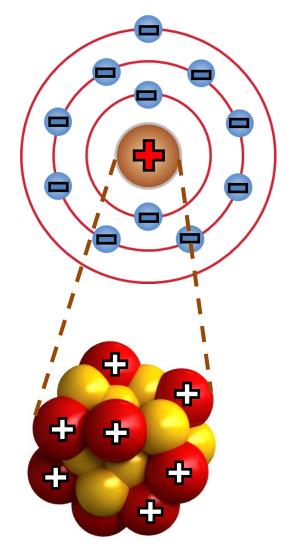
Atomic Structure Summary

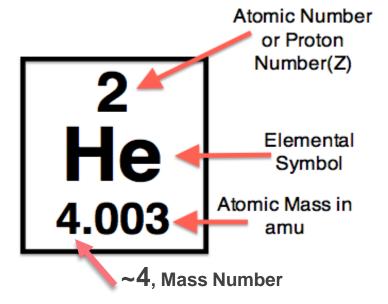
- <u>All atoms</u> have:
 - > a positively charged nucleus
 - and negatively charged electrons moving around within atomic orbitals
- Atomic nucleus consists of:
 - positively charged protons
 - and neutrons that have no electric charge
- # of protons = # of electrons



Understanding Elements

The <u>number of protons and neutrons</u> in the nucleus give the atoms their <u>specific characteristics</u>.

- All atoms of the same chemical element contain the same number of protons, defined by a unique atomic number of that element.
- For example, all <u>helium</u> atoms, and only helium atoms, contain two protons and have an <u>atomic number of 2</u>.



- Atoms are also characterized by:
 - atomic mass, "relative isotopic mass" in unified atomic mass units, which is roughly (within 1%) equal to the whole mass number (since the mass of a proton and the mass of a neutron are almost the same and the mass of the atom's electrons is negligibly small)
 - mass number, which is a sum of the number of protons and the number of neutrons in the nucleus (number of nucleons)

