

Atoms & Elements Part 1:

Atomic Structure: Isotopes and the Nucleus

Atoms are the building blocks of matter.

What is the definition of matter?

There are 3 subatomic particles that are the building block of atoms.

What are the 3 subatomic particles and their charges?

Which subatomic particle(s) create the mass of an atom?

Which subatomic particle(s) create the volume of an atom?

What is the atomic number of an atom? What is its symbol?

What is the mass number of an atom? What is its symbol?

Is every atom of an element identical? Why or why not?

What are isotopes?

Distinguishing between Isotopes

What is the mass number of an atom containing 42 protons, 42 electrons, and 47 neutrons?

Write the elemental symbol for the isotope above using the ${}^A_Z\text{E}$ format.

Iodine has an atomic number of 53. I-131 is used in the medical treatment of thyroid conditions. How many neutrons and protons are contained in the nucleus of this isotope?

The Average Atomic Mass of an element is a weighted average of the mass of its isotopes based on their natural abundance.

Do all elements have the same distribution of isotopes?

The isotopic distribution for chromium is shown below.
The atomic number for chromium is 24.

Isotope	% Abundance
^{50}Cr	4.345
^{52}Cr	83.79
^{53}Cr	9.50
^{54}Cr	2.365

Which isotope is the lightest?

Which isotope is the most abundant?

Which isotope has the largest number of neutrons?

The Atomic Number and Average Atomic Mass are listed with each element on the periodic table.

24
Cr
51.996

Atoms and Elements Part 1b: Atomic Structure & the electrons

Matter is anything with mass and volume.

What else do we know about electrons?

1)

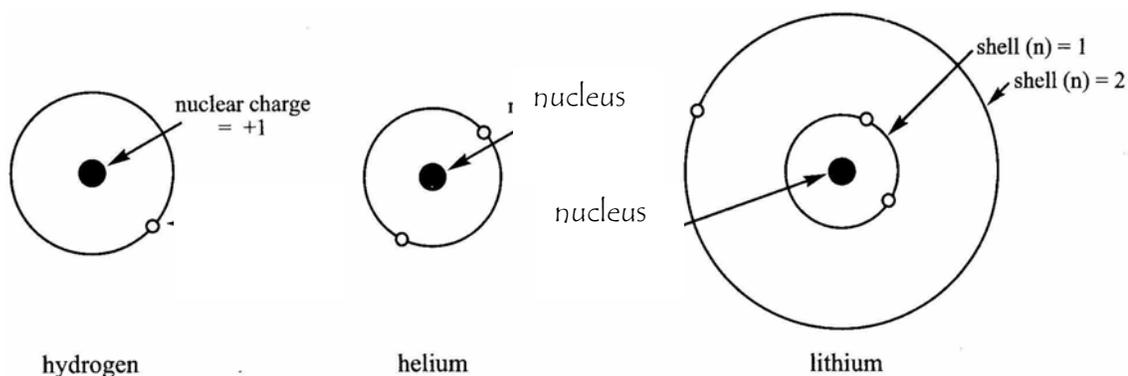
2)

3)

Electronic structure can be viewed as a peace agreement between electrons who want to share a nucleus.

Electrons travel in mathematically defined regions around the nucleus. These regions are called _____.

Shells are described by the letter 'n'. Shells with higher energy have larger values of 'n'. The higher the energy, the larger the shell becomes and the further from the nucleus the electrons are found.



The larger the value of 'n', the more electrons a shell can hold. The maximum number of electrons can be determined from the formula $2n^2$, where n is the shell number.

