The Beginnings of Atomic Theory

〉 Who came up with the first theory of atoms?

〉 In the fourth century BCE, the Greek philosopher Democritus suggested that the universe was made of indivisible units called atoms.

- Democritus did not have evidence for his atomic theory.

- **Dalton agreed with Democritus:**
  Elements are made up of atoms.
- Atoms cannot be divided, created, or destroyed.
- What did Dalton add to the atomic theory?
- **According to Dalton,**
- **1. All atoms of a given element were exactly alike,**
- **2. Atoms of different elements could join to form compounds. (This "joining" is called a chemical reaction.)**
- **3. The elements "join" in definite proportions or ratios**
  - **Example Water is always 2 parts hydrogen and 1 part oxygen** → H_2O

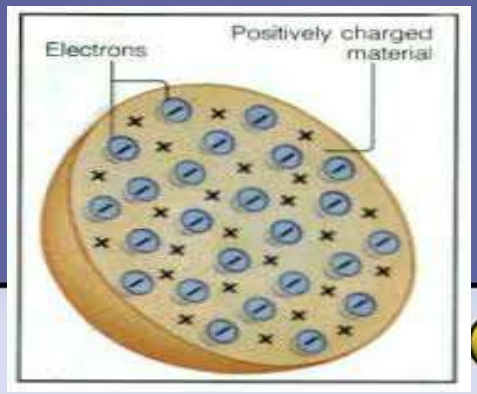
- ..\..\..\..\Videos\John Dalton's Atomic Theory.mp4

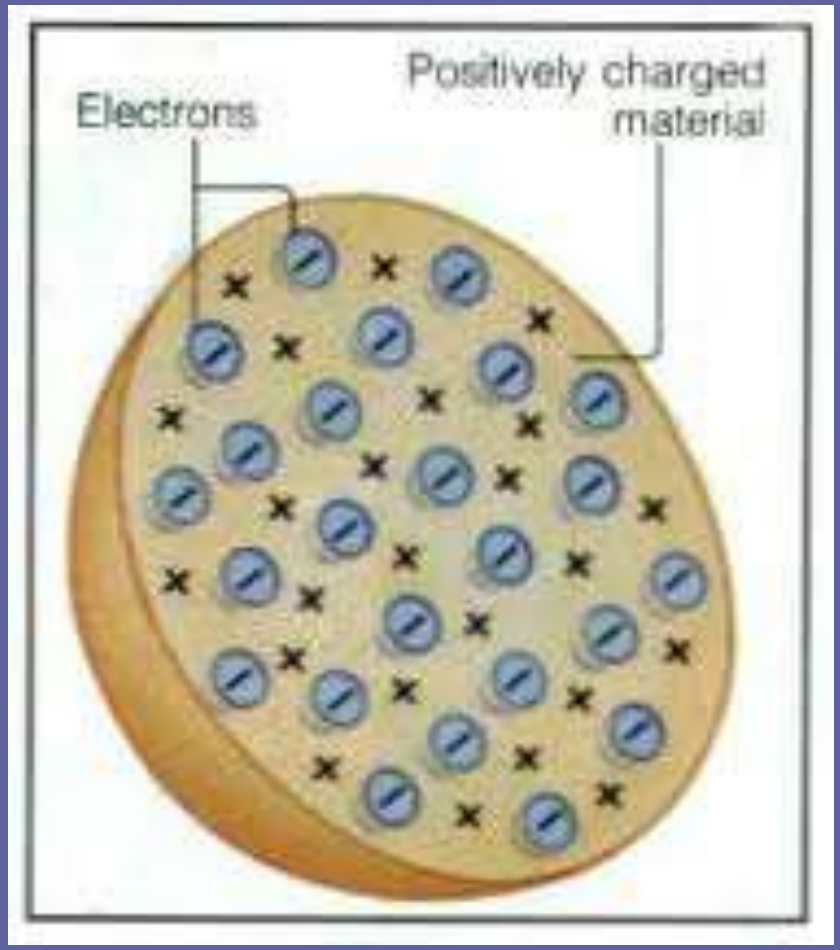
Thomson's Model of the Atom

- How did Thomson discover the electron?
- Thomson's cathode-ray tube experiment suggested that cathode rays were made of negatively charged particles that came from inside atoms.

Thomson's Model of the Atom, *continued*

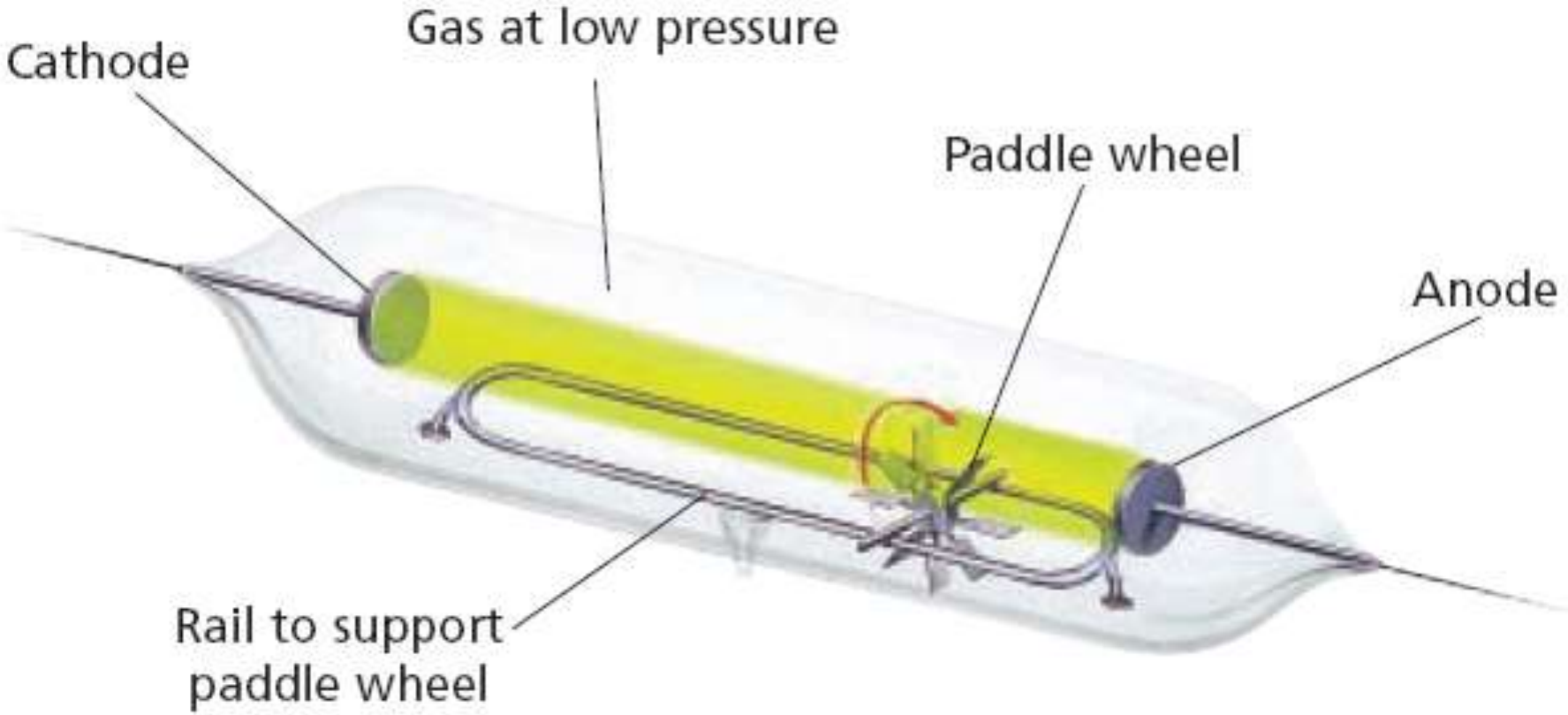
- Thomson developed the plum-pudding model.
  - In his cathode-ray tube experiment, Thomson had discovered electrons.
    - **electron:** a subatomic particle that has a negative charge
  - Thomson's *plum-pudding model:* electrons are spread throughout the atom, like blueberries in a muffin



