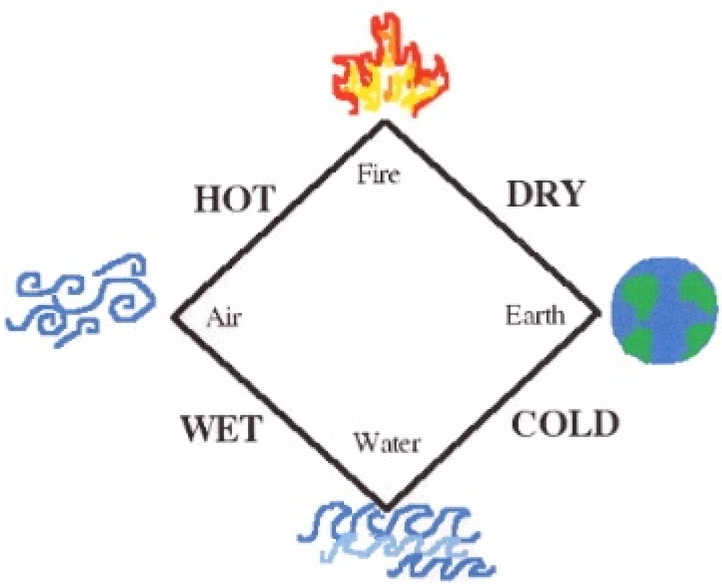
Introduction to Elements

Democritus was the first to suggest the idea of the atom- the idea that something can represent the smallest possible particle of matter. However, he did not know what these atoms were. He believed that they were indestructible. Also, he believed there had to be a vast number of these atoms with a handfull of different shapes: smooth, rough, cubical, etc. These shapes, he believed, accounted for the different physical properties of matter. For example, he hypothesized that when several rough atoms stuck together the result was a solid- something impossible to tear apart. When several smooth atoms came together they would slide past one another and result in a liquid. He believed that there were also smooth atoms that were light as well, this property of lightness gave them an ability to float- explaining gases. Combining different atoms, Democritus concluded, resulted in everything in our world. (7)

Introduction

Although Democritus ideas were noteworthy they were incorrect. Despite this, is should be recognized that his ideas started the foundation for how we think about our world, and what makes up our world. In time the ideas of Democritus were forgotten and the ideas of the famous philosopher, Aristotle, took center stage. Aristotle proposed that the world was made entirely up of four qualities: hot, cold, wet, dry. The world, he speculated was made up of combinations of these qualities. For example, water was cold and wet and fire was hot and dry. Contradictory to Democritus proposal that slippery, smooth, atoms accounted for water's wet properties Aristotle argued that its property could be attributed to its quality of "wetness." Aristotle wrote on a myriad of subjects and although a good amount of his writing made little sense his word was accepted without hesitation at the time. (5)



Finally, in the 17th century a philosophy teacher by the name of Pierre Gassendi challenged Aristotle's ideas. Gassendi did not think Aristotle's idea of four qualities made sense. This prompted Gassedi to set out and disprove Aristotle's ideas with research and induction. Gassendi, after much observation and experimentation, formulated his own theory. Instead of atoms having different shapes, like Democritus propsed, Gassendi believed that they were all fairly alike. Originally Gassendi believed atoms were little balls with hooks- and these hooks, he believed, could interconnect to allow atoms to stick together. Later, however, Gassendi proposed that there was a force, like a magnetic force, that caused the atoms to stick together. This view is similar to what scientists today believe to be truth. (8)

Upon reading Gassendi published work Issac Newton became an avid believer in the existence of atoms. He wrote, "It seems probable to me that God in the Beginning form's Matter in solid, massy, hard, impenetrable, moveable, particles, of such Sizes and Figures, and with such other Properties, and in such Proportion to space, as most conduced to the End for which He form'd them; and that these primitive Particles being Solids, are incomparably harder then any porous Bodies compounded of them; even so very hard as never to wear or break in pieces, no ordinary Power being able to divide what God Himself made one in the First Creation." (5)

