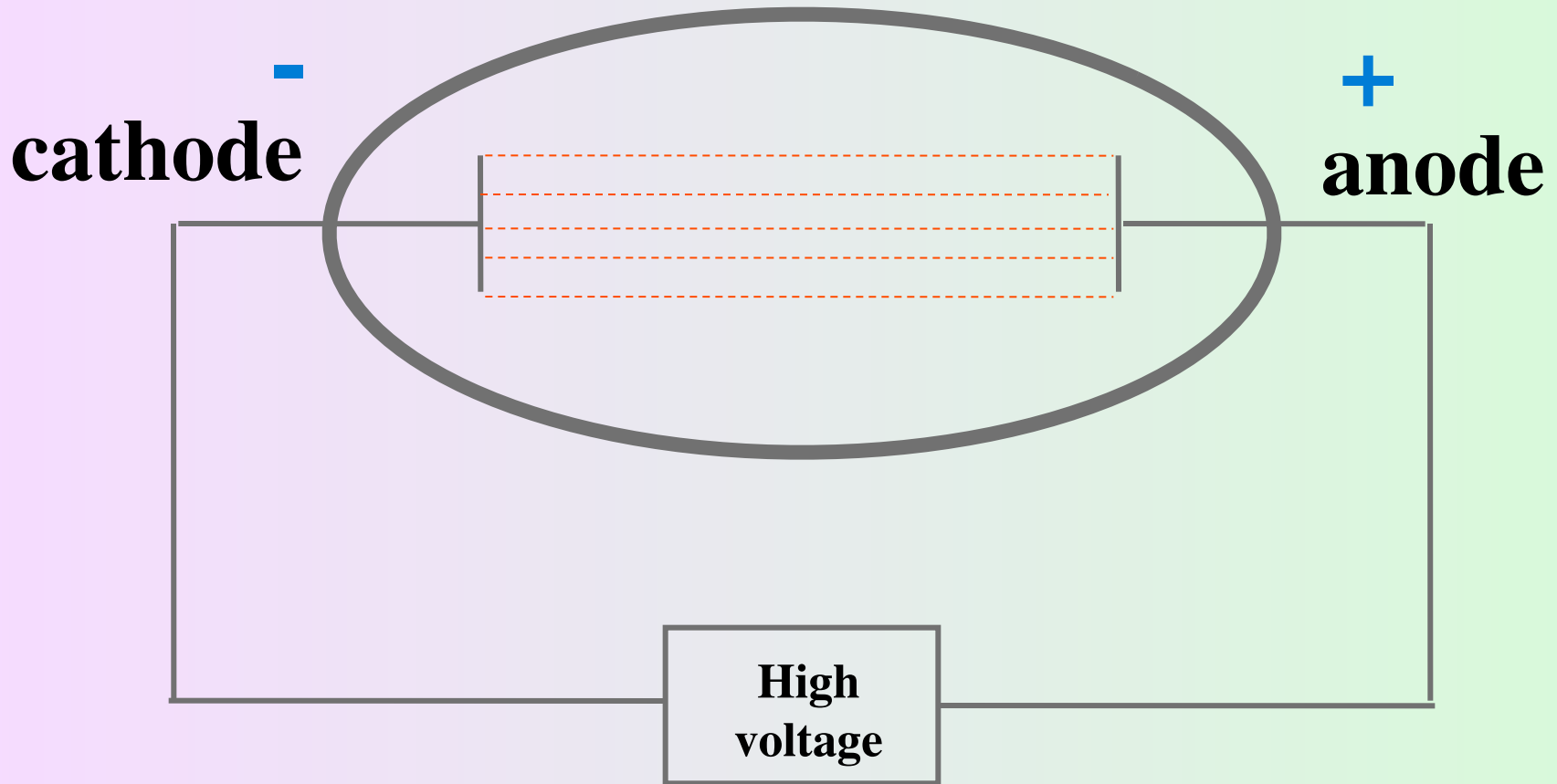
# Searching for Atomic Structure

# The Electron

The charge-to-mass ratio of an electron was determined by physicist **J.J. Thomson** in a series of experiments done between 1908 and 1917.