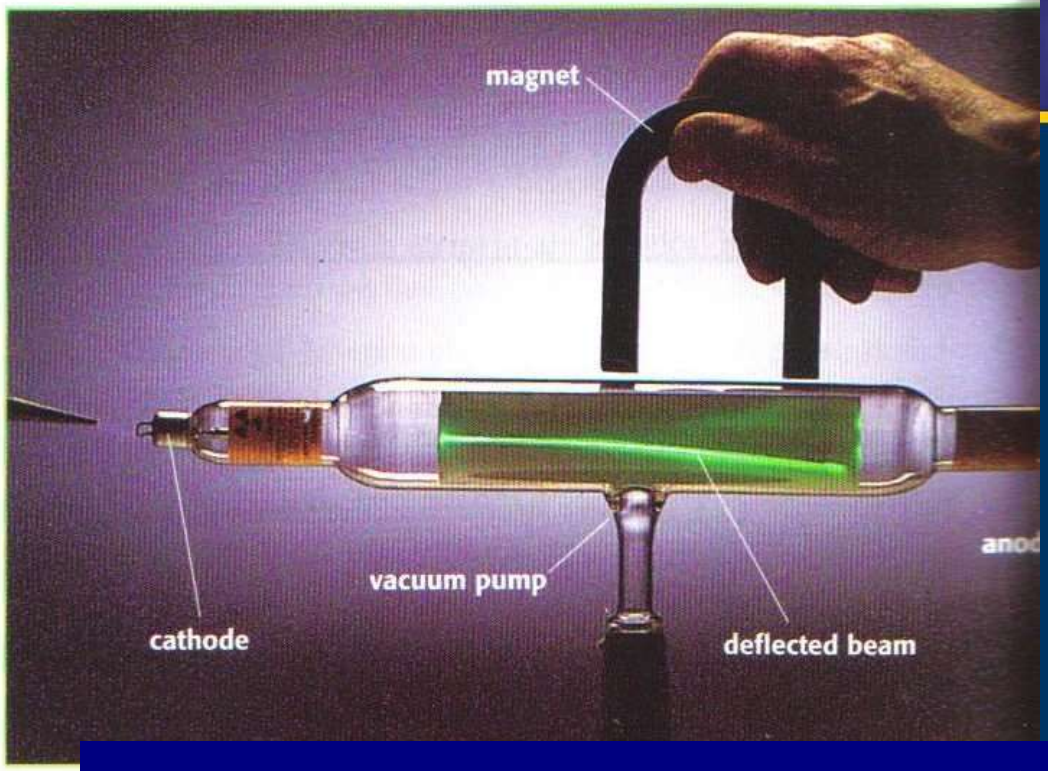


The Experiment and data

A paddle wheel placed in the path of the cathode ray moves away from the negatively charged cathode and toward the positively charged anode



Data/ Results



The green ray bent away from a negative charge and a negative magnetic field and towards positive fields.

No matter what gas was used the ray spun the paddle wheel and bent away from negative towards positive.

Furthermore, *experimental evidence showed atoms to be electrically neutral (they would not be deflected by negative or positive charges)*

Types of Elements

Metals

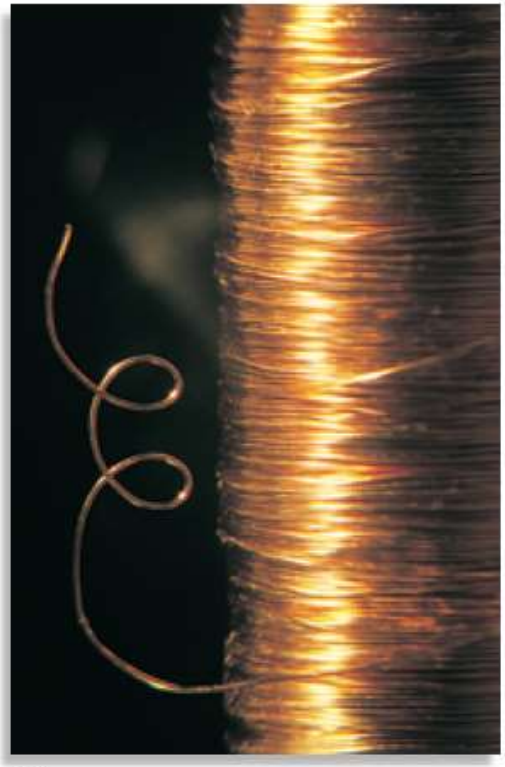
- A **metal** is an element that is a good electrical conductor of electrical charge and a good heat conductor.
    - most are solids at room temperature
    - malleable - they can be hammered or rolled into thin sheets
    - ductile - they can be drawn into a fine wire

End of Slide

Types of Elements

- Gold, copper, and aluminum are metals


(a)


(b)


(c)

Types of Elements

Nonmetals

- A **nonmetal** is an element that is a poor conductor of electrical charge and a poor conductor of heat.
  - Properties of nonmetals
    - many are gases
    - solids are brittle
    -

