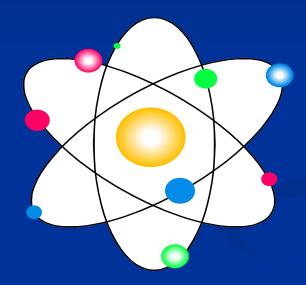
Chapter 4 "Atomic Structure"



Section 4.1 Defining the Atom OBJECTIVES: Describe Democritus's ideas about atoms.

Section 4.1 Defining the Atom OBJECTIVES: Explain Dalton's atomic theory.

Section 4.1 Defining the Atom OBJECTIVES: Identify what instrument is used to observe individual atoms.

Section 4.1 Defining the Atom
 The Greek philosopher Democritus (460 B.C. – 370 B.C.) was among the first to suggest the existence of atoms (from the Greek word "atomos")

He believed that atoms were *indivisible* and *indestructible*

His ideas did agree with later scientific theory, but did not explain chemical behavior, and was <u>not based on the</u> <u>scientific method</u> – but just philosophy

Dalton's Atomic Theory (experiment based!)



John Dalton (1766 – 1844)

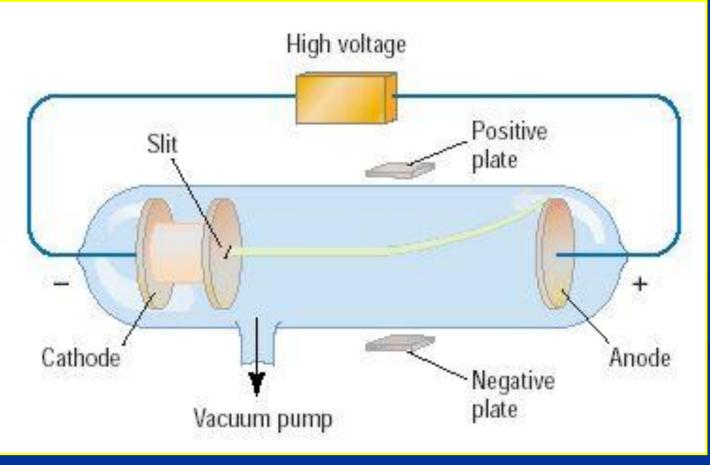
- 1) All elements are composed of tiny indivisible particles called atoms
- 2) Atoms of the same element are identical. Atoms of any one element are different from those of any other element.
- Atoms of different elements combine in simple whole-number ratios to form chemical compounds
 In chemical reactions, atoms are combined, separated, or rearranged – but never changed into atoms of another element.

Sizing up the Atom Elements are able to be subdivided into smaller and smaller particles – these are the *atoms*, and they still have properties of that element If you could line up 100,000,000 copper atoms in a single file, they would be approximately 1 cm long Despite their small size, individual atoms are observable with instruments such as scanning tunneling (electron) microscopes

Section 4.2 Structure of the Nuclear Atom **OBJECTIVES:** Identify three types of subatomic particles.

Section 4.2 **Structure of the Nuclear Atom OBJECTIVES:** Describe the structure of atoms, according to the Rutherford atomic model.

Section 4.2 Structure of the Nuclear Atom One change to Dalton's atomic theory is that atoms are divisible into subatomic particles: Electrons, protons, and neutrons are examples of these fundamental particles There are many other types of particles, but we will study these three **Discovery of the Electron** In 1897, J.J. Thomson used a <u>cathode ray</u> <u>tube</u> to deduce the presence of a negatively charged particle: the electron



Modern Cathode Ray Tubes





Television

Computer Monitor

Cathode ray tubes pass electricity through a gas that is contained at a very low pressure.