The next figure to come into play was Robert Boyle, an English scientist. Because of Robert Boyle Aristotle's idea of four "element" was eliminated entirely. In Boyle's publication of *The Sceptical Chymist* he criticized all previous philosophers (especially Aristotle). His critics evolved from the previous assumption that gold could be made from metals like iron or lead. Boyle proposed that gold could not be made. He said that it was an "element." By calling it and element he meant that it was a basic substance that did not have the ability to be created by combination of other elements. Along with gold, Boyle believed that silver, mercury, and copper were all elements as well (9). Boyle was one of the first to use the word element and in 1661 he wrote, " I mean my element certain Primitive and Simple or perfectly intermingled bodies; which not being made of any other bodies, or of one another, are the Ingredients of which all those call'd perfectly mixt Bodies are immediately compounded, and into which are ultimately resolved." (6)emo Also in his writing he explained that the different types of matter are composed of combination of a small number of simple basic substances. The idea of the element had been born!

Elements: Basic Information

Name	Atomic Number	Elemental Symbol	Atomic Mass	Classification
Hydrogen	1	H	1.00794 amu	Non-Metal
Helium	2	He	4.002602 amu	Nobel Gas
Lithium	3	Li	6.941 amu	Alkali Metal
Beryllium	4	Be	9.012182 amu	Alkaline Earth
Boron	5	B	10.811 amu	Metalloid
Carbon	6	C	12.0107 amu	Non-Metal
Nitrogen	7	N	14.00674 amu	Non-Metal
Oxygen	8	O	15.9994 amu	Non-Metal
Fluorine	9	F	18.9984 amu	Halogen
Neon	10	Ne	20.1797 amu	Nobel Gas
Sodium	11	Na	22.98977 amu	Alkali Metal
Magnesium	12	Mg	24.305 amu	Alkaline Earth
Aluminum	13	Al	26.9815 amu	Other Metal
Silicon	14	Si	28.0855 amu	Metalloid
Phosphorus	15	P	30.97376 amu	Non-Metal
Sulfur	16	S	32.066 amu	Non-Metal

Chlorine	17	Cl	35.4527 amu	Halogen
Argon	18	Ar	39.948 amu	Nobel Gas
Potassium	19	K	39.0983 amu	Alkali Metal
Calcium	20	Ca	40.078 amu	Alkaline Earth
Scandium	21	Sc	44.95591 amu	Transition Metal
Titanium	22	Ti	47.867 amu	Transition Metal
Vanadium	23	V	50.9415 amu	Transition Metal
Chromium	24	Cr	51.9961 amu	Transition Metal
Manganese	25	Mn	54.938 amu	Transition Metal
Iron	26	Fe	55.845 amu	Transition Metal
Cobalt	27	Co	58.9332 amu	Transition Metal
Nickel	28	Ni	58.6934 amu	Transition Metal
Copper	29	Cu	63.546 amu	Transition Metal
Zinc	30	Zn	64.39 amu	Transition Metal
Gallium	31	Ga	69.723 amu	Other Metal
Germanium	32	Ge	72.61 amu	Metalloid
Arsenic	33	As	74.9216 amu	Metalloid
Selenium	34	Se	78.96 amu	Non-Metal
Bromine	35	Br	79.904 amu	Halogen
Krypton	36	Kr	83.8 amu	Nobel Gas
Rubidium	37	Rb	85.4678 amu	Alkali Metal
Strontium	38	Sr	87.62 amu	Alkaline Earth
Yttrium	39	Y	88.90585 amu	Transition Metal
Zirconium	40	Zr	91.224 amu	Transition Metal
Niobium	41	Nb	92.90638 amu	Transition Metal
Molybdenum	42	Mo	95.94 amu	Transition Metal
Technetium	43	Tc	98.o amu	Transition Metal
Ruthenium	44	Ru	101.97 amu	Transition Metal
Rhodium	45	Rh	102.9055 amu	Transition Metal
Palladium	46	Pd	106.42 amu	Transition Metal
Siler	47	Ag	107.8682 amu	Transition Metal
Cadmium	48	Cd	112.41 amu	Transition Metal
Indium	49	In	114.818 amu	Other Metal
Tin	50	Sn	118.71 amu	Other Metal
Antimony	51	Sb	121.76 amu	Metalloid
Tellurium	52	Te	127.6 amu	Metalloid