End of Slide

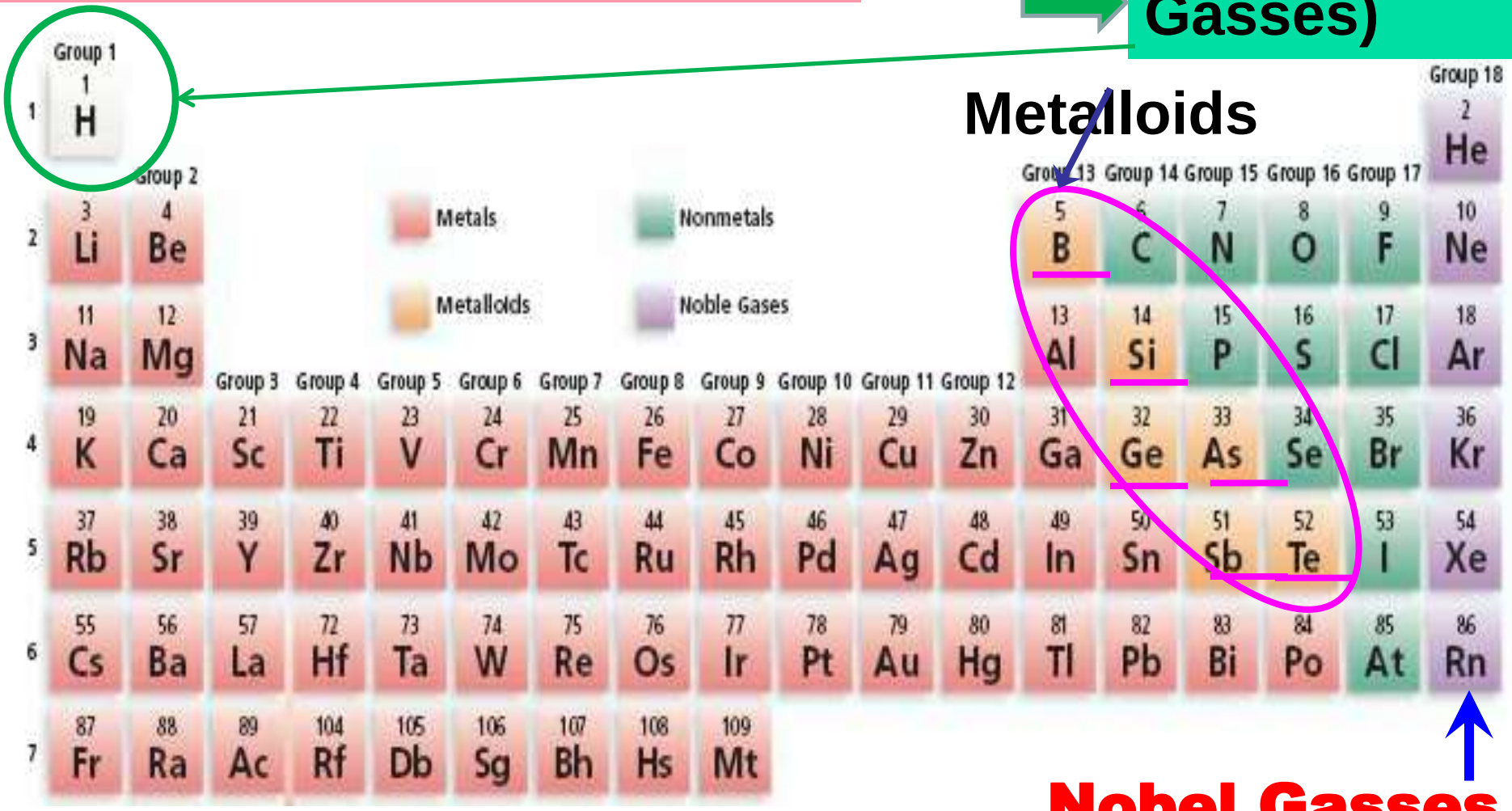
Types of Elements

- **Various nonmetal elements**

(a) carbon, (b) sulfur, (c) phosphorus, and (d) iodine

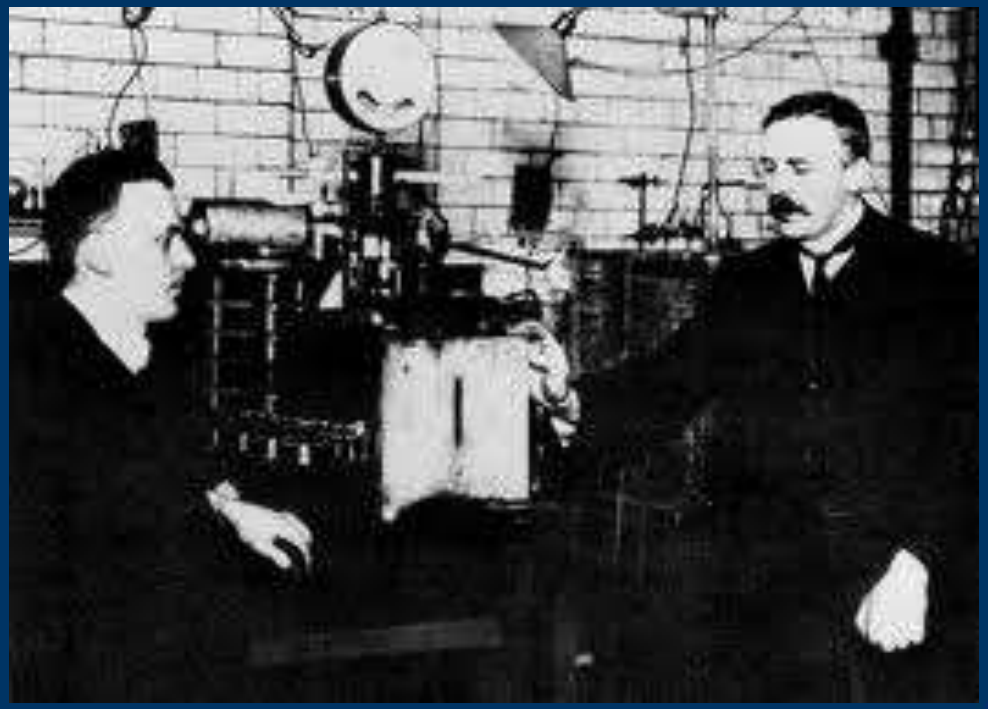
Metals (except H, which is is a non-metal)

Non-metals (includes the Nobel Gasses)