Mass of the Electron



Mass of the electron is 9.11 x 10⁻²⁸ g

The oil drop apparatus

1916 – Robert Millikan determines the mass of the electron: 1/1840 the mass of a hydrogen atom; has one unit of negative charge

Conclusions from the Study of the Electron:

a) Cathode rays have identical properties regardless of the element used to produce them. All elements must contain identically charged electrons. **b**) Atoms are neutral, so there must be positive particles in the atom to balance the negative charge of the electrons c) <u>Electrons have so little mass</u> that atoms must contain other particles that account for most of the mass

Conclusions from the Study of the Electron:

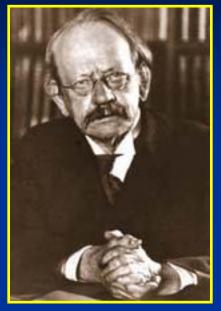
Eugen Goldstein in 1886 observed what is now called the "proton" particles with a positive charge, and a relative mass of 1 (or 1840 times that of an electron) 1932 – James Chadwick confirmed the existence of the "neutron" – a particle with no charge, but a mass nearly equal to a proton

Properties of Subatomic Particles

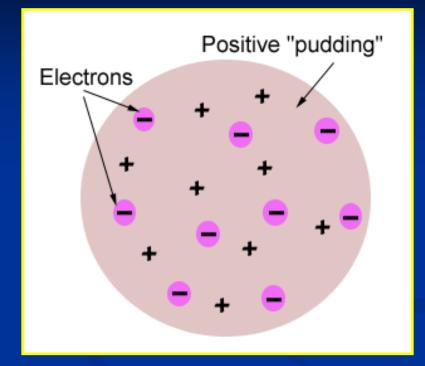
Particle Symbol	Location	Relative electrical charge	Relative mass	Actual mass (g)
Electron e ⁻	Electron cloud	1-	1/1840	9.11 × 10 ⁻²⁸
Proton p ⁺	Nucleus	1+	1	1.67 × 10 ⁻²⁴
Neutron n ⁰	Nucleus	0	1	1.67 × 10 ⁻²⁴

Protons and Neutrons have the same mass.

Thomson's Atomic Model

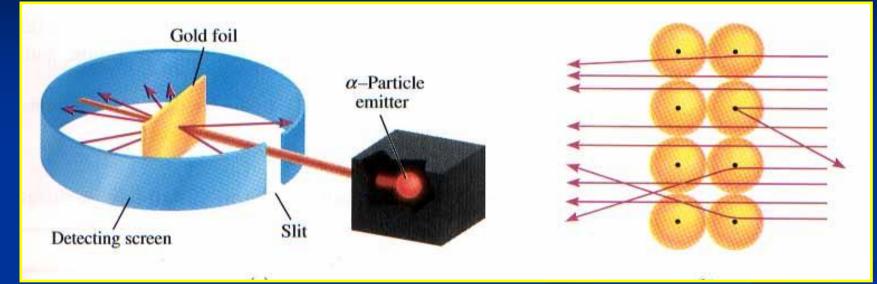


J. J. Thomson



Thomson believed that the electrons were like plums embedded in a positively charged "pudding," thus it was called the "plum pudding" model.

Ernest Rutherford's Gold Foil Experiment - 1911



Alpha particles are helium nuclei -The alpha particles were fired at a thin sheet of gold foil
Particles that hit on the detecting screen (film) are recorded

Rutherford's Findings

Most of the particles passed right through
A few particles were deflected
VERY FEW were greatly deflected

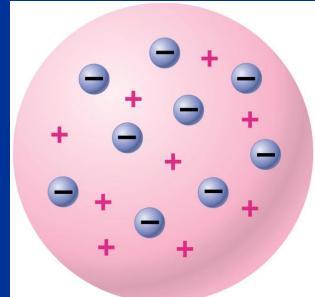
"Like howitzer shells bouncing off of tissue paper!"