Iodine	53	I	126. 90447 amu	Halogen
Xenon	54	Xe	131.29 amu	Nobel Gas
Cesium	55	Cs	132.90546 amu	Alkali Metal
Barium	56	Ba	137.327 amu	Alkaline Earth
Lanthanum	57	La	138.9055 amu	Rare Earth
Cerium	58	Ce	140.116 amu	Rare Earth
Praseodymium	59	Pr	140.90765 amu	Rare Earth
Neodymium	60	Nd	144.24 amu	Rare Earth
Promethium	61	Pm	145.0 amu	Rare Earth
Samarium	62	Sm	150.36 amu	Rare Earth
Europium	63	Eu	151.964 amu	Rare Earth
Gadolinium	64	Gd	157.25 amu	Rare Earth
Terbium	65	Tb	158.92534 amu	Rare Earth
Dysprosium	66	Dy	162.5 amu	Rare Earth
Holmium	67	Ho	164.93031 amu	Rare Earth
Erbium	68	Er	167.26 amu	Rare Earth
Thulium	69	Tm	168.9342 amu	Rare Earth
Ytterbium	70	Yb	173.04 amu	Rare Earth
Lutetium	71	Lu	174.967 amu	Rare Earth
Hafnium	72	Hf	178.49 amu	Transition Metal
Tantalum	73	Ta	180.9479 amu	Transition Metal
Tungsten	74	W	183.84 amu	Transition Metal
Rhenium	75	Re	186.207 amu	Transition Metal
Osmium	76	Os	190.23 amu	Transition Metal
Iridium	77	Ir	192.27 amu	Transition Metal
Platinum	78	Pt	195.078 amu	Transition Metal
Gold	79	Au	196.96655 amu	Transition Metal
Mercury	80	Hg	200.59 amu	Transition Metal
Thallium	81	Tl	204.3833 amu	Other Metal
Lead	82	Pb	207.2 amu	Other Metal
Bismuth	83	Bi	208.98038 amu	Other Metal
Polonium	84	Po	209.0 amu	Metalloid
Astatine	85	At	210.0 amu	Halogen
Radon	86	Rn	222.0 amu	Nobel Gas
Francium	87	Fr	223.0 amu	Alkali Metal
Radium	88	Ra	226.0 amu	Alkaline Earth

Actinium	89	Ac	227.0 amu	Rare Earth
Thorium	90	Th	232.0831 amu	Rare Earth
Protactinium	91	Pa	231.03587 amu	Rare Earth
Uranium	92	U	238.0289 amu	Rare Earth
Neptunium	93	Np	237.0 amu	Rare Earth
Plutonium	94	Pu	244.0 amu	Rare Earth
Americium	95	Am	243.0 amu	Rare Earth
Curium	96	Cm	247.0 amu	Rare Earth
Berkelium	97	Bk	247.0 amu	Rare Earth
Californium	98	Cf	251.0 amu	Rare Earth
Einsteinium	99	Es	252.0 amu	Rare Earth
Fermium	100	Fm	257.0 amu	Rare Earth
Mendelevium	101	Md	258.0 amu	Rare Earth
Nobelium	102	No	259.0 amu	Rare Earth
Lawrencium	103	Lr	262.0 amu	Rare Earth
Rutgerfordium	104	Rf	261.0 amu	Transition Metal
Dubnium	105	Db	262.0 amu	Transition Metal
Seavorgium	106	Sg	263.0 amu	Transition Metal
Bohrium	107	Bh	262.0 amu	Transition Metal
Hassium	108	Hs	265.0 amu	Transition Metal
Meitnerium	109	Mt	266.0 amu	Transition Metal
Ununnilium	110	Uun	269.0 amu	Transition Metal
Unununium	111	Uuu	272.0 amu	Transition Metal
Ununbium	112	Uub	277.0 amu	Transition Metal

Classifications of Elements:

Non-Metal:

- These elements are found in groups 13-18 of the periodic table
- They are not able to conduct electricity or heat well
- These elements are very brittle compared to metals
- These elements are not ductile (can not be rolled into wires or pounded into sheets)
- They occur as two states of matter: gases (ex. Oxygen) and solids (ex. Carbon)
- They do not have any metallic luster, nor do they reflect light
- They usually exist as molecules in their elemental form.
- They are generally gases at room temperature.
- They generally form negative ions.