Periodic Table of Elements is arranged in order of increasing atomic number

		(shown <i>color-coded</i> according											2			
4										0	He					
· · ·	to discovery timeline from										10					
Ве											Ne					
12	antiquity to 2012) 13 14 15 16 17										18					
Mg	AI SI P S CI /										Ar					
20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
Sr	Y	Zr	Nb	Мо	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te		Xe
56	57	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
Ва	-71	Hf	Та	W	Re	Os	Ir	Pt	Au	Hg	TI	Pb	Bi	Po	At	Rn
88	89	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118
Ra	-103	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Uut	FI	Uup	Lv	Uus	Uuo
	Mg 20 Ca 38 Sr 56 Ba 88	Be 12 Mg 20 21 Ca Sc 38 39 Sr Y 56 57 Ba -71 88 89	Be Se 12 Mg 20 21 22 Ca Sc Ti 38 39 40 Sr Y Zr 56 57 72 Ba -71 Hf 88 89 104	Be an 12 20 21 22 23 20 21 22 23 Ca Sc Ti V 38 39 40 41 Sr Y Zr Nb 56 57 72 73 Ba -71 Hf Ta 88 89 104 105	Be antique 12 20 21 22 23 24 20 21 22 23 24 Ca Sc Ti V Cr 38 39 40 41 42 Sr Y Zr Nb Mo 56 57 72 73 74 Ba -71 Hf Ta W 88 89 104 105 106	Be antiquity 12 Mg 20 21 22 23 24 25 Ca Sc Ti V Cr Mn 38 39 40 41 42 43 Sr Y Zr Nb Mo Tc 56 57 72 73 74 75 Ba -71 Hf Ta W Re 88 89 104 105 106 107	Bee antiquity to 2 12 Mg 20 21 22 23 24 25 26 Ca Sc Ti V Cr Mn Fe 38 39 40 41 42 43 44 Sr Y Zr Nb Mo Tc Ru 56 57 72 73 74 75 76 Ba -71 Hf Ta W Re Os 88 89 104 105 106 107 108	Be antiquity to 201 12 Mg 20 21 22 23 24 25 26 27 Ca Sc Ti V Cr Mn Fe Co 38 39 40 41 42 43 44 45 Sr Y Zr Nb Mo Tc Ru Rh 56 57 72 73 74 75 76 77 Ba -71 Hf Ta W Re Os Ir 88 89 104 105 106 107 108 109	Be antiquity to 2012) Mg 20 21 22 23 24 25 26 27 28 Ca Sc Ti V Cr Mn Fe Co Ni 38 39 40 41 42 43 44 45 46 Sr Y Zr Nb Mo Tc Ru Rh Pd 56 57 72 73 74 75 76 77 78 Ba -71 Hf Ta W Re Os Ir Pt 88 89 104 105 106 107 108 109 110	Be antiquity to 2012) Mg 20 21 22 23 24 25 26 27 28 29 Ca Sc Ti V Cr Mn Fe Co Ni Cu 38 39 40 41 42 43 44 45 46 47 Sr Y Zr Nb Mo Tc Ru Rh Pd Ag 56 57 72 73 74 75 76 77 78 79 Ba -71 Hf Ta W Re Os Ir Pt Au 88 89 104 105 106 107 108 109 110 111	antiquity to 2012) Mg 20 21 22 23 24 25 26 27 28 29 30 Ca Sc Ti V Cr Mn Fe Co Ni Cu Zn 38 39 40 41 42 43 44 45 46 47 48 Sr Y Zr Nb Mo Tc Ru Rh Pd Ag Cd 56 57 72 73 74 75 76 77 78 79 80 Ba -71 Hf Ta W Re Os Ir Pt Au Hg 88 89 104 105 106 107 108 109 110 111 112	Be B 12 antiquity to 2012) Mg 13 20 21 22 23 24 25 26 27 28 29 30 31 Ca Sc Ti V Cr Mn Fe Co Ni Cu Zn Ga 38 39 40 41 42 43 44 45 46 47 48 49 Sr Y Zr Nb Mo Tc Ru Rh Pd Ag Cd In 56 57 72 73 74 75 76 77 78 79 80 81 Ba -71 Hf Ta W Re Os Ir Pt Au Hg TI 88 89 104 105 106 107 108 109 110 111 112 113	Be B C 12 12 11 14 Mg 13 14 20 21 22 23 24 25 26 27 28 29 30 31 32 Ca Sc Ti V Cr Mn Fe Co Ni Cu Zn Ga Ge 38 39 40 41 42 43 44 45 46 47 48 49 50 Sr Y Zr Nb Mo Tc Ru Rh Pd Ag Cd In Sn 56 57 72 73 74 75 76 77 78 79 80 81 82 Ba -71 Hf Ta W Re Os Ir Pt Au Hg Tl Pb 88 89 104 105 106 107 108 109 110 111 112 113 114	Be C N 12 A <td>Be C N O 12 A<td>Be C N O F 12 antiquity to 2012) 13 14 15 16 17 Mg 13 14 15 16 17 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 Ca Sc Ti V Cr Mn Fe Co Ni Cu Zn Ga Ge As Se Br 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 Sr Y Zr Nb Mo Tc Ru Rh Pd Ag Cd In Sn Sb Te I 56 57 72 73 74 75 76 77 78 79 80 81 82 83 84 85 Ba -71 Hf Ta W</td></td>	Be C N O 12 A <td>Be C N O F 12 antiquity to 2012) 13 14 15 16 17 Mg 13 14 15 16 17 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 Ca Sc Ti V Cr Mn Fe Co Ni Cu Zn Ga Ge As Se Br 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 Sr Y Zr Nb Mo Tc Ru Rh Pd Ag Cd In Sn Sb Te I 56 57 72 73 74 75 76 77 78 79 80 81 82 83 84 85 Ba -71 Hf Ta W</td>	Be C N O F 12 antiquity to 2012) 13 14 15 16 17 Mg 13 14 15 16 17 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 Ca Sc Ti V Cr Mn Fe Co Ni Cu Zn Ga Ge As Se Br 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 Sr Y Zr Nb Mo Tc Ru Rh Pd Ag Cd In Sn Sb Te I 56 57 72 73 74 75 76 77 78 79 80 81 82 83 84 85 Ba -71 Hf Ta W