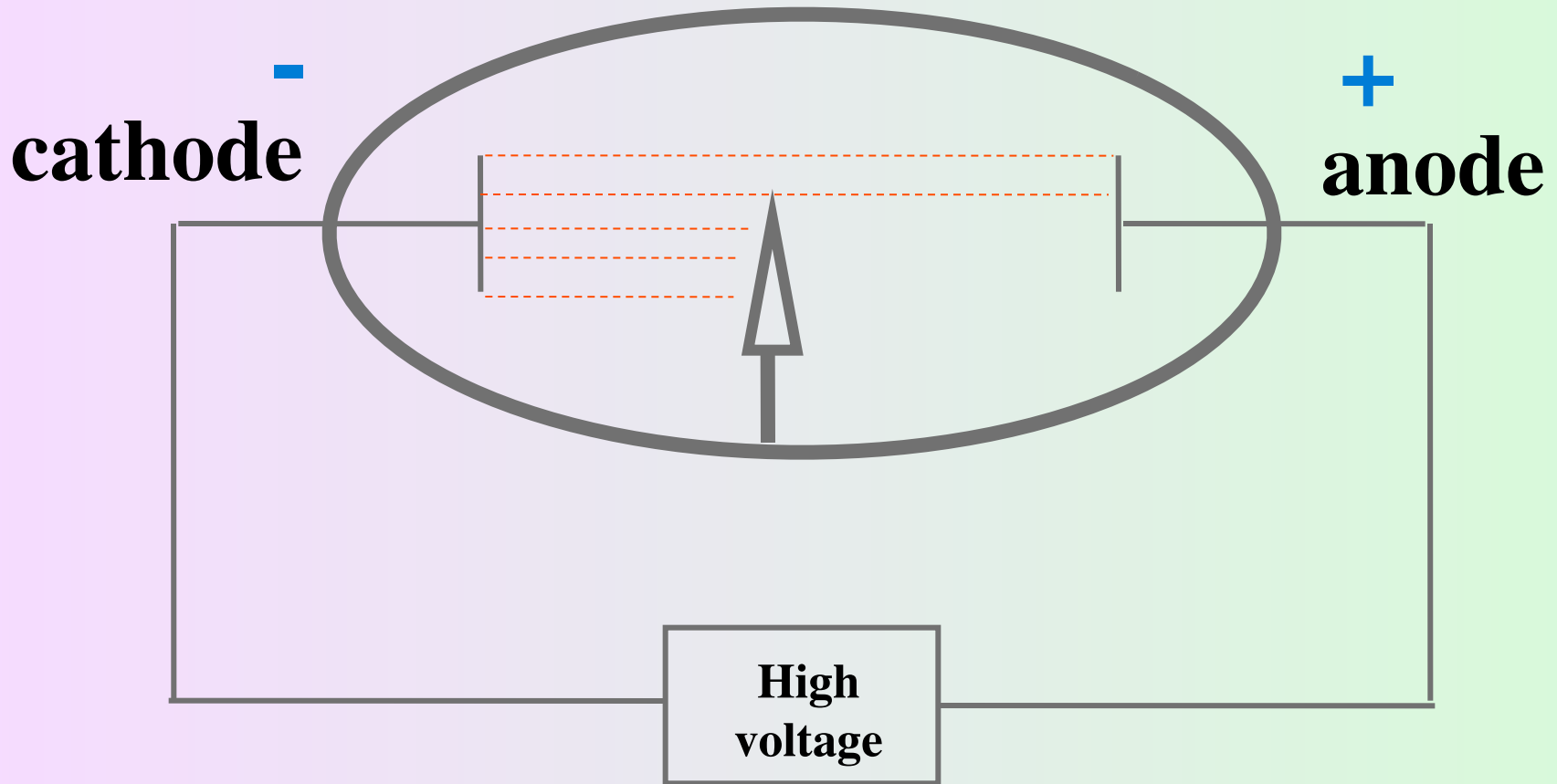
**charge-to-mass ratio =  $-1.76 \times 10^8$  coulomb/g**