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Uuu	Uub			Uuq		Uuh		Uuo
		Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu		
		Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr		

non-metals

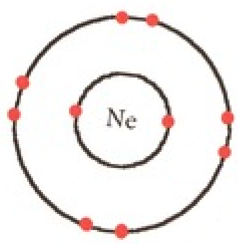
Noble Gas:

- These elements are found in group 18 of the periodic table
- Group 18 are nobles gases, but are still non-metals
- There are 6 noble gases
- They have an oxidation state of 0
- This oxidation state of 0 prevents them from forming compounds readily
- They have the maximum number of electron in their outer shell (Helium has 2 where as the others have 8)
- Because their outer shell is full they are stable elements
- They have high ionization energies.
- They have very low electronegativities.
- They have very low boiling points (all gases at room temperature).

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Uuu	Uub			Uuq		Uuh		Uuo
		Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu		
		Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr		

non-metals

noble gases



Example:

Alkali Metal:

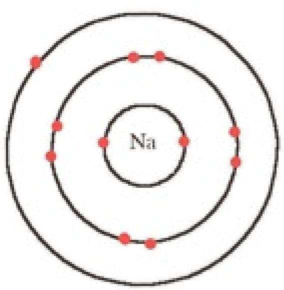
- These elements are located in group 1 of the periodic table
- They are very reactive elements
- Because they are so reactive they do not occur freely in nature
- These elements have only one electron in their outer shell
- They are ready to loss their single electron in ionic bonding with other elements
- Like all metals they are malleable, ductile, and good conductors of electricity
- These metals tend to be softer then most other metals
- Cesium and Francium are the most reactive Alkali Metals
- Exposure to water can result in an explosion
- They have lower densities than other metals.
- They have one loosely bound electron.
- They have low ionization energies and low electronegativities.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg			Uuq				
		Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu		
		Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr		

non-metals

noble gases

alkali metals



Example:

Alkaline Earth:

- These elements are found in the second group of the periodic table
- They are metallic
- They have a oxidation number of +2
- Having an oxidation number of +2 makes these elements very reactive
- They are not found free in nature because of their reactivity
- They are present in the earth's crust but not in their basic form.
- They have high boiling and melting points.
- They have low density, electron affinity, and electronegativity.
- They react easily with halogens and water.
- They are softer and stronger than other metals (except the alkali metals).

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Uuu	Uub			Uuq		Uuh		Uuo

		Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu		
		Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr		

non-metals

noble gases

alkali metals

alkali earth metals

Metalloid:

- These elements are located on the border between metals and non-metals
- These elements have properties of metal and non-metals
- Some of these elements are semi-conductors (they have a ability to carry an electrical charge under certain conditions)
- They can be shiny or dull.
- Their shape is easily changed.
- They typically conduct heat better and electricity better than nonmetals, but not as well as metals.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Uuu	Uub			Uuq		Uuh		Uuo
		Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu		
		Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr		

non-metals

noble gases

alkali metals

alkali earth metals

metalloids

Halogen:

- These elements are located in group 17 of the periodic table
- There are only 5 Halogens
- They are non-metallic elements
- "Halogen" means "salt-former" and compounds that contain halogens are called "salts"
- They have 7 electron in their outer shell
- They have an oxidation number of -1
- At room temperature Halogens exist in all three states of matter

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Uuu	Uub			Uuq		Uuh		Uuo
		Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu		
		Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr		

non-metals

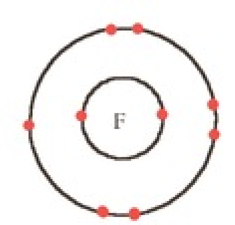
noble gases

alkali metals

alkali earth metals

metalloids

halogens



Example:

Transition Metals:

- These elements are found in group 3 through 12 of the periodic table
- There are 38 elements in this group
- Like all metals they are ductile, malleable, and conduct electricity, and heat
- Their oxidation states are variable
- This group contains iron, cobalt, and nickel, the only elements known to produce and electric field
- They have low ionization energies.
- They have positive oxidation states.
- They have high boiling and melting points.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn

Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Uun	Uuu	Uub		Uuq		Uuh		Uuo
		Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu		
		Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr		

non-metals

noble gases

alkali metals

alkali earth metals

metalloids

halogens

transition metals

Other Metals:

- These elements are located in groups 13. 14 and 15
- They are ductile and malleable
- All elements are solid
- They have rather high densities
- They have oxidation numbers of +4, -4, +3, -3

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar

K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Uun	Uuu	Uub		Uuq		Uuh		Uuo
		Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu		
		Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr		

non-metals

noble gases

alkali metals (metals)

alkali earth metals (metals)

metalloids

halogens

transition metals (metals)

other metals (metals)

Rare Earth Elements:

- They are found in group 3 of the periodic table and the 6th and 7th periods
- There are 30 rare earth elements
- They compose the lanthanide and actinide series
- One element in the lanthanide and most elements in the actinide series are synthetic (man-made)

- They tend to be soft and goldish in color.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Uun	Uuu	Uub		Uuq		Uuh		Uuo
		Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu		
		Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No			

non-metals

noble gases

alkali metals (metals)

alkali earth metals (metals)

metalloids

halogens

transition metals (metals)

other metals (metals)

lanthanides

actinides

Atomic Mass

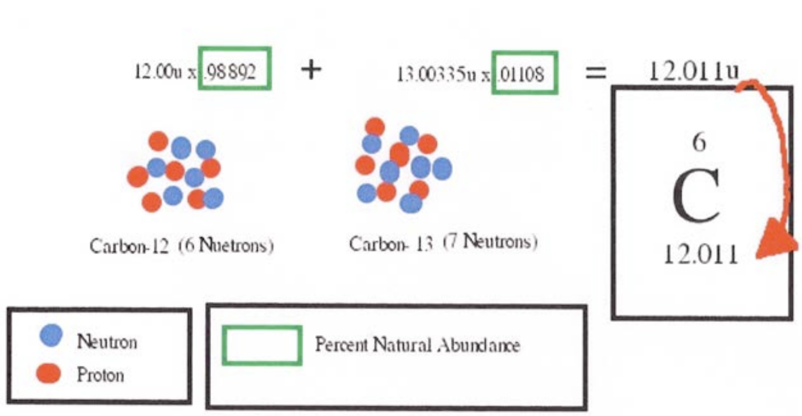
The atomic mass of an element, that which appears on the periodic table, is the average of the isotopic masses. Now, you might be wondering what an isotope is. **Isotopes** are atoms of the same element with different numbers of neutrons. Because there are different numbers of neutron in isotopes then the mass of the isotope is larger then that of the actual atom. The mass we see on the periodic table is the sum of all the isotopic masses times their percent natural abundance (the relative abundance of an isotope found in nature). Lets look at an example.

The atomic mass of Carbon on the periodic table reads 12.011u. We know, however, that carbon-12 has a mass of 12u- so why is the mass on the periodic table slightly larger? Carbon occurs in two forms, Carbon-12 and Carbon-13. These atoms have 6 and 7 neutrons, and masses of 12u and 13.00335u respectively. The percent natural abundance of these elements are Carbon-12, 98.892% and Carbon-13, 1.108%. When we multiply the percent natural abundances by the masses we get the following:

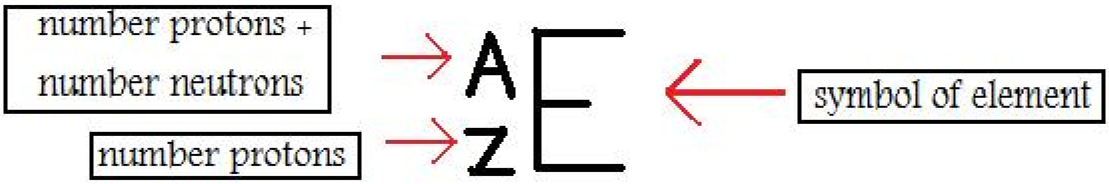
$$12.00u\ (0.98892) + 13.0335u\ (0.01108) = 12.011u$$

This value of 12.011u is what we see on the periodic table. The mass is driven up from 12u because of the mass of Carbon-13, even if its percent natural abundance is small. Therefore, it should be noted that the masses we see on the periodic table, for atoms with isotopes, is always slightly larger then the mass of the actual atom.

