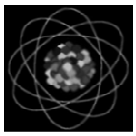
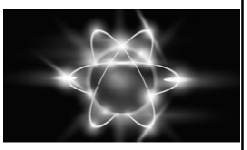
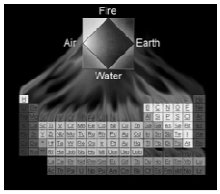
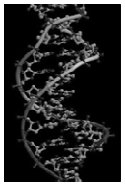




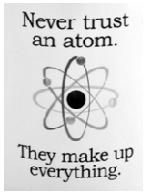
The Atom





LPT

Atoms Are The Building Blocks Of The Universe



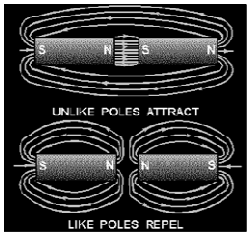
Everything is composed of atoms

LPT

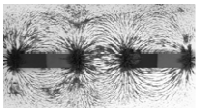
Basic Principle of Charged Particles

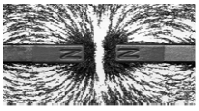
Like charges repel
Opposite charges attract

Schematic: Lines of Force



Iron Filings Show Lines of Force





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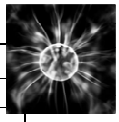
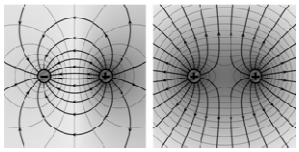
Attract or Repel?

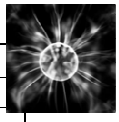


Particle 1	Particle 2	Behavior
+1	+1	
+1	-1	
-1	+1	
-1	-1	

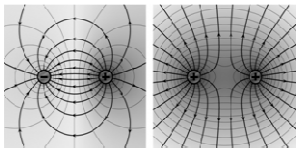


LPT

Attract or Repel?



Particle 1	Particle 2	Behavior
+1	+1	Repel
+1	-1	Attract
-1	+1	Attract
-1	-1	Repel



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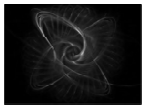
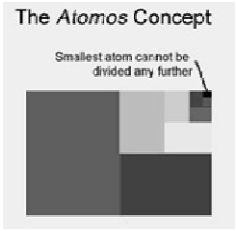
Understanding "atoms" begins with "Atomos"





Start with any substance
Cut in half
Continue process
When cannot cut anymore,
What remains is an atom

Democritus (~400 BCE)

Everything is either atoms or empty space

LPT

Dalton's Atomic Theory (1808)

Each element composed of tiny particles called atoms
All atoms of a certain element have same chemical properties

Atoms are indivisible; they cannot be created or destroyed (No!)

Element atoms are identical in every respect. (No!)

Law of Multiple Proportions
Atoms of one element combine with atoms of another element to form chemical compounds (ratio of small, whole numbers)

Law of Constant (Definite) Composition
The mass % of elements in a compound is always the same

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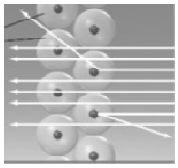
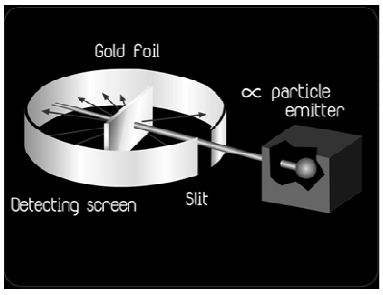
Nuclear Atom

Rutherford's 1911 Experiments (Alpha Scattering)





Demonstrated that atoms have small, dense core
Large volume of empty space

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Rutherford's Model Atom

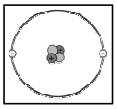
Most mass concentrated in a small, dense core

Positive charge located at core

Thinly populated outer region carries negative charge

Same number of positive and negative charges

He Atom



For He atom: If Nucleus the size of a penny,
Atom sphere = the size of the pentagon

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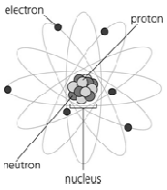
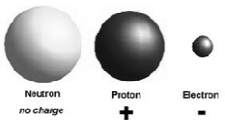
Primary Subatomic Particles

Particle	Location (Nucleus)	Charge	Mass (g)	Mass (amu)
Neutron (n^0)	Inside	0	1.675×10^{-24}	1.00867 (~1)
Proton (p^+)	Inside	+1	1.673×10^{-24}	1.00728 (~ 1)
Electron (e^-)	Outside	-1	9.11×10^{-28}	0.000549 (~0)





Mass Order: n > p >> e

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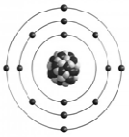
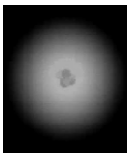
Rutherford's "Planetary" Atom Model