# Cathode Ray Tube



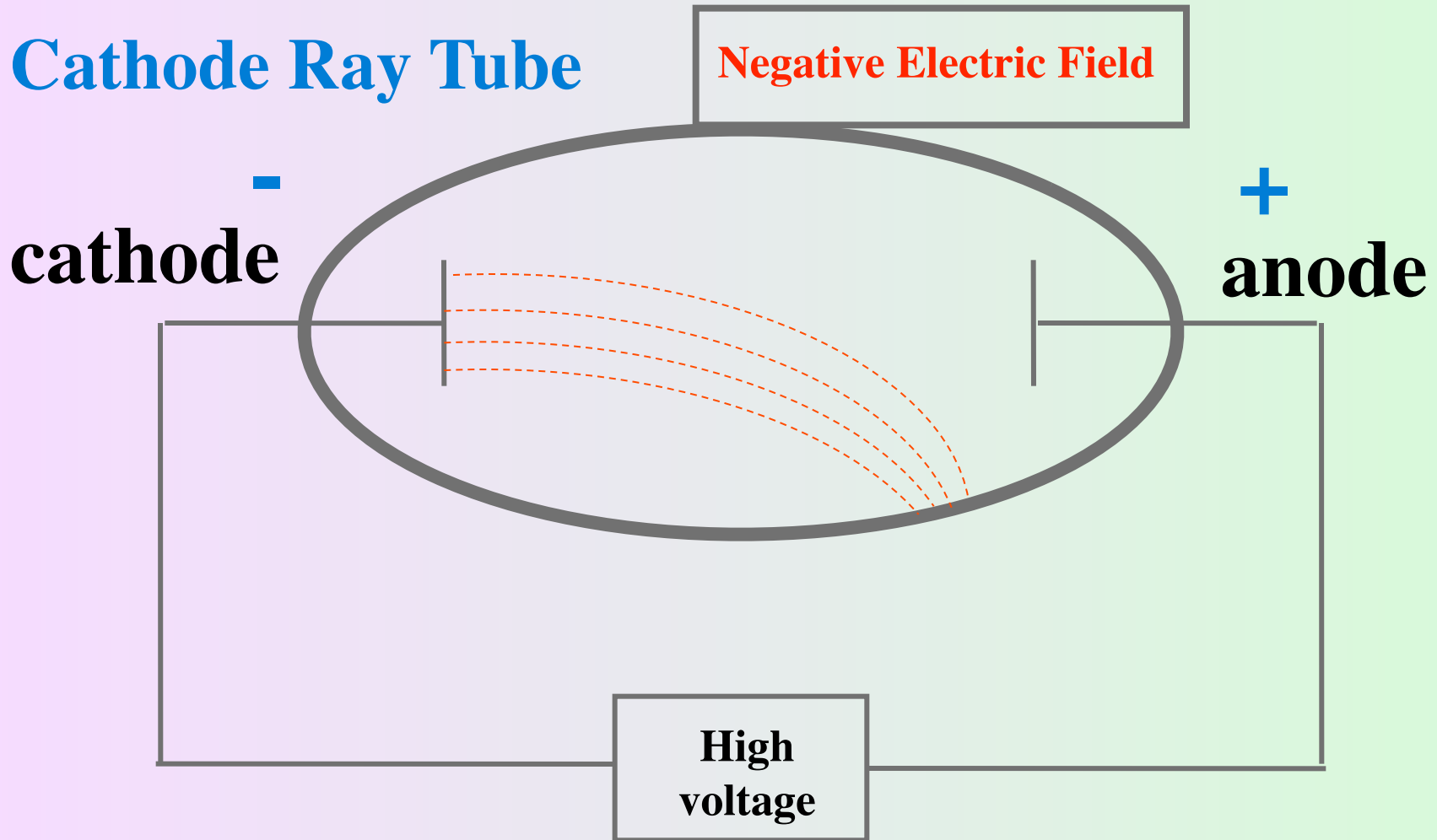
**When high voltage is applied to the electrodes a glow was noticed between them.**

# Cathode Ray Tube



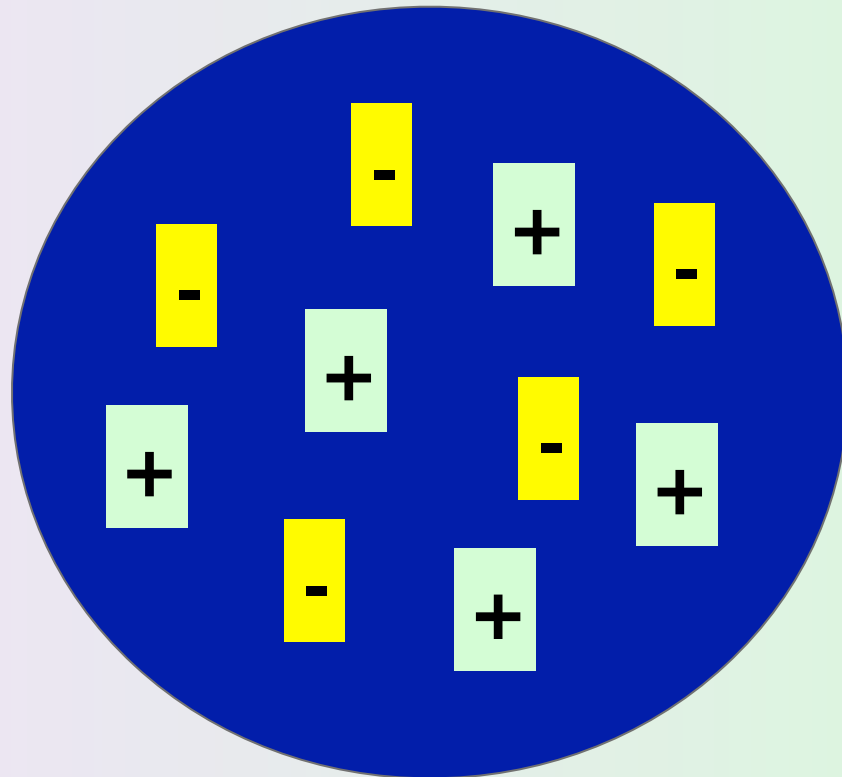
**When an object was placed in the path of the glow, it blocked part of the beam showing that the beam originated at the negative electrode.**