The letter "u" stands for Atomic Mass Unit, also known as a dalton (Da). It is the standard unit of mass for atoms and molecules and is approximately 1/12 the mass of a carbon-12 atom.



To represent any atom, there needs to be the chemical symbol, the number of protons, neutrons, and electrons. This could be shown like this:



Since isotopes have different masses,they are written differently. For example,there is Carbon-12 and Carbon 13 are represented as:

$^{12}_{6}C$ $^{13}_{6}C$

Carbon-12 and Carbon-13 have the same number of protons (6), but have different number of neutrons; Carbon-12 has 6 neutrons but Carbon-13 has 7.

Ions

Ions are atoms that carry net charges because it lost or gained an electron. Gaining an electron(s) to an electrically neutral atom would produce a negatively charged ion. Losing an electron(s) would result in a positively charged ion. Note that the number of protons does not change within the process. The charge on an ion is equal to the number of electrons subtracted from the number of protons. This is shown as:

Another example is $^{16}O^{2-}$ ion. There are 8 protons, 8 neutrons, and 10 electrons (8 protons - 10 electrons = -2).

Elements: Fun Facts

Elements	Discoverer	Year Discovered	Color	Uses
Hydrogen	Henry Cavendish	1766	colorless	oil refining processes, metal refining, chemical/scientific applications, formerly balloons
Helium	Jules Janssen, Norman Lockyer	1868	colorless	deep sea diving, balloons, lasers, supercold refrigerant

Lithium	Johan A. Arfwedson	1817	silver- white	cooling systems, ceramics, lubricants, batteries, impact resistant ceramic cookware
Beryllium	Louis Vauquelin	1798	silver- gray	spacecraft, missiles, aircrafts
Boron	Sir Humphry Davy, J.L Gay-Lussac	1808	black	heat resistant alloys, stiff fibers, semiconductor
Carbon	Unknown	ancient in lineage	graphite is black, diamond is colorless	steel, filters, wood, paper, cloth, plastic, electrodes, fibers
Nitrogen	Daniel Rutherford	1772	colorless	forms most of the atmosphere, breathing, fire, minerals, oxides
Oxygen	Carl Wilhelm Scheele	1772	colorless as a gas, liquid is pale blue. Ozone is blue.	found in air, breathing aid, rocket fuel, steel manufacturing, oxidizer for welding etc.
Fluorine	Joseph Henri Moissan	1886	greenish	refrigerants, lasers, supercold refrigerants, fluoro-polymers, toothpaste
Neon	Daniel Rutherford	1772	colorless	neon tubes in advertising signs
Sodium	Sir Humphrey Davy	1807	silvery	medicine, agriculure, salt, baking soda, antacids, lye, soap, street lamps
Magnesium	Sir Humphrey Davy	1808	grayish	airplanes, missles, cars, flares, antacids
Aluminum	Hans Christian Oersted	1825	silver	airplanes, soda cans, kitchenware, clay, ceramics
Silicon	Jons Berzelius	1823	grey	glass, semiconductor, computer chips, siloxane rubber
Phosphorus	Henning Brand	1669	white	matches and other incediary applications, phosphate for fertilizers, detergents, additives
Sulfur	Unknown	very old in lineage	yellow	sulfuric acid, gunpowder, medicines, rubber treatment
Chlorine	Carl Wilhelm Scheele	1774	green	water treatment, bleaches, drinking waters, plastic and solvents production
Argon	Sir William Ramsay	1894	colorless	lighting (light bulbs), "neon" tubes, lasers, welding gas, inter-pane window gas
Potassium	Sir Humphrey Davy	1807	silvery	salts, nerves, nutrient in fruits and vegetables, soap, fertilizer, potash, matches, gunpowder
Calcium	Sir Humphrey Davy	1808	silvery	life sustaining agent for bones and shells
Scandium	Lars Nilson	1879	silvery	aluminum alloys, racing bikes, stadium lamps, furnace bricks, aquamarines
Titanium	William Gregor	1791	silvery	prostheses and implants, white pigment, structural metal, racing bikes, paper, catalyst
Vanadium	Nils Sefstrom	1830	silvery	catalyst, dye, color-renewer, alloying