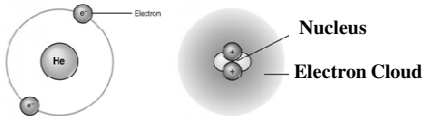
Negative Electrons Orbit Positive Nucleus

Nucleus = neutrons + protons
Shell = electrons
No Longer Accepted,
but good way to start learning about atoms



Current Belief:
Electrons exist in regions of space called Orbitals
Orbitals are math probability descriptions





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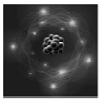
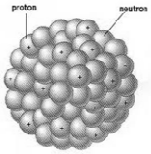
Element Nomenclature



Atomic Number (Z)

of protons in the nucleus

Determines elemental identity
Atoms of the same element have same Z
Z = # of p^+ = # of e^- in an uncharged atom



Z from German Atom Zahl

Or

Atom number

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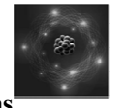
Element Nomenclature



Mass Number (A)

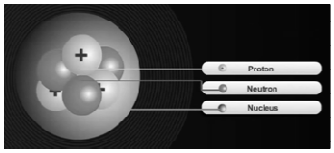
Sum of the # of protons + # of neutrons

 # neutrons = A - Z

No relationship between number of n & p

knowing #p (Z) does not give #n or A

Mass number has no units … its just a number



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Nuclide Notation

Mass Number (A) **Charge (0 for neutral atom)**

symbol for the element

Atomic Number (Z) **# Atoms** **1 (understood)**

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Nuclide Notation

Mass Number (except for $^{1}_{1}H$) always larger

(A) # protons + neutrons

X

(Z) # protons = # electrons

A – Z = # neutrons

Nomenclature "sets up" the subtraction to give # neutrons

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Nuclide Notation

Carbon

$^{12}_{6}C$

Number Protons = 6
Number Electrons = 6
Number Neutrons (12 – 6) = 6

Oxygen

$^{16}_{8}O$

Number Protons = 8
Number Electrons = 8
Number Neutrons (16 – 8) = 8

Gold

$^{197}_{79}Au$

Number Protons = 79
Number Electrons = 79
Number Neutrons (197 – 79) = 118

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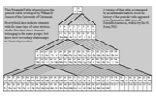
Nuclide Notation



Sodium

$^{23}_{11}Na$

Number Protons = 11
Number Neutrons (23 – 11) = 12
Number Electrons = 11

Krypton

$^{82}_{36}Kr$

Number Protons = 36
Number Neutrons (82 – 36) = 46
Number Electrons = 36

Krypton

$^{84}_{36}Kr$

Number Protons = 36
Number Neutrons (84 – 36) = 48
Number Electrons = 36

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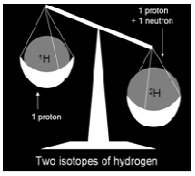
Isotopes

Atoms having same Z, but different A

Atoms have same # protons, but different # neutrons
Atoms of the same element, but different masses



From Greek "the same place"

Isotopes invalidate Dalton's "All atoms of an element are identical"

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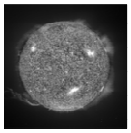
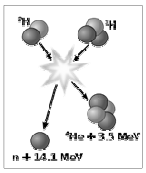
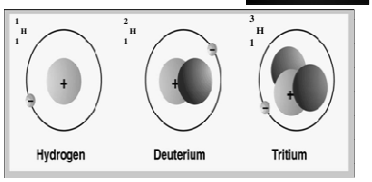
Isotopes of Hydrogen



Thermonuclear Fusion
Atoms "fuse" together





Isotope = Same Z, Different A

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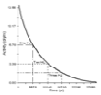
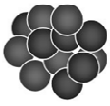
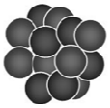
Isotopes of Carbon



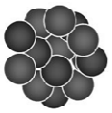
Useful for "Radiocarbon" (C-14) Dating



carbon-12
98.9%
6 protons
6 neutrons



carbon-13
1.1%
6 protons
7 neutrons



carbon-14
<0.1%
6 protons
8 neutrons

Michigan Mastodon
15,000 years old

Cave Painting
30,000 years old

Isotope = Same Z, Different A

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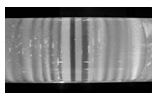
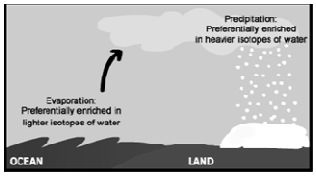
Isotopes of Oxygen

Ice Cores Useful for Estimating Previous Earth Temperatures



Ice Cores



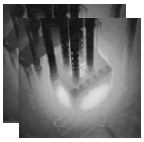
Natural Abundance:
^{16}O: 99.76%
^{18}O: 0.20 %
Ratio
$H_2{}^{16}O$ to $H_2{}^{18}O$
Infers earth's temperature