# Cathode Ray Tube



The fact that the rays were repelled by the negative electric field indicated that they had a negative charge with an  $e/m$  ratio of  $-1.76 \times 10^8$

# J.J. Thomson's plum pudding model

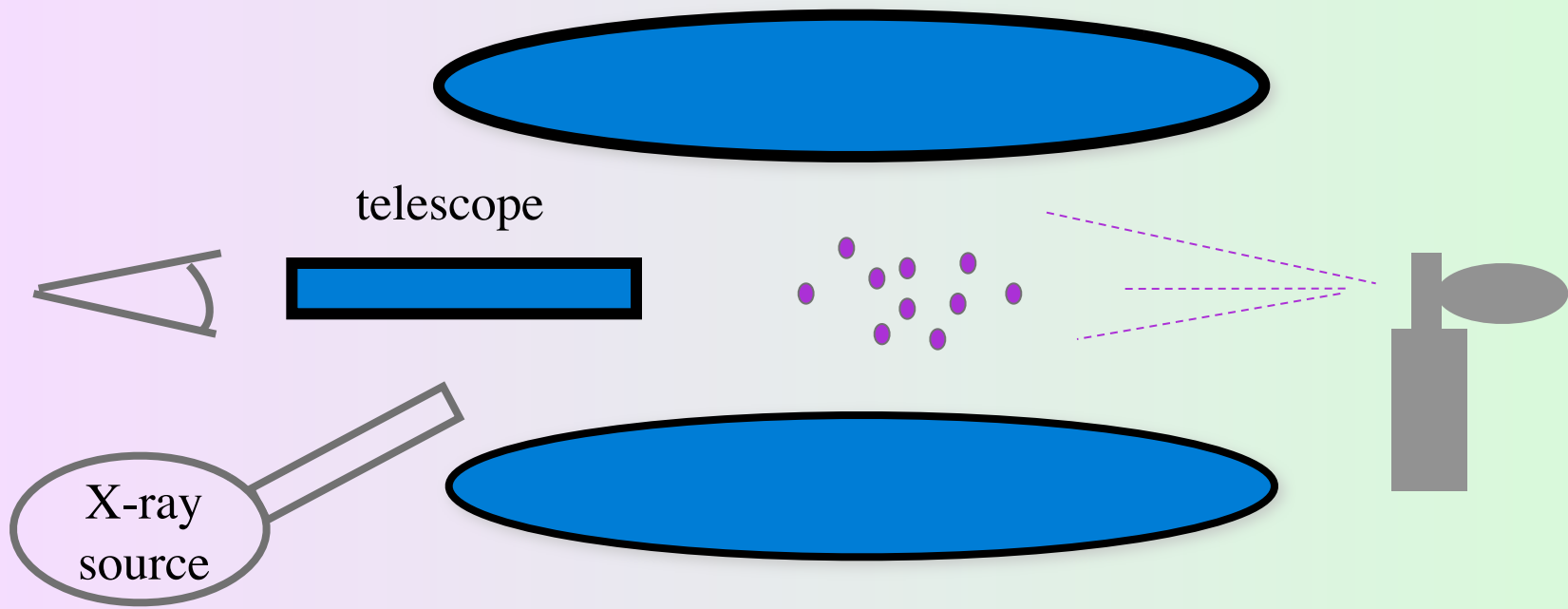


# The Electron

**R.A. Millikan measured the charge of an electron to be  $-1.60 \times 10^{-19}$  coulomb**

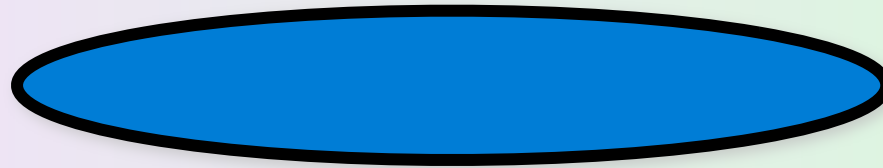
**Since the charge-to-mass ratio is  $-1.76 \times 10^8$  coulomb/g, the mass of an electron must be  $9.11 \times 10^{-31}$  kg.**



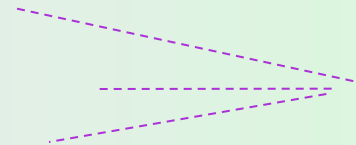