5	7	58	59	60	61	62	63	64	65	66	67	68	69	70	71
Li	a	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Но	Er	Tm	Yb	Lu
8	9	90	91	92	93	94	95	96	97	98	99	100	101	102	103
A	С	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

Known in antiquity

also known when (akw) Levoisier published his list of elements (1789)

akw Mendeleev published his periodic table (1869)

akw Deming published his periodic table (1923)

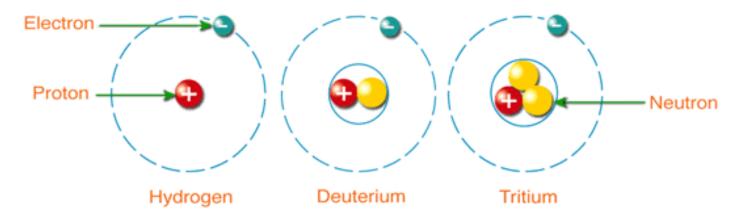
akw Seaborg published his periodic table (1945)

also known (ak) up to 2000

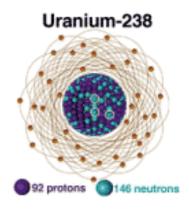
ak to 2012

What is *Isotope*?

<u>Isotopes</u> are different <u>forms of a given element</u> that have the <u>same number of protons</u> in each atom but differ in number of <u>neutrons</u>.



Most elements have more than one isotope.

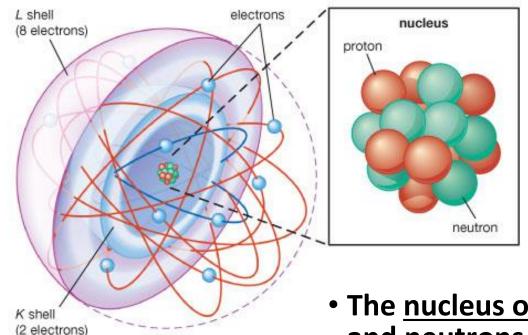




There are 20 Plutonium isotopes, all of them *unstable*!

 $Pu^{228} \longrightarrow Pu^{247}$

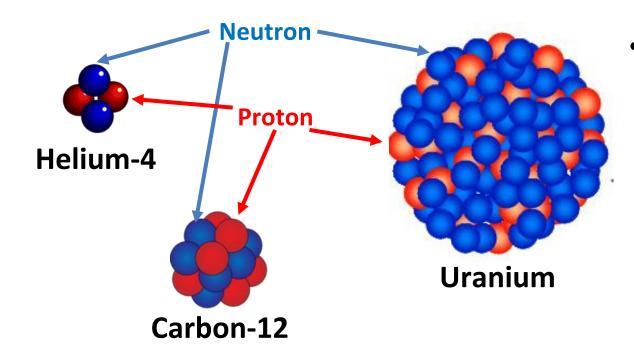
What Holds an Atom Together?



- The <u>electrons</u> are kept in orbit around the nucleus due to an <u>electromagnetic field</u> of attraction between the positive (+) charge of the protons and the negative (-) charge of the electrons.
- The <u>nucleus of protons</u> <u>and neutrons</u> is kept together by the <u>nuclear</u> (strong) force, which opposes and overcomes the electromagnetic repulsion when particles are very close to each other (~1 fm!).