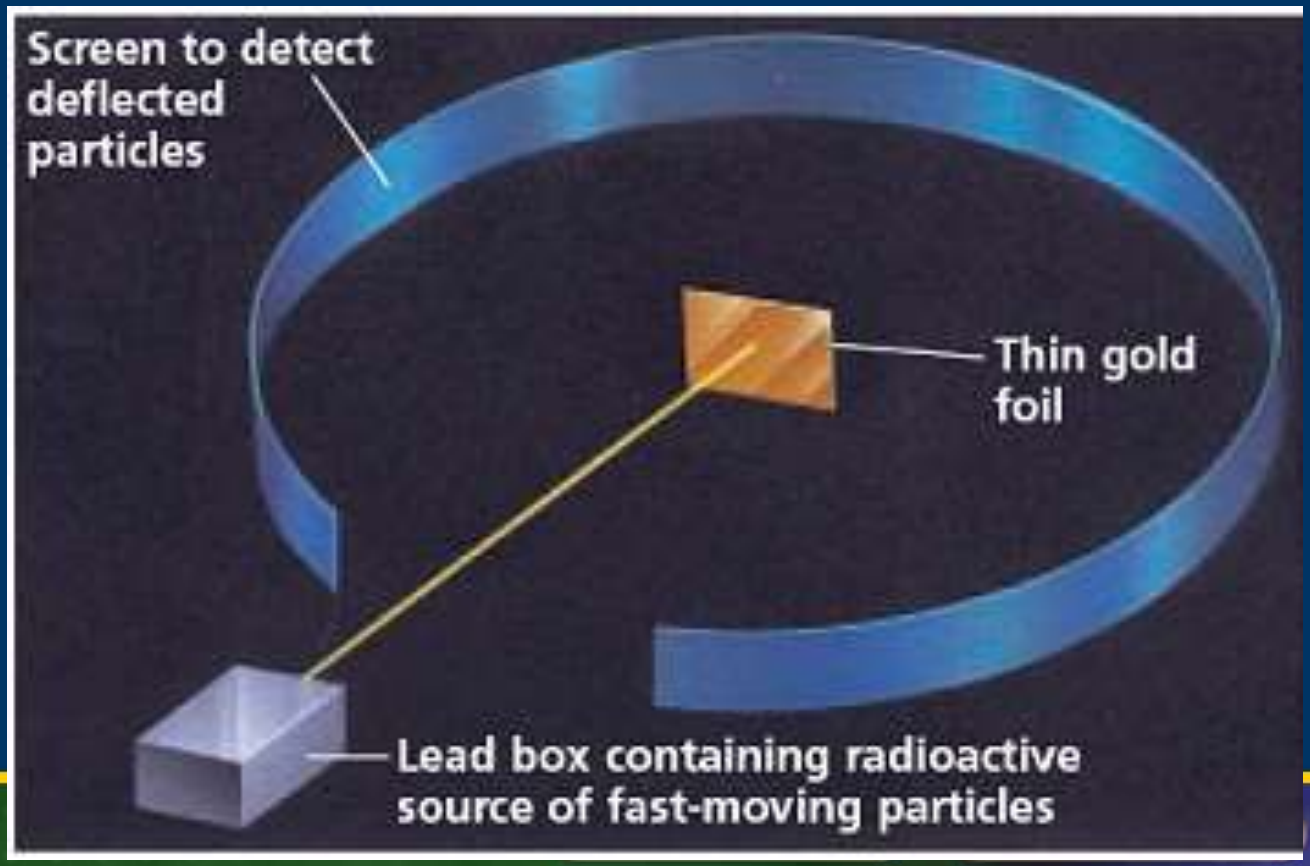
Metals to the left of the stairs, non-metals to the right.

Ernest Rutherford

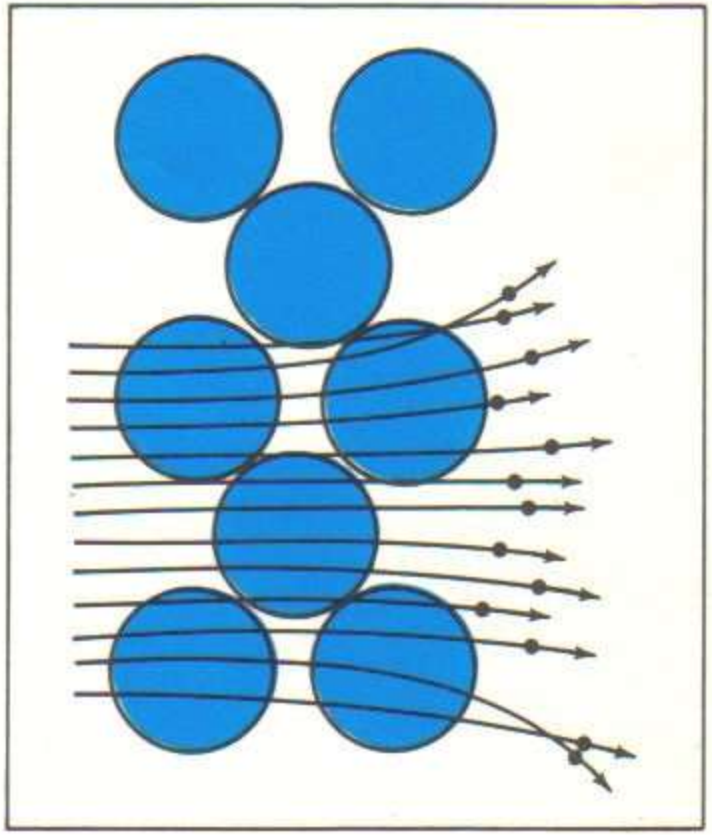


In 1911 Ernest Rutherford decided to test Thompson's theory that states the atom is net neutral at any given point

He did this by shooting positively charged particles, called alpha particles, at atoms.

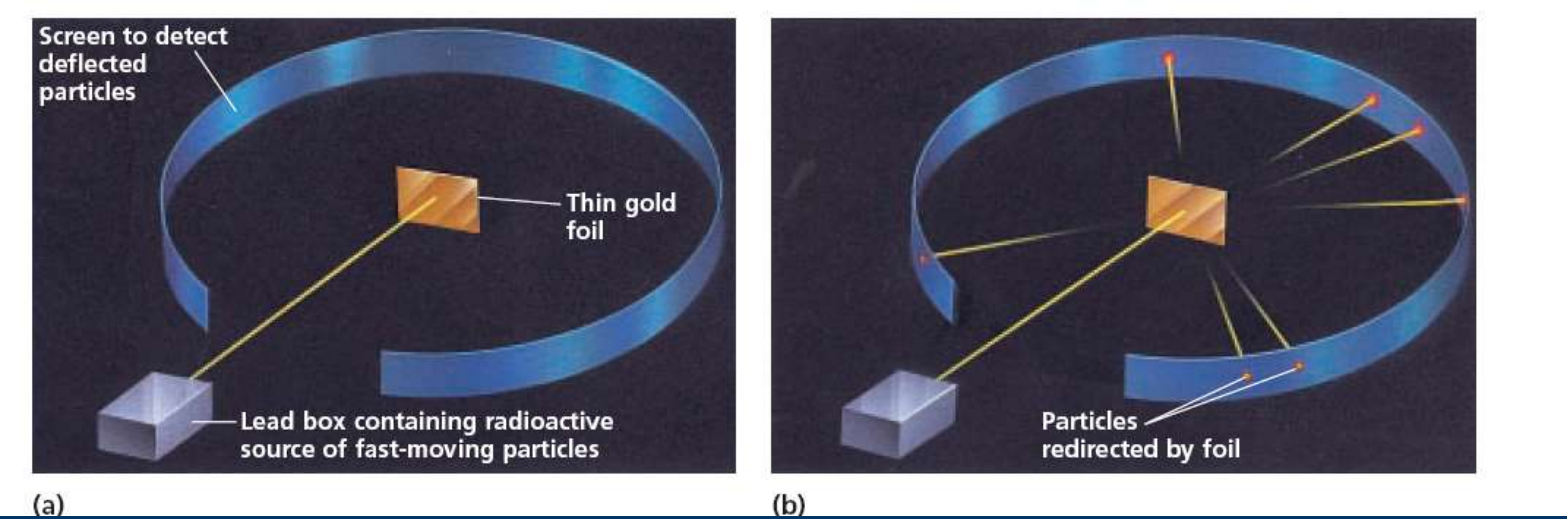


Rutherford's 1st hypothesis: the positively charged alpha particles will scatter per the figure because the Thompson theory states the atom is net neutral at any given point



The figure shows how the alpha particle scattering would look like if the Thompson theory was correct.