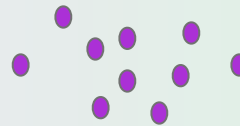


**Oil droplets settle into a beam of X rays causing them to become charged with electrons.**

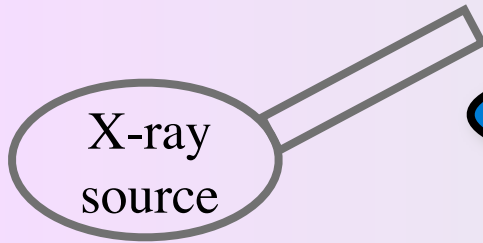
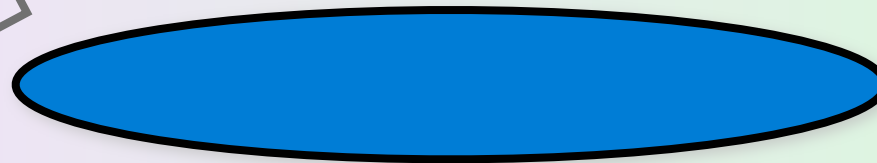
Positively charged plate +



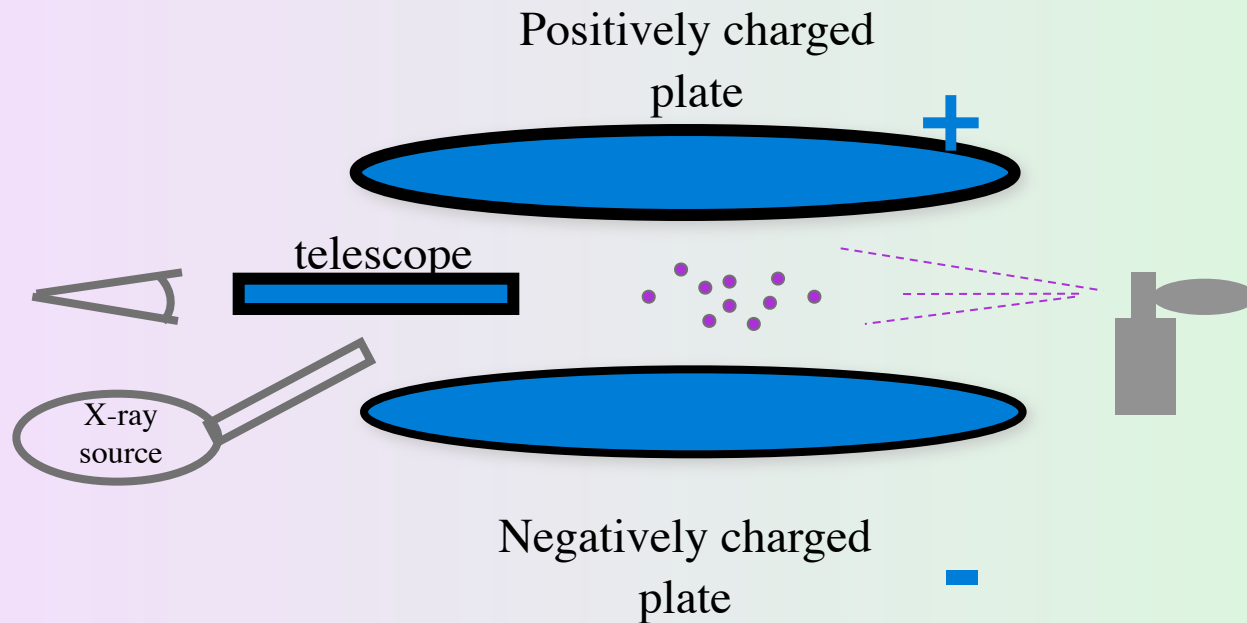
telescope



Negatively charged plate -



**A positive plate attracts the “negative oil droplets” the negative plate repels them making the droplets stand still**



Knowing the density of the oil, Millikan could calculate the mass,  $m$ , of each oil droplet (**volume x density = mass**)