Conclusions:
a) The nucleus is small
b) The nucleus is dense
c) The nucleus is positively charged

The Rutherford Atomic Model Based on his experimental evidence: The atom is mostly empty space All the positive charge, and almost all the mass is concentrated in a small area in the center. He called this a "nucleus" The nucleus is composed of protons and neutrons (they make the nucleus!) The electrons distributed around the nucleus, and occupy most of the volume His model was called a "nuclear model"

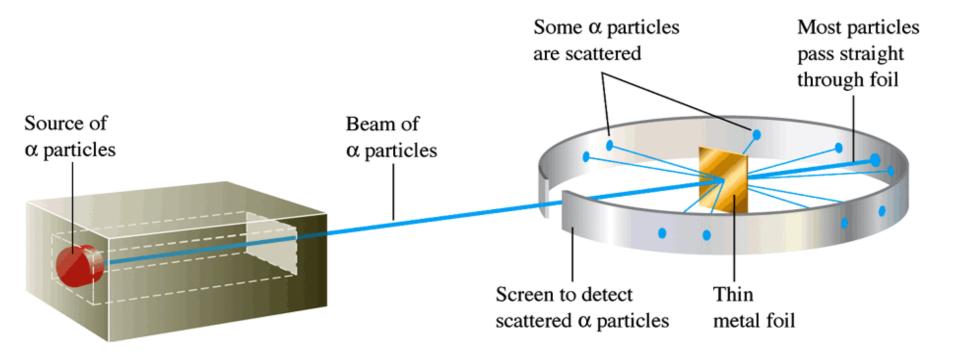
Ernest Rutherford

Rutherford discovered the nucleus by shooting alpha particles (have a positive charge) at a very thin piece of gold foil.



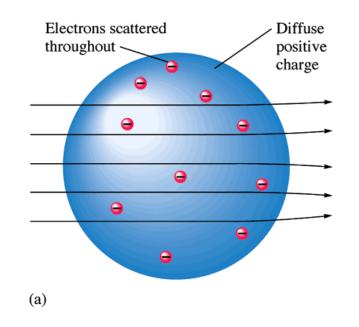
He predicted that the particles would go right through the foil at some small angle.

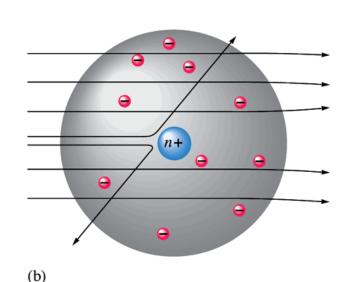
Rutherford's Gold Foil Experiment



Rutherford's Gold Foil Experiment

- some particles (1/8000) bounced back from the foil
- this meant there must be a "powerful force" in the foil to hit particle back

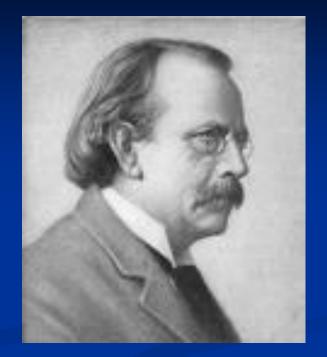




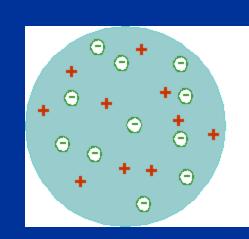
Models of the Atom

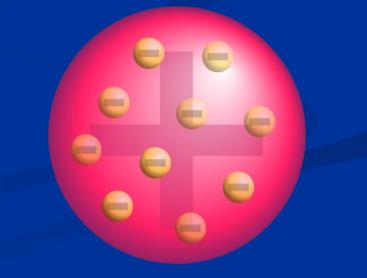
J.J. Thomson

 "Plum pudding" atom negatively charged e⁻ stuck into a lump of positively charged material
 – similar to chocolate chip cookies