				agent
Chromium	Louis Vauquelin	1797	grey	stainless steel, corrosion-resistant plating
Manganese	Johann Gahn	1774	silver/greyish	steel, batteries, ceramics
Iron	Unknown	ancient in lineage	silvery	steel and other alloys, wrought iron
Cobalt	George Brandt	1737	silver	magnets, ceramics, special glasses, alloying agent
Nickel	Alex Cronstedt	1751	white	various metal alloys incuding for electroplating, nickel-cadmium batteries
Copper	Unknown	ancient in lineage	red/ orange	electrical conductor, jewelry, coins, plumbing, brass, bronze, and other alloys
Zinc	Andreas Marggraf	1746	bluish	metal coating, rust protection
Gallium	Paul Emile Lecoq de Boisbaudran	1875	white/ silver	semiconductor protection
Germanium	Clemens Winkler	1886	grayish	semiconductor, transistors, rectifiers, diodes, photocells, lenses, infrared windows
Arsenic	Unknown	ancient in lineage	grey	Poison, semiconductor dopant
Selenium	Jons Berzelius	1871	grey	photoelectric cells, TVs, cameras
Bromine	Antoine J. Balard	1826	red	disinfectant, pools and spas, photo film, flame retardant, leaded gas, sedatives
Krypton	Sir William Ramsay	1898	colorless	lighting
Rubidium	R. Bunsen	1861	silver	catalyst, photocells, atomic clocks, global navigation (GPS), vacuum tube scavenger
Strontium	A. Crawford	1790	yellowish	flares, fireworks, crimson color
Yttrium	Johann Gadolin	1794	silvery	color TVs, radars
Zirconium	Martin Klaproth	1789	greyish	nuclear applications
Niobium	Charles Hatchet	1801	white	chemical pipelines, superconductors, magnetic levitation trains, MRI magnets
Molybdenum	Carl Wilhelm Scheele	1778	silvery	aircraft, missiles, alloying agent
Technetium	Carlo Perrier	1937	N/A	Tc-99m is used for radioactive tracing in medicine
Ruthenium	Karl Klaus	1844	silvery	heat resistant alloys
Rhodium	William Wollaston	1803	silvery	coatings, catalysis
Palladium	William Wollaston	1803	white	jewelry, medical instruments
Silver	Unknown	ancient in lineage	silver	jewelry, photography, electrical conductor, coins
Cadmium	Fredrich Stromeyer	1817	silvery	poisonous, nickel-cadmium batteries

Indium	Ferdinand Reich	1863	silvery	coating of high-speed bearings
Tin	Unknown	ancient in lineage	white	coating for steel cans, bronze
Antimony	Unknown	ancient in lineage	bluish	hardens lead, plastics, chemicals
Tellurium	Franz Muller von Reichenstein	1782	silvery	coloring of glass and ceramics, thermoelectric devices
Iodine	Bernard Courtois	1811	blackish solid; purple vapors	disinfectant for wounds and drinking water, added to salt to prevent thyroid disease, photo film
Xenon	Sir William Ramsay	1898	colorless	powerful lamps, bubble chambers
Cesium	Fustov Kirchoff	1860	silver	removes air traces in vacuum tubes
Barium	Sir Humphrey Davy	1808	silver	medical applications, fireworks colorant
Lanthanum	Carl Mosander	1839	white	expensive camera lenses
Cerium	W. von Hisinger	1803	grey	heat-resistant alloys
Praseodymium	C.F. Aver von Welsbach	1885	N/A	coloring glass and ceramics
Neodymium	C.F. Aver von Welsbach	1925	silvery	coloring glass and ceramics, infrared radiation filtering
Promethium	J.A. Marinsky	1945	N/A	luminous dials, sheet thickness gauges
Samarium	Paul Emile Lecoq de Boisbaudran	1879	silver	magnets, in alloys with cobalt, and nuclear reactors
Europium	Eugene Demarcay	1901	silver	color TVs
Gadolinium	Jean de Marignac	1880	silvery	magnetic
Terbium	Carl Mosander	1843	silvery	color TVs
Dysprosium	Paul Emile Lecoq de Boisbaudran	1886	N/A	nuclear reactors
Holmium	J.L. Soret	1878	silver	nuclear reactors
Erbium	Carl Mosander	1843	greyish	ceramics
Thulium	Per Theodor Cleve	1879	silvery	power for portable x-ray machines
Ytterbium	Jean de Marignac	1878	silvery	metallurgical and chemical experiments
Lutetium	Georges Urbain	1907	silvery	cancer-fighting photodynamic (light-activated) medicine
Hafnium	Dirk Coster	1923	silver	nuclear reactors
Tantalum	Anders Ekeberg	1802	grey	capacitors, camera lenses
Tungsten	Fausto and Juan Jose de Elhuyar	1783	silver	used widely in electronics industry, hardening alloy, welding electrode
Rhenium	Walter Noddack	1925	silvery	filaments for mass spectrographs
Osmium	Smithson Tenant	1803	silvery	tip gold pen points, instrument pivots, electrical light filaments
Iridium	S. Tenant	1804	white	tip gold pens, crucible and special containers