the force of gravitational attraction was  **$Force = m G$**

the force of electrical force was  **$Force = E e$**

*$E$  is the applied voltage,  $e$  is the charge of the electron*

$$m_{droplet} G = E e$$

$$e = -1.6 \times 10^{-19} \text{coulomb}$$

**It was found that certain elements  
spontaneously emit radiation**

# Radioactivity

**Radioactive substances emit three kinds of particles and/or radiation(light):**

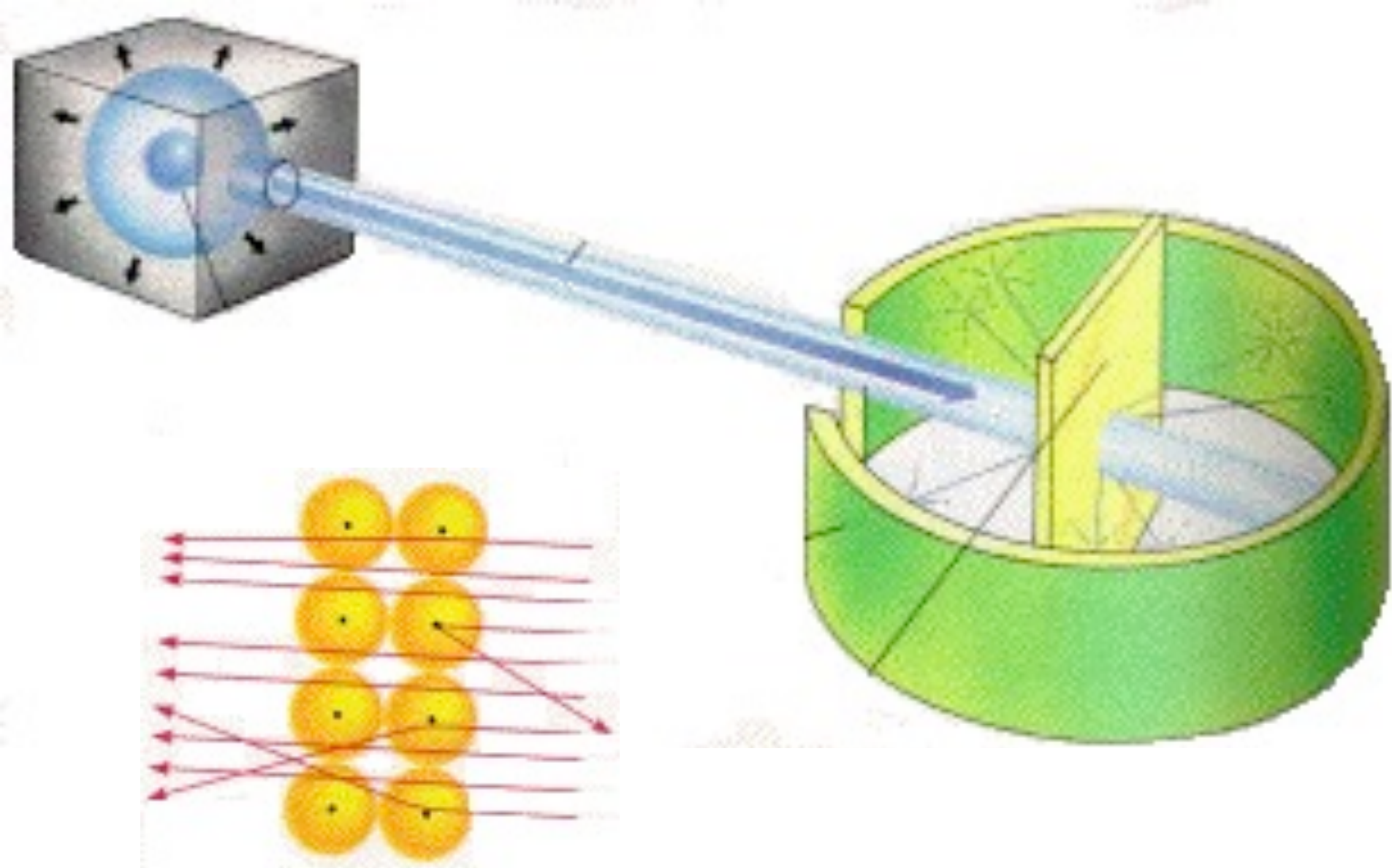
**$\alpha$  particles (helium nuclei)**

**$\beta$  particles (electrons)**

**$\gamma$  rays**

# The Nucleus

**Ernest Rutherford** (gold foil experiment) deduced the nuclear model of the atom, with an extremely small, dense and positively charged nucleus surrounded by empty space sparsely occupied by electrons.