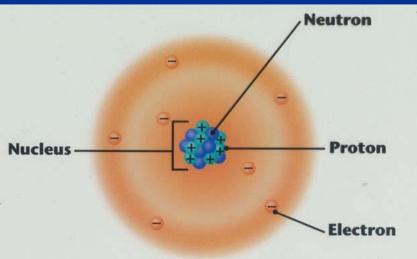




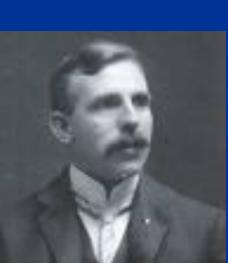


Ernest Rutherford

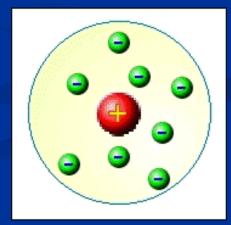
In Rutherford's gold foil experiment he discovered electrons surround a dense positive nucleus





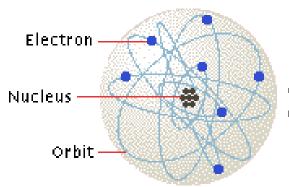






Bohr Model

electrons are arranged in fixed orbits around the nucleus.



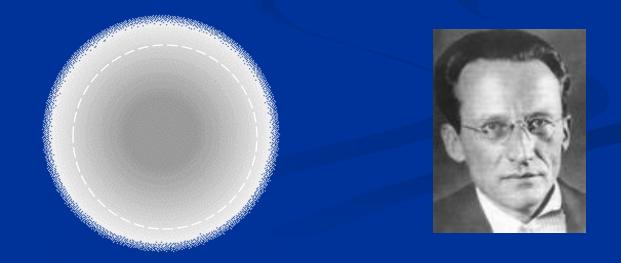
The Bohr Model

'quantized' the orbits in order to explain the stability of the atom.



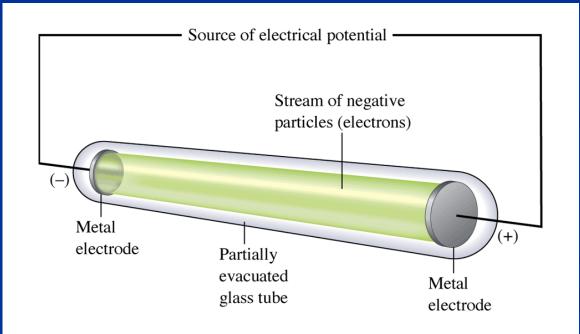
Quantum Mechanical Model

- Quantum mechanics was developed by Erwin Schrodinger
- Estimates the probability of finding an e⁻ in a certain position
- Electrons are found in an "electron cloud"



Discovery of Electron
 resulted from scientists passing electric current through gases to test conductivity

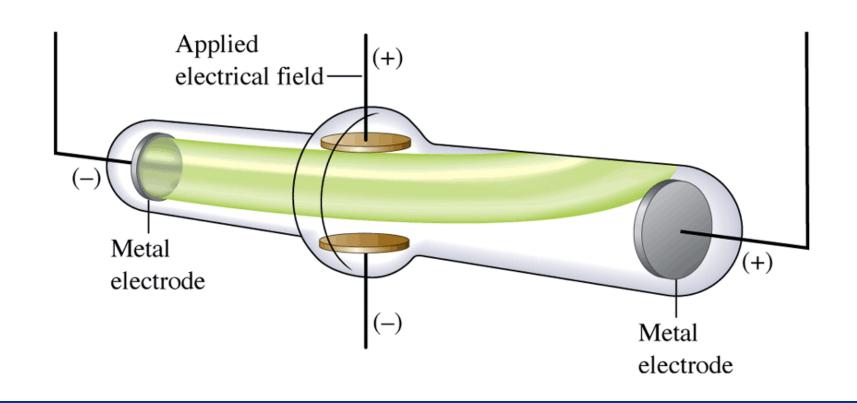
used <u>cathode-ray tubes</u>



Scientists noticed that when current was passed through a glow (or "ray") was produced

Discovery of Electron

• This led scientists to believe there were negatively charged particles inside the **cathode ray**



Section 4.3 **Distinguishing Among Atoms OBJECTIVES:** Explain what makes elements and isotopes different from each other.