Electron shell	Max Number of electrons
$n = 1$	
$n = 2$	
$n = 3$	
$n = 4$	

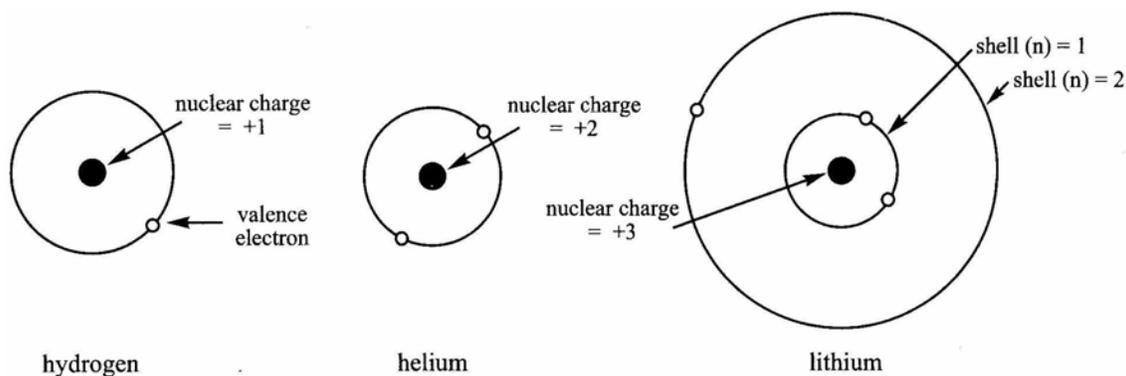
Not all electrons are equal.

The outer most electron shell is called the **valence shell**.

Everything else is the **core**.

Valence electrons

Core electrons



How many electrons are in the valence shell of Li?

How many inner shell (core) electrons does Li have?

If core charge = nuclear charge + core electron charge, then what is the core charge of Li?

Valence electrons

The periodic table is arranged so that elements with same number of valence electrons occur in the same column. These columns are called "groups". The number of valence electrons can be determined from the group number at the top of each column.

of valence electrons =

1 Group IA		2 Group IIA												13 Group IIIA	14 Group IVA	15 Group VA	16 Group VIA	17 Group VIIA	18 Group VIIIA										
1 H 1.01																					2 He 4.00								
3 Li 6.94	4 Be 9.01																					5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18		
11 Na 22.99	12 Mg 24.30	3 Group IIIB	4 Group IVB	5 Group VB	6 Group VIB	7 Group VIIB	8 Group VIII	9 Group VIII	10 Group VIII	11 Group IB	12 Group IIB	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95												
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.84	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.41	31 Ga 69.72	32 Ge 72.64	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80												
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29												
55 Cs 132.91	56 Ba 137.33	57 La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)												
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (264)	108 Hs (269)	109 Mt (268)	110 Ds (271)	111 - (272)	112 - (277)			114 - (289)															

of core electrons =

core charge =

Element	total # e ⁻	# valence e ⁻	# core e ⁻	nuclear charge	core charge
O					
Al					
K					

Valence electrons and Chemical Reactivity

Chemical properties are determined by the number of valence electrons.
Elements can gain or lose valence electrons.

Metals lose their valence electrons.

Non-metals gain valence electrons to fill their outermost shell (subshell).

For our course, we will focus on elements that fill their outermost shell/subshells with 8 electrons (octet).

The dark, stair-step line separates the metals from the non-metals.
All of the elements touching the stair-step are called metalloids EXCEPT aluminum.

1 Group IA		2 Group IIA												13 Group IIIA	14 Group IVA	15 Group VA	16 Group VIA	17 Group VIIA	18 Group VIIIA
1 H 1.01																			2 He 4.00
3 Li 6.94	4 Be 9.01												5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18	
11 Na 22.99	12 Mg 24.30	3 Group IIIB	4 Group IVB	5 Group VB	6 Group VIB	7 Group VIIB	8 Group VIII	9 Group VIII	10 Group VIII	11 Group IB	12 Group IIB	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95		
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.84	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.41	31 Ga 69.72	32 Ge 72.64	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80		
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29		
55 Cs 132.91	56 Ba 137.33	57 La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)		
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (264)	108 Hs (269)	109 Mt (268)	110 Ds (271)	111 - (272)	112 - (277)		114 - (289)						

What is the charge of the ion formed when the following atoms lose their valence electrons?

- a) Ca
- b) Al

What is the charge of the ion formed when the following atoms gain valence electrons to form an octet?