Positive alpha particles(helium nuclei)  
deflected by positive gold nuclei

# The Proton

**Ernest Rutherford** discovered that the positive charge was not spread out over the entire volume of the atom but was concentrated in the nucleus.

The positively charged particles in the nucleus are called protons. They have the same charge as an electron but have almost 2,000 times more mass.



# **Rutherford's Atomic Model left one major problem**

**It was known that the hydrogen atom contained one proton and that the helium atom contained two protons. So the mass ratio should have been 2:1.**

**In reality the ratio is 4:1.**

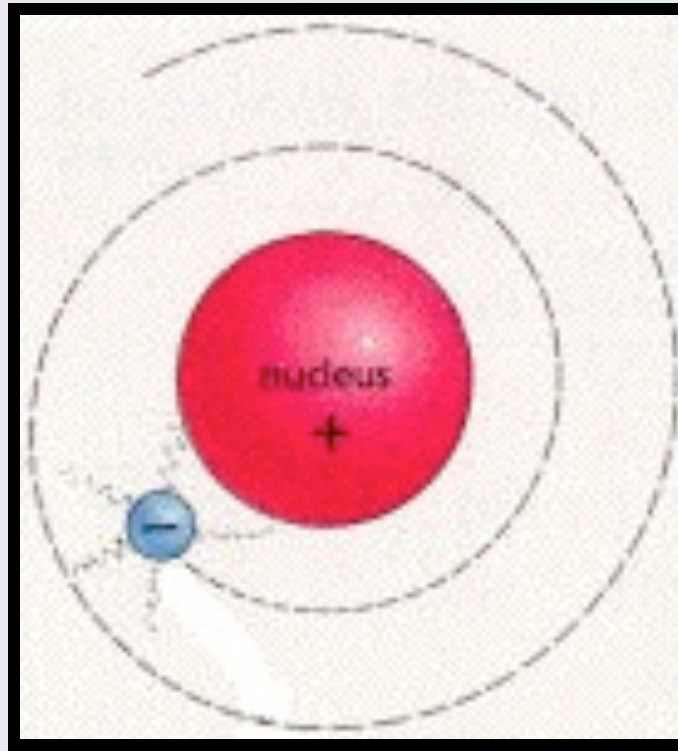
**There must be another particle...**

# The Neutron

Was discovered by **James Chadwick** in 1932. It is neutral (uncharged) and has slightly greater mass than a proton.

**Mystery solved.**

# **Shortcomings of Rutherford's Model**



Classical physics states that a charged particle traveling in a curved path radiates energy.

Electrons would continually give off energy, slow down and spiral in towards the nucleus.