Section 4.3 **Distinguishing Among Atoms OBJECTIVES:** Calculate the number of neutrons in an atom.

Section 4.3 **Distinguishing Among Atoms OBJECTIVES:** Calculate the atomic mass of an element.

Section 4.3 **Distinguishing Among Atoms OBJECTIVES:** Explain why chemists use the periodic table.

Atomic Number

Atoms are composed of *identical* protons, neutrons, and electrons How then are atoms of one element different from another element? Elements are different because they contain different numbers of **PROTONS** The "atomic number" of an element is the number of protons in the nucleus # protons in an atom = # electrons

Atomic Number

Atomic number (Z) of an element is the number of protons in the nucleus of each atom of that element.

Element	# of protons	Atomic # (Z)
Carbon	6	6
Phosphorus	15	15
Gold	79	79

Mass Number

Mass number is the number of protons and neutrons in the nucleus of an isotope: Mass # = p⁺ + n⁰

Nuclide	<mark>p+</mark>	n ⁰	e -	Mass #
Oxygen - 18	8	10	8	18
Arsenic - 75	33	42	33	75
Phosphorus - 31	15	16	15	31

Complete Symbols

Contain the symbol of the element, the mass number and the atomic number.

Superscript \rightarrow

Mass number

Subscript \rightarrow

Symbols Find each of these: a) number of protons b) number of neutrons c) number of electrons d) Atomic number e) Mass Number

 $^{80}_{35}Br$

Symbols

If an element has an atomic number of 34 and a mass number of 78, what is the: a) number of protons b) number of neutrons c) number of electrons d) complete symbol

Symbols

If an element has 91 protons and 140 neutrons what is the a) Atomic number b) Mass number c) number of electrons d) complete symbol

Symbols

If an element has 78 electrons and 117 neutrons what is the a) Atomic number b) Mass number c) number of protons d) complete symbol

Isotopes

Dalton was wrong about all elements of the same type being identical

Atoms of the same element can have different numbers of <u>neutrons</u>.

Thus, different mass numbers.
These are called *isotopes*.

Isotopes



Frederick Soddy (1877-1956) proposed the idea of isotopes in 1912

Isotopes are atoms of the same element having different masses, due to varying numbers of neutrons.

Soddy won the Nobel Prize in Chemistry in 1921 for his work with isotopes and radioactive materials.

Naming Isotopes

We can also put the mass number after the name of the element: carbon-12 carbon-14

uranium-235

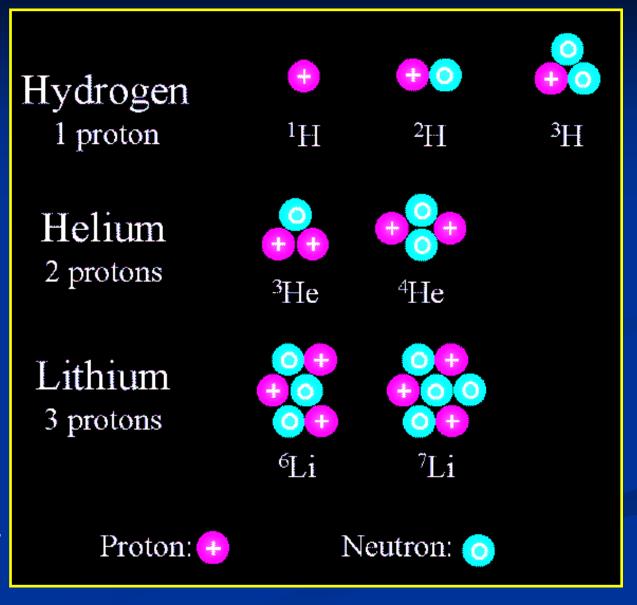
<u>Isotopes</u> are atoms of the same element having *different masses*, due to varying numbers of neutrons.

