

Atomic Structure

Elements

- Only about 118 different elements make up all the materials we know
 - ← Only 88 of these are found in nature
 - ← The remaining elements are made in laboratories and are too unstable (radioactive) to occur in nature in significant amounts
 - ← Greater than 99% of matter on earth is formed by about a dozen elements
 - ← Life - mostly oxygen, carbon, hydrogen, nitrogen, & calcium
 - ← Hydrogen is most abundant element in universe

The periodic table of the elements

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118
---	---	---	---	---	---	---	---	---	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

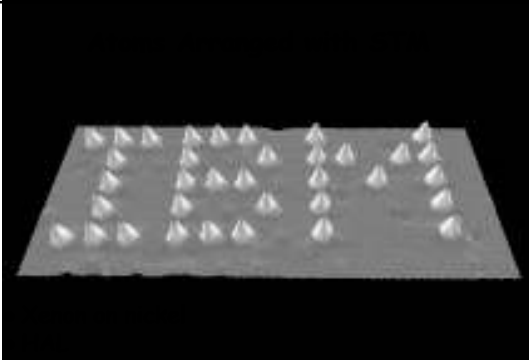
Legend:

- Alkali
- Alkaline Earth
- Transition Metals
- Lanthanides/Actinides
- Gases

First Photo of Individual Atoms



- Photo made in 1970 with a scanning electron microscope by researchers at the University of Chicago's Enrico Fermi Institute.
- Strings of dots are chains of thorium atoms.



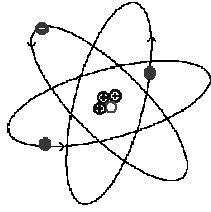
48 Iron Atoms on Copper Crystal



- Iron atoms positioned into a circular ring that "corrals" electrons.
- Taken with a scanning tunneling microscope at the IBM Almaden Laboratory in San Jose, CA.

Atom

- Smallest particle of an element that maintains the properties of the element
- Greek origin - atomos which means indivisible
- In particle accelerators and in stars, subatomic particles can be found
- Atoms composed of protons, neutrons, and electrons
 - ← Actually, protons and neutrons can be further split into quarks



Atomic Structure

- Electrons are negatively charged
- Protons have equal positive charge
- Neutrons are neutral
- Atoms are electrically neutral
- Protons and neutrons in nucleus
 - ← Since like charges repel, how are the protons bound together in the nucleus?
 - » Strong nuclear force - only apparent at distances of 1 - 2 femtometers (10^{-15}m)
- Electrons orbit outside
- Why are neutrons needed?
 - ← Nuclear stability

Atomic Size & Recyclability



- About 10^{23} atoms in a thimbleful of water
- Perpetually moving
 - ← Diffusion
 - ← About 6 years for one of your exhaled breaths to become mixed in the atmosphere

As many atoms in a breath of air as breathfuls of air in Earth's atmosphere

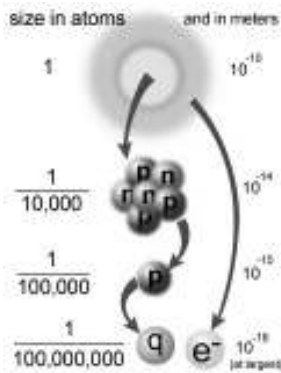


Atomic Scale



- Toyota - Dorito Model
 - ← Nucleons (protons and neutrons) are like toyotas (2000 lb cars)
 - ← Electrons are like bags of doritos (1 lb objects)
 - ← Doritos are orbiting the cars at a distance of a few miles
- (Nucleus) BB on the 50 yard line with the electrons at a distance of about 50 yards from the BB
- Atom is mostly empty space
- Size is electronic

Atomic Scale



Atomic Mass Unit

- Atomic Mass Unit: amu
- approximate mass of a single proton or neutron is 1 amu
- mass of an atom in atomic mass units is simply the sum of its protons and neutrons and is known as the atomic mass number
- mass of an electron is so small that it's disregarded

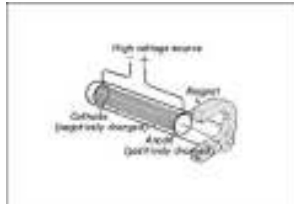
Isotopes

- number of protons in a nucleus exactly matches the number of electrons around the nucleus in a neutral atom,
- number of protons in the nucleus need not match the number of neutrons there
- all hydrogen nuclei have a single proton but most have no neutrons.
- small percentage contain one neutron and a smaller percentage, two neutrons.
- most iron nuclei with 26 protons contain 30 neutrons, while a small percentage contain 29 neutrons.
- Atoms of the same element that contain different numbers of neutrons are isotopes

Electrons



J.J. Thomson
1856-1940



- Cathode Rays
← Deflected by charged particles
← Deflected by magnetic field

Charge on Electron



Robert A. Millikan
1868 - 1953

- Determined charge on electron
- Millikan Oil Drop Experiment



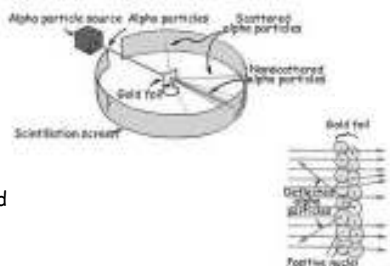
Nucleus



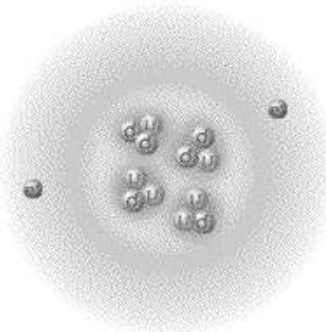
Ernest Rutherford

1871 - 1937

- Rutherford's Gold Foil Experiment
- Deflection of alpha particles showed the atom to be mostly empty space with a concentration of mass at its center



Quarks Make Up Nucleons



- Proton:
2 ups + 1 down
- Neutron:
2 downs + 1 up

AntiMatter

- antimatter is composed of atoms with negative nuclei and positive electrons, or positrons
- positron has the same mass as an electron and the same magnitude of charge but the opposite sign.
- antiprotons have the same mass as protons but are negatively charged



Other Terms

- Element --
- Compound: chemical combination of elements
- Mixtures
- Molecules: smallest particle of a compound that has all the compound's chemical properties.
Atoms combine to form molecules

Dark Matter

- Unseen and unidentified matter
- evident by its gravitational pull on stars in the galaxies
- composing perhaps 90 percent of the matter of the universe
