

1

Atoms

≈ 400 BC Greek - uncuttable
1803 AD John Dalton

2

Dalton's Atomic Theory

1. All matter is made up of indivisible and indestructible particles called atoms.
2. All atoms of a given element are identical, both in mass and in properties.
3. Compounds are formed when atoms of different elements combine in the ratio of small whole numbers.
4. Elements and compounds are composed of definite arrangements of atoms, and chemical change occurs when the atomic arrays are rearranged.

3

Dalton's Atomic Theory Was Immediately Accepted Because it Could Explain Three Laws

4

Dalton's Atomic Theory Could Explain Three Laws

Antoine Lavoisier

Carefully weighed *products* and *reactants* and found that the mass was always equal.

Law of Conservation of Matter- Matter is neither lost nor gained during a chemical reaction.

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Dalton's Atomic Theory Could Explain Three Laws

Joseph Proust

If you purify water from many sources, it is always H₂O- 11.2% H, 88.8% O

Law of Definite Proportions- In a compound, the constituent elements are always present in a definite proportion by mass.

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Dalton's Atomic Theory Could Explain Three Laws

John Dalton

CO CO₂ never CO_{1.8}

Law of Multiple Proportions- In the formation of 2 or more compounds from the same elements, the masses of one element that combine with a fixed mass of a second element are in a ratio of small whole numbers.

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Although Dalton's atomic theory was brilliant, he was wrong about some things.

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The Atom is Divisible

- Radioactivity
 $^{238}\text{U} \rightarrow \dots \rightarrow ^{222}\text{Rn} + \text{radioactive parts}$
- Electrical Nature of Matter
 Repulsion of like charges

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Structure of the Atom - the Electron

- The electron was the first *subatomic particle* to be discovered, by J.J. Thompson.
- The Cathode Ray Tube.
- The charge on an electron is negative.
- Determining the charge on an electron
 - » $-1.60217733 \times 10^{-19} \text{ C}$
 - » this amount of charge is designated as -1
- Determining the mass of an electron
 - » $9.19389 \times 10^{-28} \text{ g}$ or 0.00055 amu
 - » this amount of mass is designated as 0 amu

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Structure of the Atom - the Proton

the Canal tube
 charge of $+1.60217733 \times 10^{-19} \text{ C}$ (+1)
 mass of $1.672623 \times 10^{-24} \text{ g}$ (1.0087 amu) 1 amu

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Structure of the Atom - the Neutron

uncharged particles
 mass of $1.6749286 \times 10^{-24} \text{ g}$ (1.0073 amu) 1 amu

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Summary of the Subatomic Particles

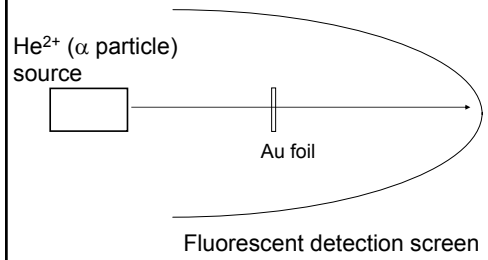
<u>Subatomic Particle</u>	<u>Charge</u>	<u>Mass</u>
Proton	+1	1 amu
Neutron	+0	1 amu
Electron	-1	0 amu

13 **How Are These Subatomic Particles Arranged?**

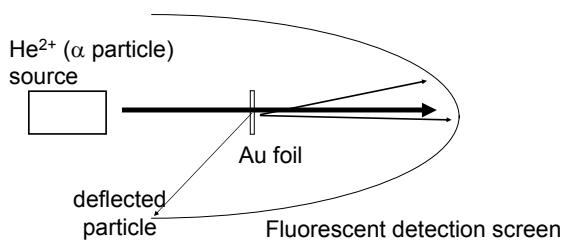
Ernest Rutherford and the alpha particles

- alpha (α) +charge He^{2+}
- beta (β) -charge - e^-
- gamma (γ) no charge, no mass - light rays

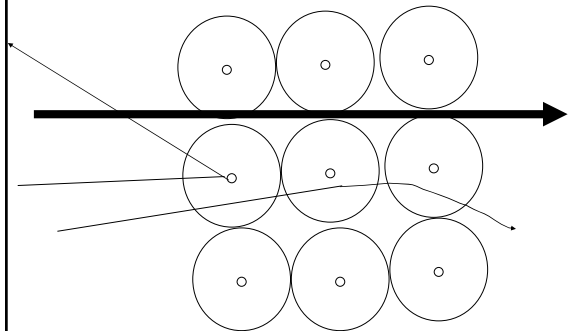
14 **Rutherford's Famous Experiment...**



15 **Rutherford's Famous Experiment...**



16 **...and His Interpretation of the Results**



17 **Modern View of the Atom**

- Very small
- equal number of protons and electrons
- Nucleus: protons and neutrons
- electron cloud
- sports stadium analogy

Subatomic Particle	Charge	Mass	Location
Proton	+1	1 amu	Nucleus
Neutron	+0	1 amu	Nucleus
Electron	-1	0 amu	cloud

18 **The Atomic Number Indicates the Number of Protons**



The number of protons determines what element the atom is

There is an equal number of protons and electrons under normal conditions.