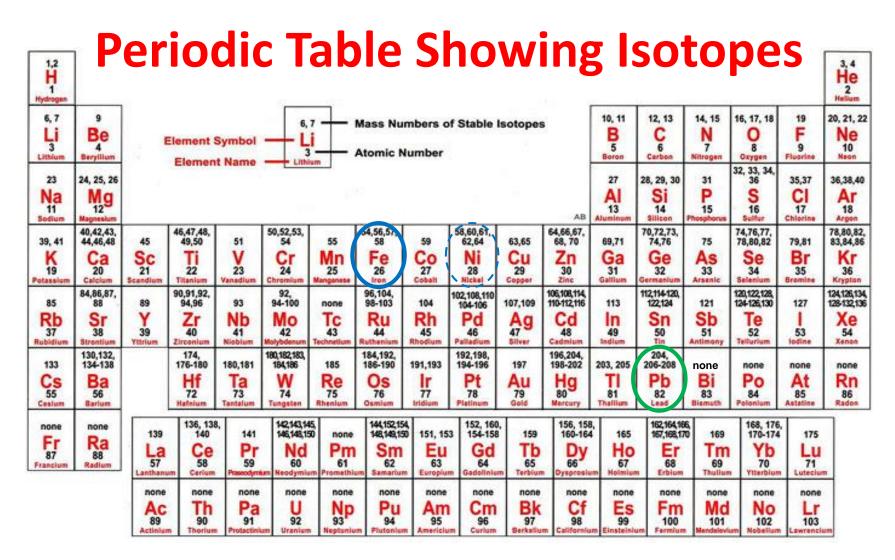
Binding Energy and Atom Stability

Nuclear (binding) energy is the energy associated with the nuclear force.



 A <u>stable atom</u> is an atom that has <u>enough binding energy</u> to hold the nucleus together permanently. An <u>unstable atom</u> does not have enough binding energy to hold the nucleus together permanently and <u>will lose neutrons</u> as it attempts to become stable...

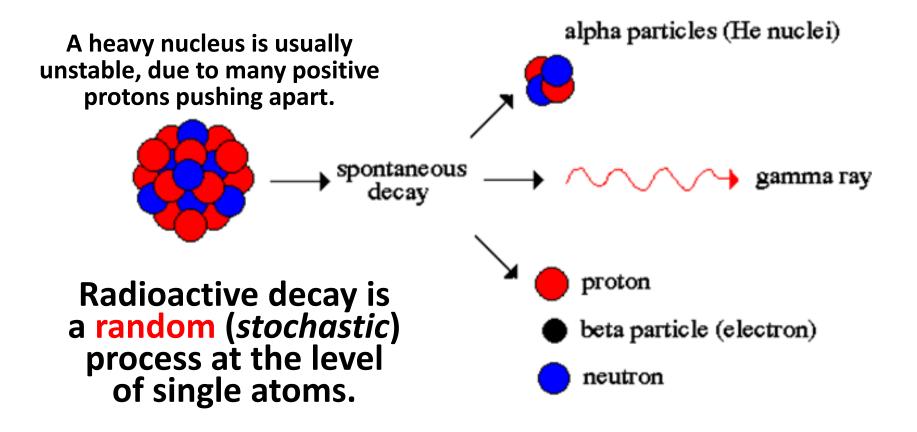
...radioactivity!



- The nucleus of an iron isotope with mass number 56 is more stable than any other element's nucleus (the farther from 56 an element's mass number is, the more unstable that element's nucleus tends to be).
- The <u>heaviest element</u> that still has stable isotopes is Lead.

Radioactive Decay

<u>Radioactive decay</u>, also known as <u>radioactivity</u> or <u>nuclear decay</u>, is the process by which a nucleus of an unstable atom loses energy by emitting ionizing radiation: ⁴He (alpha particles), β particles (electrons), γ rays (energetic photons), neutrons.



Half-Life of Radioactive Isotope

The <u>decay rate</u> of a radioactive isotope is characterized by its half-life: the *time it takes for one-half of the atoms* of a radioactive material *to disintegrate*.

<u>Radioisotope</u>	<u>Half-life</u>					
Polonium-215	0.0018 seconds					
Bismuth-212	60.5 seconds					
Sodium-24	15 hours					
lodine-131	8.07 days					
Cobalt-60	5.26 years					
Radium-226	1600 years					
Uranium-238	4.5 billion years					