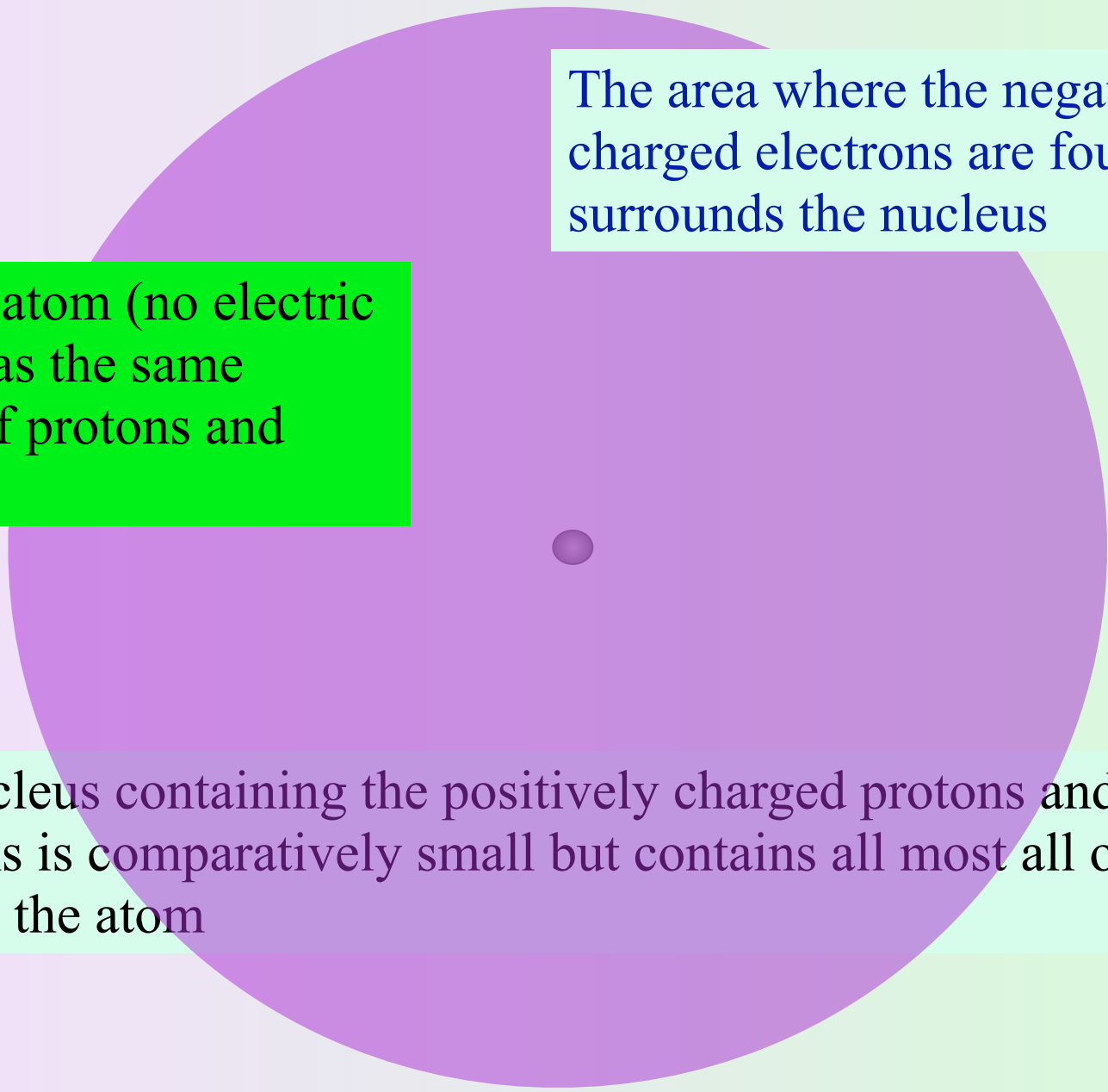
The properties of atoms and molecules are not governed by the same physical laws as larger objects.

**Quantum Mechanics:**

the physics of the very small

*To be continued*

# **The Modern View of Atomic Structure**

A diagram of an atom. A large, light purple circle represents the electron cloud. In the center of this circle is a small, dark purple dot representing the nucleus. Three text boxes are overlaid on the diagram: a green box on the left, a light blue box at the top right, and a light green box at the bottom.

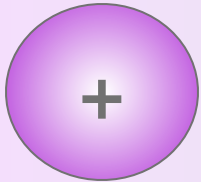
The area where the negatively charged electrons are found surrounds the nucleus

A neutral atom (no electric charge) has the same number of protons and electrons.

The nucleus containing the positively charged protons and neutral neutrons is comparatively small but contains almost all of the mass in the atom

# Atoms are composed of

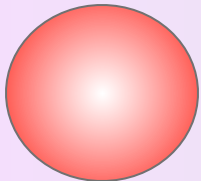
## PROTONS



positively charged

mass =  $1.6726 \times 10^{-27}$  kg

## NEUTRONS



neutral

mass =  $1.6750 \times 10^{-27}$  kg

## ELECTRONS

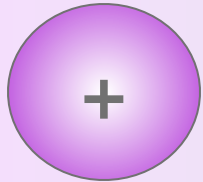


negatively charged

mass =  $9.1096 \times 10^{-31}$  kg

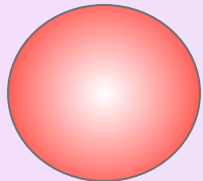


## PROTONS



positively charged

## NEUTRONS



neutral

## ELECTRONS



negatively charged

mass =  $9.1096 \times 10^{-31}$  kg

## Nucleons

General term for a particle found in the nucleus