- a) O
- b) Br

Atoms & Elements Part 2:

Valence Electrons & the Octet Rule

Chemical properties are determined by the number of valence electrons. The elements are arranged in the periodic table so that elements with same number of valence electrons occur in the same column. The number of valence electrons can be determined from the group number at the top of each column. We can show the valence electrons as dots around the element symbol.

Periodic Table of the Elements

1 Group IA		2 Group IIA												13 Group IIIA	14 Group IVA	15 Group VA	16 Group VIA	17 Group VIIA	18 Group VIIIA	
1 H 1.01	3 Li 6.94	11 Na 22.99	19 K 39.10	27 Co 58.93	35 Br 79.90	43 Tc (98)	51 Sb 121.76	59 Pr 140.91	67 Ho 164.93	75 Re 186.21	83 Bi 208.98	91 Pa 231.04	99 Es (252)	107 Bh (264)	115 Nh (289)	119 Ts (289)	127 Nh (289)	135 Nh (289)	137 Nh (289)	
2 He 4.00	4 Be 9.01	10 Ne 20.18	18 Ar 39.95	26 Fe 55.84	34 Se 78.96	42 Mo 95.94	50 Sn 118.71	58 Ce 140.12	66 Dy 162.50	74 W 183.84	82 Pb 207.2	90 Th 232.04	98 Cf (251)	106 Lv (260)	112 Cn (277)	118 Xe 131.29	126 Lv (260)	134 Lv (260)	136 Lv (260)	138 Lv (260)
5 B 10.81	6 C 12.01	12 Mg 24.30	20 Ca 40.08	28 Ni 58.69	36 Kr 83.80	44 Ru 101.07	52 Te 127.60	60 Nd 144.24	68 Er 167.26	76 Os 190.23	84 Po (209)	92 U 238.03	100 Fm (260)	108 Lv (260)	114 Fl (289)	120 Dn (289)	128 Lv (260)	136 Lv (260)	138 Lv (260)	140 Lv (260)
7 N 14.01	8 O 16.00	13 Al 26.98	21 Sc 44.96	29 Cu 63.55	37 Rb 85.47	45 Rh 102.91	53 I 126.90	61 Pm (145)	69 Tm 168.93	77 Ir 192.22	85 At (210)	93 Np (237)	101 Md (260)	109 Mt (268)	117 Ts (289)	123 Nh (289)	131 Nh (289)	139 Nh (289)	141 Nh (289)	143 Nh (289)
9 F 19.00	10 Ne 20.18	14 Si 28.09	22 Ti 47.87	30 Zn 65.39	38 Sr 87.62	46 Pd 106.42	54 Xe 131.29	62 Sm 150.36	70 Yb 173.04	50 Sn 118.71	86 Rn (222)	94 Pu (242)	102 No (259)	110 Dn (289)	118 Og (289)	124 Lv (260)	132 Lv (260)	140 Lv (260)	142 Lv (260)	144 Lv (260)
15 P 30.97	16 S 32.06	15 P 30.97	23 V 50.94	31 Ga 69.72	39 Y 88.91	39 Y 88.91	55 Cs 132.91	63 Eu 151.96	71 Lu 174.97	47 Ag 107.87	83 Bi 208.98	95 Am (243)	103 Lr (262)	111 Rg (272)	119 Og (289)	125 Lv (260)	133 Lv (260)	141 Lv (260)	143 Lv (260)	145 Lv (260)
17 Cl 35.45	18 Ar 39.95	16 S 32.06	24 Cr 52.00	32 Ge 72.64	40 Zr 91.22	40 Zr 91.22	56 Ba 137.33	64 Gd 157.25	72 Hf 178.49	48 Cd 112.41	84 Po (209)	96 Cm (248)	104 Fl (260)	112 Cn (277)	120 Dn (289)	126 Lv (260)	134 Lv (260)	142 Lv (260)	144 Lv (260)	146 Lv (260)