LPT

Isotopes of Uranium

~ 99.28 %

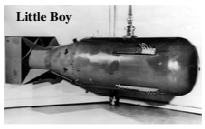
~ 0.71 %



Nuclear Fission
Atoms "Split"

Since Z is the same, chemical properties of the isotopes are identical

Enola Gay



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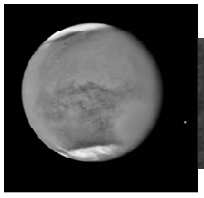
Xenon-129
Formed in thermonuclear explosions



Analysis of Martian atmosphere suggests thermonuclear explosion
Energy of ~ 10 billion megatons of TNT
(~ 7 x 10^7 greater than Hiroshima … planet-wide catastrophe)

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Other Common Radioisotopes

Americium-241
Radiation source in smoke detectors

Cobalt-60 gamma ray source
Used in radiation therapy to kill cancer cells
Used to sterilize foods

Helium-3 found on the moon
Potential fusion energy source

Radon-222
Radioactive gas
Lung cancer threat in Michigan soil

Strontium-90 found in atmosphere
Indicates nuclear processes
Health concern since animals incorporate Sr for Ca

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Isotopes?

$^{23}_{11}Na$	$^{24}_{11}Na$	Yes
$^{238}_{92}U$	$^{235}_{92}U$	Yes
$^{238}_{92}U$	$^{238}_{94}Pu$	No

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Naming Isotopes

Element name - mass number

Carbon-12, Carbon-13 & Carbon-14
Uranium-235 & Uranium-238
Oxygen-16 & Oxygen-18
Strontium-90
Polonium-210

339 Natural Isotopes
3100 Isotopes Known

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Naming Isotopes

What is the nuclide symbol for iron-56?

$^{56}_{26}Fe$

How many neutrons in this atom?

30
(56-26)

LPT

Naming Nuclide Symbols

Nuclide	Protons	Electrons	Neutrons	
$^{9}_{4}Be$	4	4	5	Beryllium-9
$^{82}_{36}Kr$	36	36	46	Krypton-82
$^{84}_{36}Kr$	36	36	48	Krypton-84

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Complete the following table:

Nuclear Symbol	# p^+	# n^0	# e^-	Name of Isotope
$^{9}_{4}Be$				
		36	46	
$^{86}_{?}Kr$				
	29	34		

LPT

Complete the following table:

Nuclear Symbol	# p^+	# n^0	# e^-	Name of Isotope
$^{9}_{4}Be$	4	5	4	Beryllium-9
$^{82}_{46}Pd$	46	36	46	Palladium-82
$^{86}_{36}Kr$	36	50	36	Krypton-86
$^{63}_{29}Cu$	29	34	29	Copper-63

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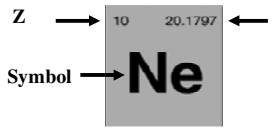
For Each Element in Periodic Table



decimals depends on:
- source
- intended use
- publisher's font

After Hydrogen, atomic mass always the larger value

* in Atomic Mass Units (AMU) or Daltons (Da)
Newer term: Unified Mass Unit (u)
All now defined as 1/12 the mass of C-12 atom

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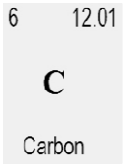
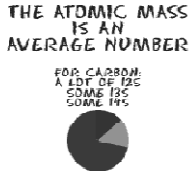
Atomic Mass (Weighted Average)

For Carbon

Carbon -12 (12.00000 amu) 98.13%
Carbon -13 (13.00354 amu) 1.07%
Carbon- 14 (14.00324 amu) trace (~ 10^{-10} %)

Atomic Mass = 12.01 u (weighted average)
There is no actual atom with mass of 12.01 amu





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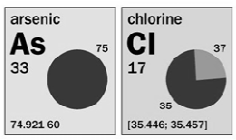
New IUPAC Table: Atomic Mass Range for 10 Elements

Element	Range
Hydrogen	1.00784 - 1.00811
Lithium	6.938 - 6.970
Boron	10.806 - 10.824
Carbon	12.0096 - 12.0116
Nitrogen	14.00643 - 14.00728
Oxygen	15.99903 - 15.99977
Silicon	28.084 0 - 28.0855
Sulfur	32.059 - 32.076
Chlorine	35.446 - 35.457
Thallium	204.382 - 204.385



Reflects global changes in natural abundance

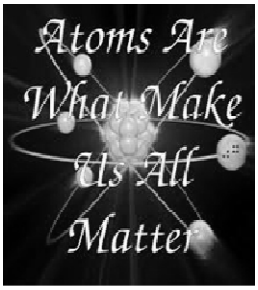
Radioactive isotope decay alters amounts of isotopes

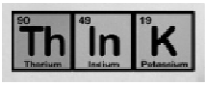
Over generations, atomic mass values will change

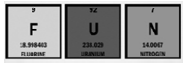
LPT

Reminder:

Memorize the Element Symbols







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