Rutherford's 1st hypothesis: the positively charged alpha particles will scatter per figure 8-13 because the Thompson theory states the atom is net neutral at any given point.



Rutherford's experiment gave a result that hypothesis could not explain.

Figure 8-13 show how the alpha particle scattering would look like if the Thompson theory was correct.

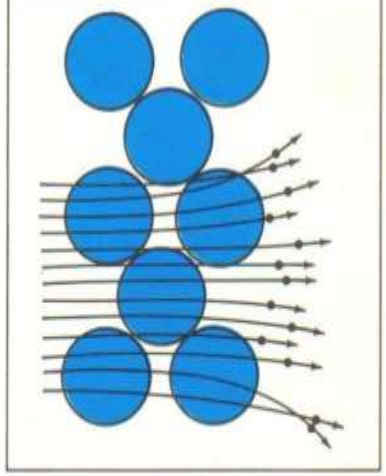


FIGURE 8-13

The scattering of alpha particles by a metallic crystal made up of Thomson atoms. Rutherford's results are *not* explained.

Figure 8-14 show the actual results of the alpha particle scattering experiment.

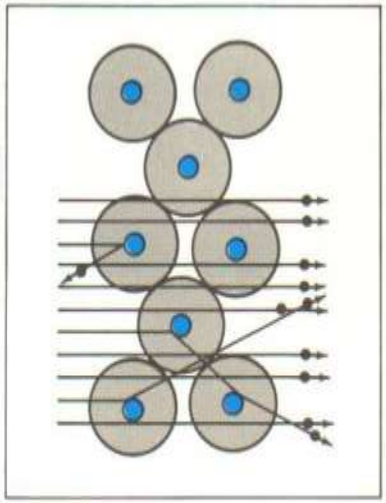


FIGURE 8-14

The scattering of alpha particles by a metallic crystal made up of Rutherford atoms. Rutherford's results *are* explained.

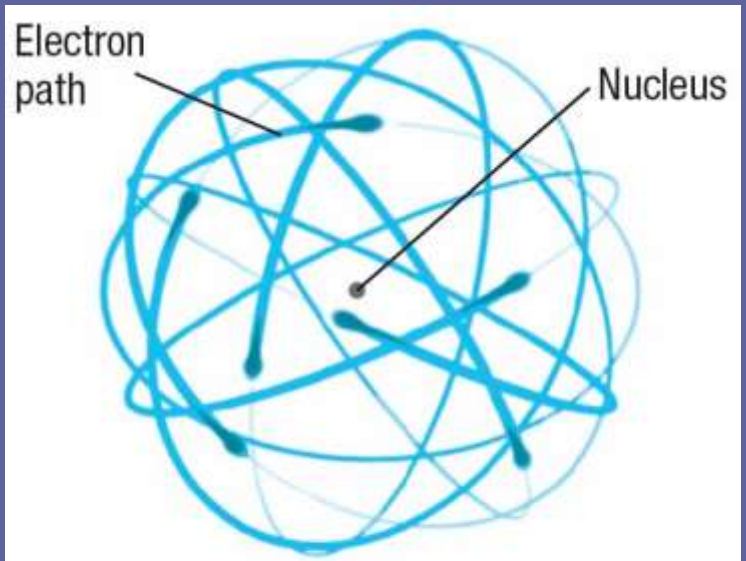
Rutherford's 2nd hypothesis: An atom has a very small positively charged nucleus which is surrounded by electrons.

Rutherford's Model of the Atom

- What is Rutherford's atomic model?
- Rutherford proposed that most of the mass of the atom was concentrated at the atom's center.

Rutherford's Model of the Atom, *continued*

- Rutherford conducted the gold-foil experiment.
- Rutherford discovered the nucleus.
  - **nucleus:** an atom's central region, which is made up of protons and neutrons



The Rutherford model of the atom

Properties of Subatomic Particles

Particle	Symbols	Relative electric charge	Mass number
Electron	e^-,	–1	0
Proton	p^+	+1	1
Neutron	n°	0	1

What Is in an Atom?, *continued*

- Each element has a unique number of protons.
- Unreacted atoms have no overall charge.
  - Because there is an equal number of protons and electrons, the charges cancel out.
- The electric force holds the atom together.
  - Positive protons are attracted to negative electrons by the *electric force.*
  - This force holds the atom together.

Ions

An **ion** is an atom or group atoms that has a positive or negative charge.

A positive ion is known as a **cation**.

A cation has more positive charge than negitive charge

Thus it has a positive charge.

A negative ion is known as an **anion**.

An anion has more negitive charge than positive charge

Thus it has a negative charge.

Ions

An **ion** is an atom or group atoms that has a positive or negative charge.

A positive ion is known as a **cation**.

If an atom loses an electron it has more protons than electrons.

Thus it has a positive charge

A negative ion is known as an **anion**.

If an atom gains an electron it has more electrons than protons.