19 K 39.10	20 Ca 40.08	25 Mn 54.94	33 As 74.92	41 Nb 92.91	41 Nb 92.91	41 Nb 92.91	57 La 138.91	65 Tb 158.93	73 Ta 182.04	54 Xe 131.29	85 At (210)	97 Bk (247)	105 Nh (260)	113 Nh (289)	121 Nh (289)	127 Nh (289)	135 Nh (289)	143 Nh (289)	145 Nh (289)	147 Nh (289)
21 Sc 44.96	22 Ti 47.87	26 Fe 55.84	34 Se 78.96	42 Mo 95.94	42 Mo 95.94	42 Mo 95.94	58 Ce 140.12	66 Dy 162.50	74 W 183.84	55 Cs 132.91	86 Rn (222)	98 Cf (251)	106 Lv (260)	114 Fl (289)	122 Lv (260)	130 Lv (260)	138 Lv (260)	146 Lv (260)	148 Lv (260)	150 Lv (260)
23 V 50.94	24 Cr 52.00	30 Zn 65.39	40 Zr 91.22	48 Cd 112.41	48 Cd 112.41	48 Cd 112.41	60 Nd 144.24	68 Er 167.26	76 Os 190.23	56 Ba 137.33	87 Fr (223)	99 Es (252)	107 Nh (289)	115 Nh (289)	123 Nh (289)	131 Nh (289)	139 Nh (289)	147 Nh (289)	149 Nh (289)	151 Nh (289)
25 Mn 54.94	26 Fe 55.84	31 Ga 69.72	44 Ru 101.07	52 Te 127.60	52 Te 127.60	52 Te 127.60	62 Sm 150.36	70 Yb 173.04	78 Pt 195.08	57 La 138.91	88 Ra (226)	100 Fm (260)	108 Lv (260)	116 Lv (260)	124 Lv (260)	132 Lv (260)	140 Lv (260)	148 Lv (260)	150 Lv (260)	152 Lv (260)
27 Co 58.93	28 Ni 58.69	32 Ge 72.64	46 Pd 106.42	54 Xe 131.29	54 Xe 131.29	54 Xe 131.29	64 Gd 157.25	72 Hf 178.49	80 Hg 200.59	58 Ce 140.12	89 Ac (227)	101 Md (260)	109 Mt (268)	117 Ts (289)	125 Lv (260)	133 Lv (260)	141 Lv (260)	149 Lv (260)	151 Lv (260)	153 Lv (260)
29 Cu 63.55	30 Zn 65.39	33 As 74.92	48 Cd 112.41	56 Ba 137.33	56 Ba 137.33	56 Ba 137.33	66 Dy 162.50	74 W 183.84	82 Pb 207.2	59 Pr 140.91	90 Th 232.04	102 No (259)	110 Dn (289)	118 Og (289)	126 Lv (260)	134 Lv (260)	142 Lv (260)	150 Lv (260)	152 Lv (260)	154 Lv (260)
31 Ga 69.72	32 Ge 72.64	35 Br 79.90	50 Sn 118.71	58 Ce 140.12	58 Ce 140.12	58 Ce 140.12	68 Er 167.26	76 Os 190.23	84 Po (209)	61 Pm (145)	91 Pa 231.04	103 Lr (262)	111 Rg (272)	119 Og (289)	127 Nh (289)	135 Nh (289)	143 Nh (289)	151 Nh (289)	153 Nh (289)	155 Nh (289)
33 As 74.92	34 Se 78.96	38 Sr 87.62	52 Te 127.60	60 Nd 144.24	60 Nd 144.24	60 Nd 144.24	70 Yb 173.04	78 Pt 195.08	86 Rn (222)	62 Sm 150.36	92 U 238.03	104 Fl (260)	112 Cn (277)	120 Dn (289)	128 Lv (260)	136 Lv (260)	144 Lv (260)	152 Lv (260)	154 Lv (260)	156 Lv (260)
35 Br 79.90	36 Kr 83.80	40 Zr 91.22	54 Xe 131.29	62 Sm 150.36	62 Sm 150.36	62 Sm 150.36	72 Hf 178.49	80 Hg 200.59	88 Ra (226)	63 Eu 151.96	93 Np (237)	105 Nh (260)	113 Nh (289)	121 Nh (289)	129 Nh (289)	137 Nh (289)	145 Nh (289)	153 Nh (289)	155 Nh (289)	157 Nh (289)