Isotope	Protons	Electrons	Neutrons	Nucleus
Hydrogen-1				
(protium)	1	1	0	+
Hydrogen-2				
(deuterium)	1	1	1	
Hydrogen-3 (tritium)	1	1	2	

<u>Isotopes</u>

Elements occur in nature as <u>mixtures</u> of isotopes.

Isotopes are atoms of the same element that differ in the number of neutrons.



Atomic Mass

How heavy is an atom of oxygen?

- It depends, because there are different kinds of oxygen atoms.
- We are more concerned with the <u>average</u> <u>atomic mass.</u>
- This is based on the abundance (percentage) of each variety of that element in nature.
 - We don't use grams for this mass because the numbers would be too small.

Measuring Atomic Mass Instead of grams, the unit we use is the Atomic Mass Unit (amu) It is defined as one-twelfth the mass of a carbon-12 atom. Carbon-12 chosen because of its isotope purity. Each isotope has its own atomic mass, thus we determine the

average from percent abundance.

To calculate the average: Multiply the atomic mass of each isotope by it's abundance (expressed as a decimal), then add the results.

 If not told otherwise, the mass of the isotope is expressed in <u>atomic mass</u> <u>units</u> (amu)

Atomic Masses Atomic mass is the average of all the naturally occurring isotopes of that element.

Isotope	Symbol	Composition of the nucleus	% in nature
Carbon-12	¹² C	6 protons	98.89%
		6 neutrons	
Carbon-13	¹³ C	6 protons	1.11%
		7 neutrons	
Carbon-14	¹⁴ C	6 protons	<0.01%
		8 neutrons	

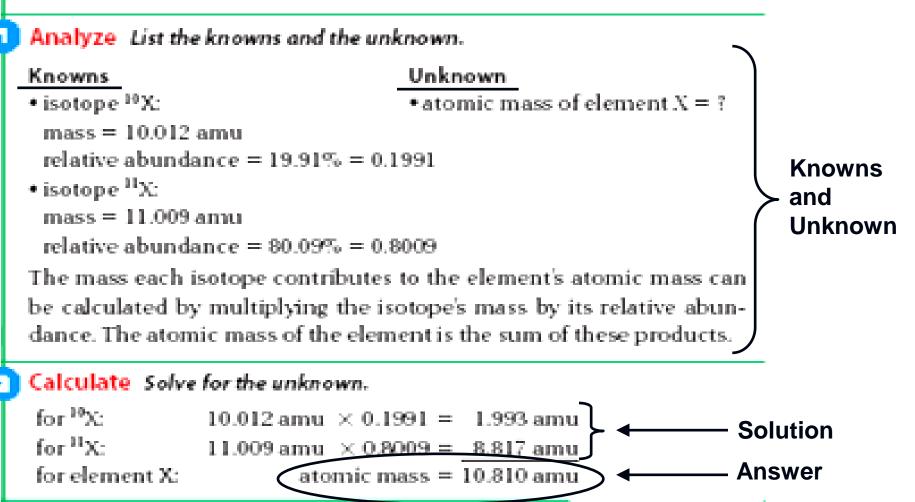




Calculating Atomic Mass

Element X has two natural isotopes. The isotope with a mass of 10.012 amu (¹⁰X) has a relative abundance of 19.91%. The isotope with a mass of 11.009 amu (¹¹X) has a relative abundance of 80.09%. Calculate the atomic mass of this element.





The Periodic Table: A Preview A "periodic table" is an arrangement of elements in which the elements are separated into groups based on a set of repeating properties The periodic table allows you to easily compare the properties of one element to another

The Periodic Table: A Preview

Each horizontal row (there are 7 of them) is called a period Each vertical column is called a group, or family Elements in a group have similar chemical and physical properties Identified with a number and either an "A" or "B" More presented in Chapter 6