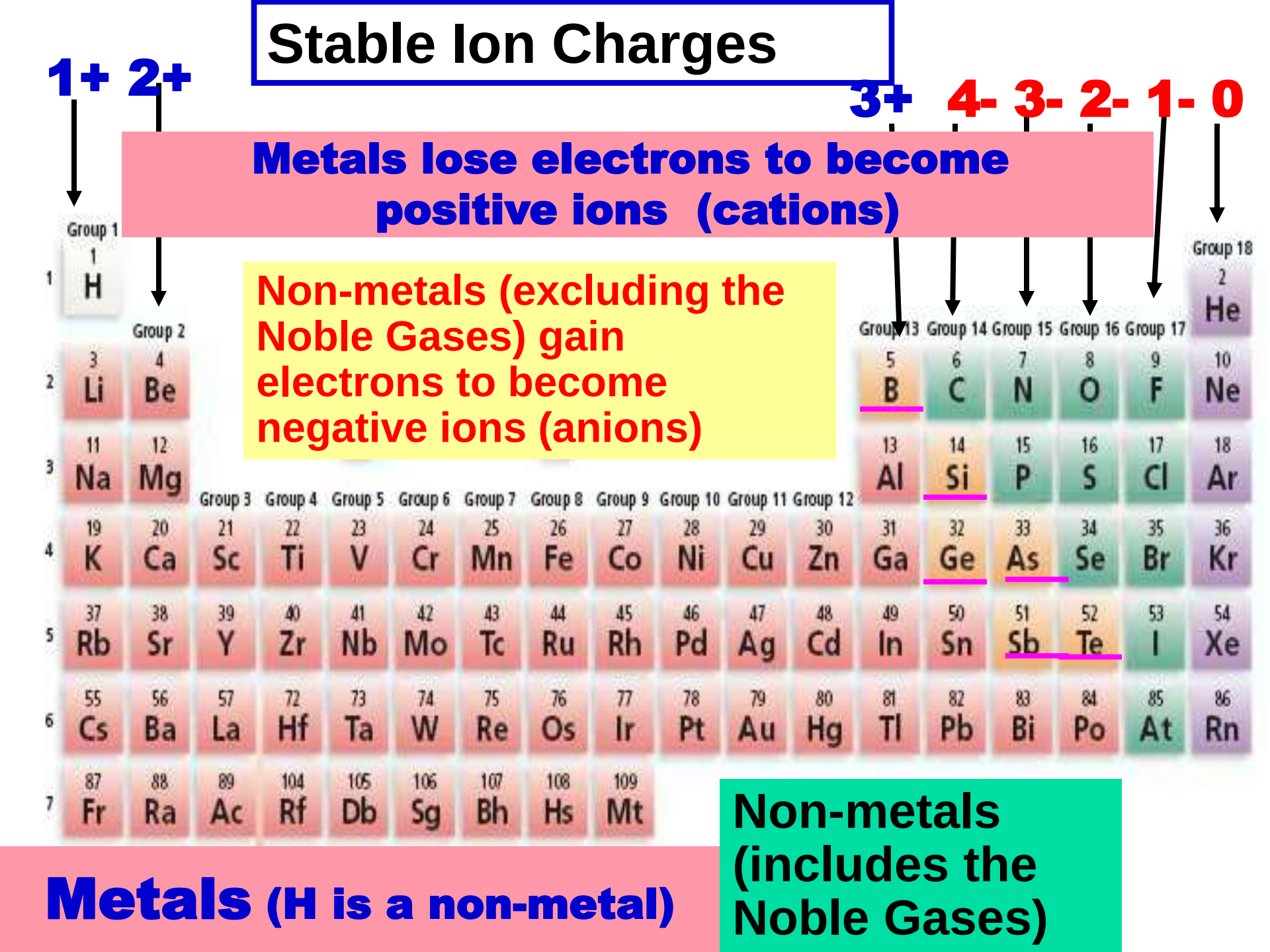
Thus it has a negative charge.

Charge = (p^+) + $(-e^-)$

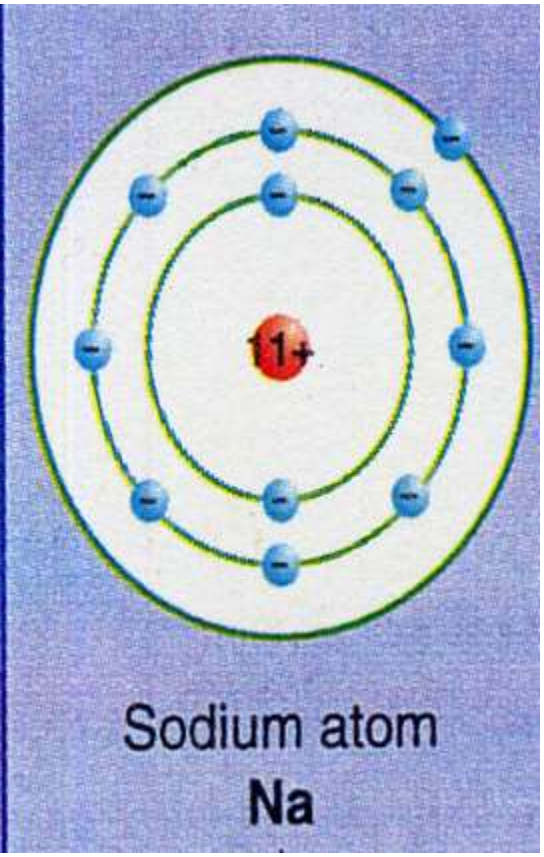
p+ = number of protons as a positive number

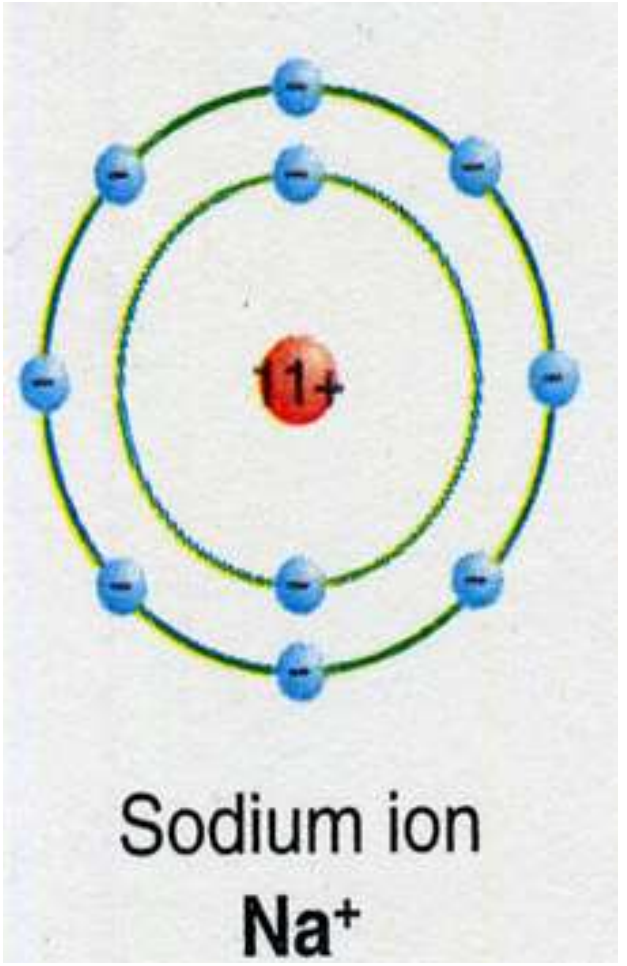
$-e^-$ = number of electrons as a negative number

Stable Ion Charges



Metals lose electrons and become positive ions.