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The Mass Number Indicates the Mass of the Atom



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Neutrons and Isotopes

Atomic number- indicates the number of protons

Mass number- the mass of the atom



19-9= 10 neutrons

Isotopes- atoms of the same element having different mass numbers

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Atomic Mass and Atomic Weight

Atomic Weight- the average mass of the isotopes of an element

EX: ${}^{20}\text{Ne}$ ${}^{21}\text{Ne}$ ${}^{22}\text{Ne}$
 90.92% 0.26% 8.82%

$$(0.9092)(20) + (0.0026)(21) + (0.0882)(22)$$

$$= 18.184 + 0.0546 + 1.9404$$

$$= 20.179$$

10
Ne
20.179

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Electrons

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Electron Arrangements in Atoms

- Electrons are very important in determining how elements react.
- Light is used to figure out where e^- are located

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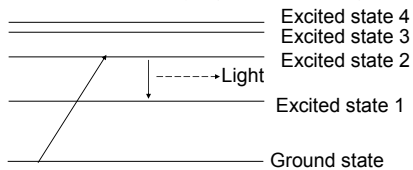
Where are Electrons in Atoms?

- Analogy: White Light $\xrightarrow{\text{Prism}}$ Rainbow
- Many chemicals give off colored flames.
- There are many different wavelengths that can be examined to explore our world- visible light is only a very small portion.
 - EX: Ultraviolet (UV) light- tanning
 - EX: Infrared (IR) light- heat lamps, night vision goggles

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Line Emission Apparatus

- 1913 Niels Bohr determined the relative positions and energies of electrons of H
- $H_2(g)$ excited with electric charge, light passed through a prism- different colors could be observed, with varying colors (energies)



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9-12-05



Exam Fri
 Help session
 Wednesday 7PM
 Problem set
 Questions
 New material

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Element 20 - Calcium (Ca)

An *alkaline earth metal*

3.64% of Earth's crust (5th in order of abundance)

sea water 400 g Ca/ton of water

never found in nature uncombined

principle commercial source limestone

important uses: limestone buildings, bones

$CaCO_3$ - Calcium Carbonate - limestone

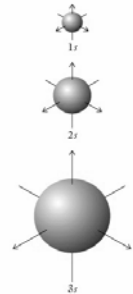
Electron configuration: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$

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Principle Energy Levels

Fig. 2.12 Blei and Odian

- 1-7

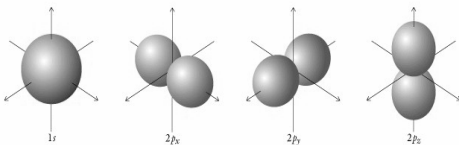


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Electron Orbital Shapes

Fig. 2.11 Blei and Odian

- s- sphere
- p- hourglass shaped, go in 3 directions (x, y, z)
- d and f shapes beyond our scope.



These shapes tell us only the probability of where an electron will be found, not what its path looks like

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The Maximum Number of Electrons in an Orbital Is 2

- s hold 2
- p hold 6 (x, y and z)
- d and f hold 10 and 14

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Electron Configurations

1. The Aufbau Principle- Electrons occupy the lowest energy level and sublevel possible.
 $1s^1, 1s^2, 2s^1, 2s^2, 2p^1$ etc.
2. Spin-pair rule- two electrons on the same level travel in opposite directions.
3. Hunds Rule- Electrons in partially filled sublevels spread out to occupy as many orbitals as possible in that sublevel.

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Valence Electrons in Yellow: Groups Have Similar Electron Configuration

H	$1s^1$		
He	$1s^2$	full	Noble gas
Li	$1s^2, 2s^1$		
Be	$1s^2, 2s^2$		
B	$1s^2, 2s^2, 2p^1$		
C	$1s^2, 2s^2, 2p^2$		
N	$1s^2, 2s^2, 2p^3$		
O	$1s^2, 2s^2, 2p^4$		
F	$1s^2, 2s^2, 2p^5$		
Ne	$1s^2, 2s^2, 2p^6$	full	Noble gas

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Sample Test Question

What is the electron configuration of calcium-41?