Platinum	Julius Scaliger	1735	silvery	jewelry, catalyst, scientific applications
Gold	Unknown	circa 3000 BC	gold	electronics, jewelry, coins
Mercury	Unknown	ancient in lineage	silver	thermometers, barometers, fluorescent lamps, batteries, amalgams
Thallium	Sir William Crookes	1861	bluish	rat and ant poisons, detecting infrared radiation
Lead	Unknown	ancient in lineage	bluish	batteries, solder, ammunition, shielding against radiation, fishing line weights
Bismuth	Unknown	ancient in lineage	white	pharmaceuticals, fuses, water sprinklers against fire
Polonium	Pierre and Marie Curie	1898	N/A	first radioactive element found, small traces in nature, anti-static brushes, tobacco
Astatine	D.R. Corson	1940	N/A	cancer medicine
Radon	Fredrich Ernst Dorn	1898	colorless	surgical implants for cancer treatment, environmental hazards
Francium	Marguerite Derey	1939	N/A	studied in laser atom traps
Radium	Pierre and Marie Curie	1898	silvery	treating cancer, formerly for glowing dials
Actinium	Andre Debierne	1899	silvery	small traces in nature, cancer medicine, neutron source, radwaste
Thorium	Jons Berzelius	1828	silvery	strong alloys, ultraviolet photoelectric cells, possible nuclear fuel in future
Protactinium	Fredrich Soddy	1917	N/A	N/A
Uranium	Martin Klaproth	1789	silvery	fuel for nuclear reactors, ammunition (illegitimate), shielding
Neptunium	E.M. McMillan	1940	N/A	N/A
Plutonium	G.T. Seaborg	1940	N/A	bombs, nuclear reactors
Americium	G.T. Seaborg	1945	N/A	smoke detectors
Curium	G.T. Seaborg	1944	N/A	scientific instruments, mineral analyzers
Berkelium	G.T. Seaborg	1949	N/A	N/A
Californium	G.T. Seaborg	1950	N/A	scientific instruments, mineral analyzers
Einsteinium	Argonne, Los Alamos, University of California	1952	N/A	N/A
Fermium	Argonne, Los Alamos, University of California	1953	N/A	N/A
Mendelevium	G.T. Seaborg	1955	N/A	N/A
Nobelium	Nobel Institute for Physics	1957	N/A	N/A

Lawrencium	Albert Ghiorso	1961	N/A	N/A
Rutherfordium	Albert Ghiorso	1969	N/A	N/A
Dubnium	Albert Ghiorso	1970	N/A	N/A
Seaborgium	Albert Ghiorso	1974	N/A	N/A
Bohrium	Peter Armbruster, Gottfried Munzenber and others	1976	N/A	N/A
Hassium	Peter Armbruster, Gottfried Munzenber and others	1984	N/A	N/A
Meitnerium	Heavy Ion Research Laboratory	1982	N/A	N/A
Ununnilium	Organessian, et al	1987	N/A	N/A
Unununium	S. Hofmann	1994	N/A	N/A
Ununbium	S. Hofmann, V. Ninov, F. P. Hessbuger	1996	N/A	N/A

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