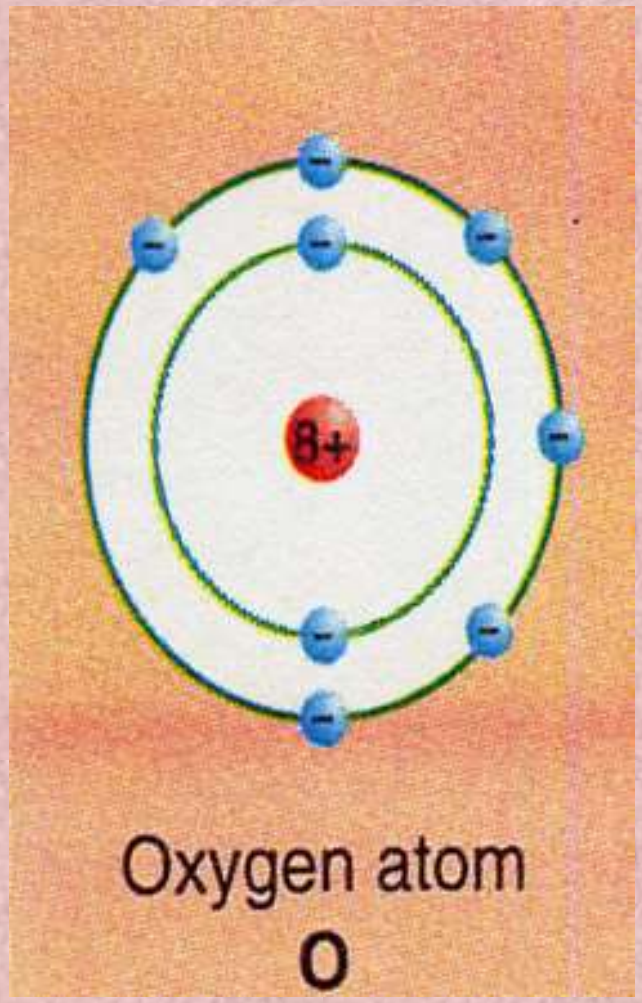




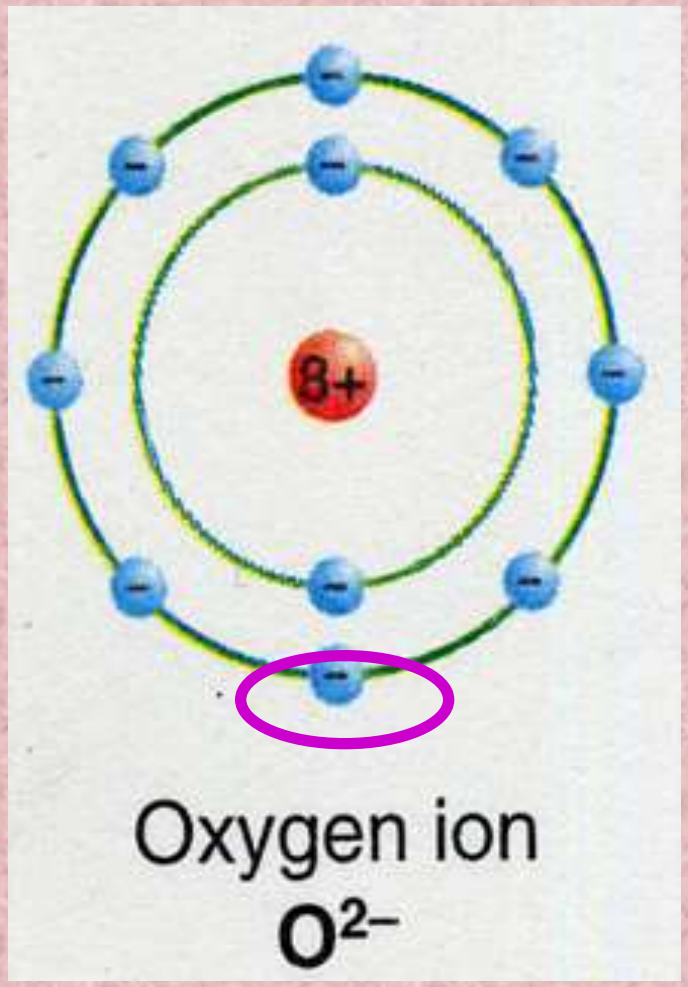
11 electrons

10 electrons

Non metals gain electrons become negative ions



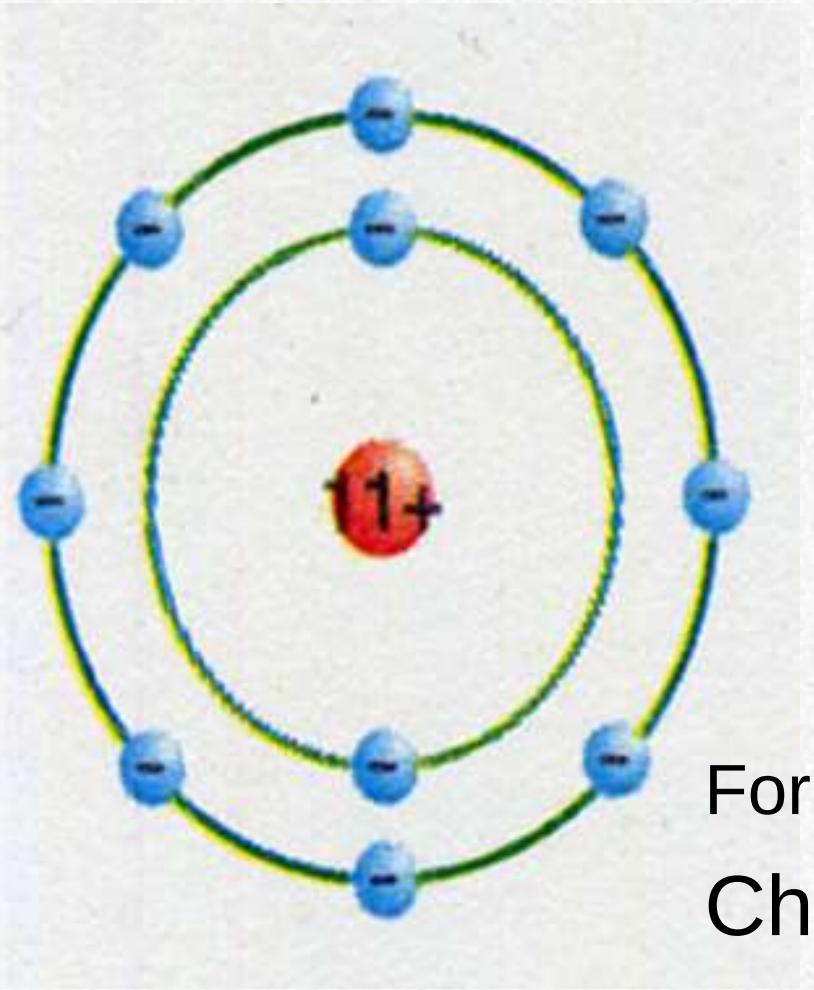
+ 2 e^-



8 electrons

10 electrons

Gaining 2 e^- = negative ion that is 2 negative



Charge = (p^+) + ($-e^-$)

p+ = number of protons as a positive number

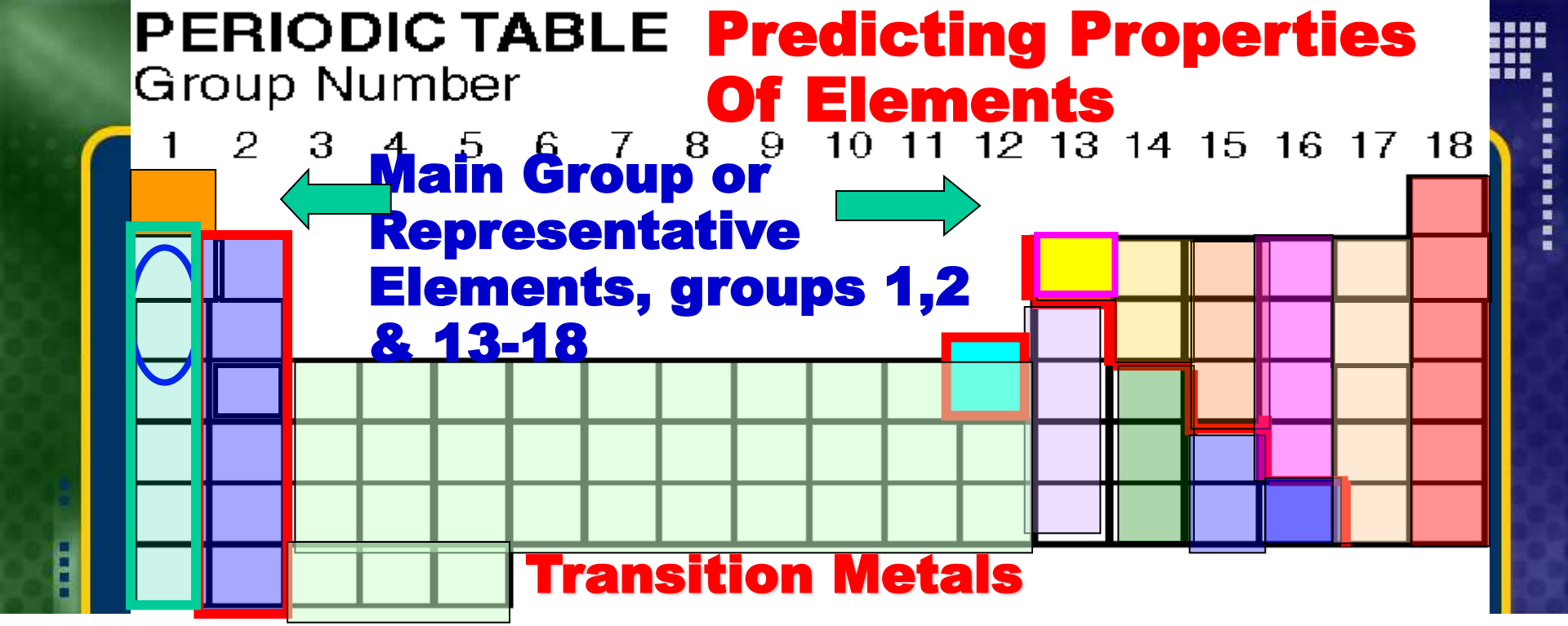
$-e^-$ = number of electrons as a negative number

For this sodium (Na) ion

Charge = (+11) + (-10)

Charge = +1

The ion is written as Na^+

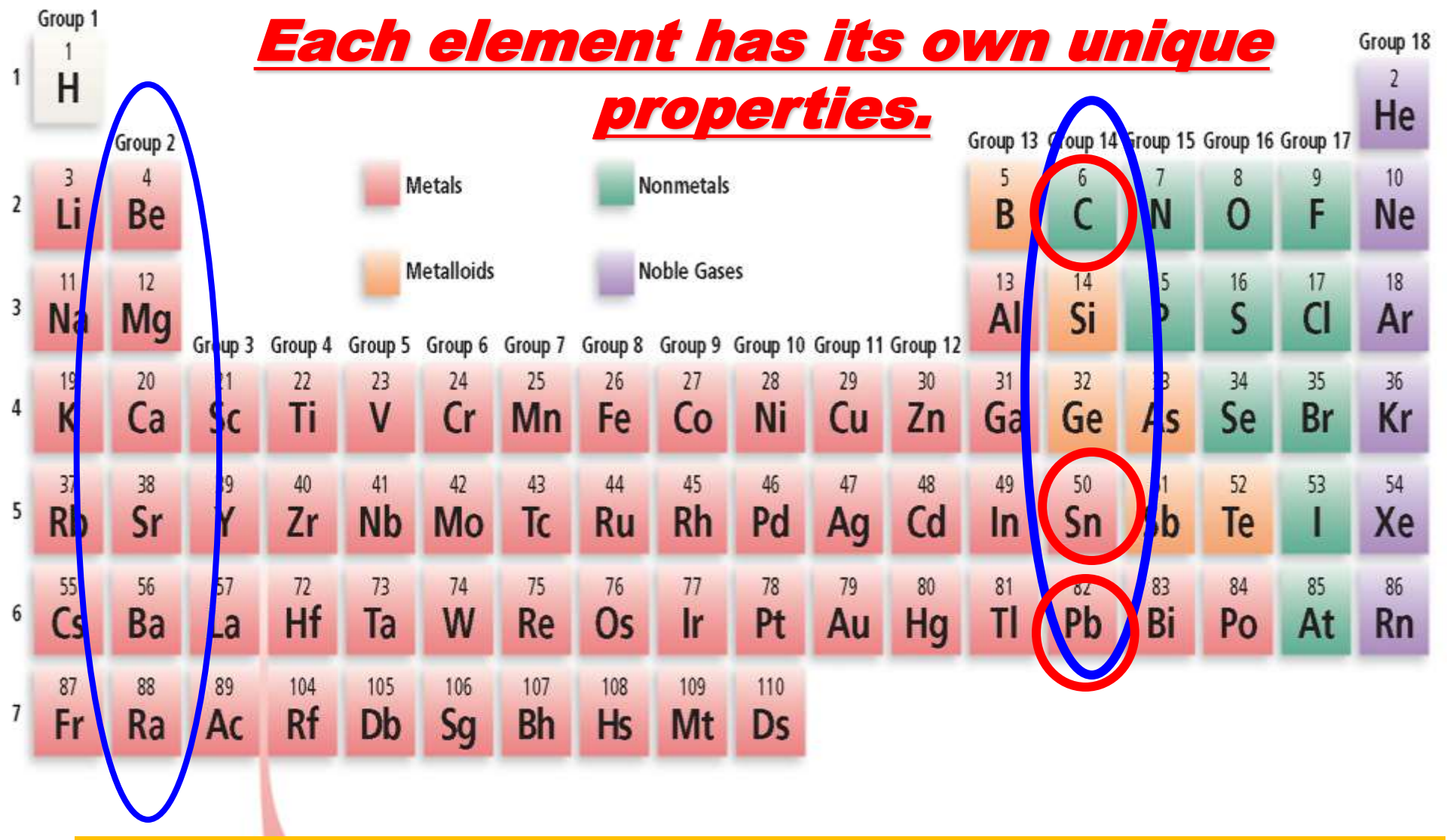


Properties of elements can be predicted from knowing the element's location on the periodic table.

Metals in the same group have the most similar properties as do non-metals in the same group.

If the elements are in different groups their properties can be predicted by knowing if the element is a metal, or non-metal.

Each element has its own unique properties.



In group 14, carbon is a non-metal and tin (Sn) and lead (Pb) are metals. Silicon (Si) is a metalloid.