37 Rb 85.47	38 Sr 87.62	44 Ru 101.07	58 Ce 140.12	66 Dy 162.50	66 Dy 162.50	66 Dy 162.50	76 Os 190.23	84 Po (209)	92 U 238.03	64 Gd 157.25	94 Pu (242)	106 Lv (260)	114 Fl (289)	122 Lv (260)	130 Lv (260)	138 Lv (260)	146 Lv (260)	154 Lv (260)	156 Lv (260)	158 Lv (260)
39 Y 88.91	40 Zr 91.22	46 Pd 106.42	60 Nd 144.24	68 Er 167.26	68 Er 167.26	68 Er 167.26	78 Pt 195.08	86 Rn (222)	94 Pu (242)	65 Tb 158.93	95 Am (243)	107 Nh (260)	115 Nh (289)	123 Nh (289)	131 Nh (289)	139 Nh (289)	147 Nh (289)	155 Nh (289)	157 Nh (289)	159 Nh (289)
41 Nb 92.91	42 Mo 95.94	50 Sn 118.71	64 Gd 157.25	72 Hf 178.49	72 Hf 178.49	72 Hf 178.49	82 Pb 207.2	90 Th 232.04	98 Cf (251)	67 Ho 164.93	96 Cm (248)	108 Lv (260)	116 Lv (260)	124 Lv (260)	132 Lv (260)	140 Lv (260)	148 Lv (260)	156 Lv (260)	158 Lv (260)	160 Lv (260)
43 Tc (98)	44 Ru 101.07	54 Xe 131.29	68 Er 167.26	76 Os 190.23	76 Os 190.23	76 Os 190.23	86 Rn (222)	94 Pu (242)	102 No (259)	69 Tm 168.93	97 Bk (247)	109 Mt (268)	117 Ts (289)	125 Lv (260)	133 Lv (260)	141 Lv (260)	149 Lv (260)	157 Nh (289)	159 Nh (289)	161 Nh (289)
45 Rh 102.91	46 Pd 106.42	58 Ce 140.12	72 Hf 178.49	80 Hg 200.59	80 Hg 200.59	80 Hg 200.59	90 Th 232.04	98 Cf (251)	106 Lv (260)	70 Yb 173.04	98 Cf (251)	110 Dn (289)	118 Og (289)	126 Lv (260)	134 Lv (260)	142 Lv (260)	150 Lv (260)	158 Lv (260)	160 Lv (260)	162 Lv (260)
47 Ag 107.87	48 Cd 112.41	62 Sm 150.36	76 Os 190.23	84 Po (209)	84 Po (209)	84 Po (209)	94 Pu (242)	102 No (259)	110 Dn (289)	71 Lu 174.97	99 Es (252)	111 Rg (272)	119 Og (289)	127 Nh (289)	135 Nh (289)	143 Nh (289)	151 Nh (289)	159 Nh (289)	161 Nh (289)	163 Nh (289)
49 In 114.82	50 Sn 118.71	66 Dy 162.50	80 Pb 207.2	88 Ra (226)	88 Ra (226)	88 Ra (226)	96 Cm (248)	104 Fl (260)	112 Cn (277)	73 Ta 182.04	100 Fm (260)	112 Cn (277)	120 Dn (289)	128 Lv (260)	136 Lv (260)	144 Lv (260)	152 Lv (260)	160 Lv (260)	162 Lv (260)	164 Lv (260)
51 Sb 121.76	52 Te 127.60	70 Yb 173.04	84 Po (209)	92 U 238.03	92 U 238.03	92 U 238.03	100 Fm (260)	108 Lv (260)	116 Lv (260)	74 W 183.84	102 No (259)	114 Fl (289)	122 Lv (260)	130 Lv (260)	138 Lv (260)	146 Lv (260)	154 Lv (260)	162 Lv (260)	164 Lv (260)	166 Lv (260)
53 I 126.90	54 Xe 131.29	74 Ta 182.04	88 Ra (226)	96 Cm (248)	96 Cm (248)	96 Cm (248)	104 Fl (260)	112 Cn (277)	120 Dn (289)	75 Re 186.21	104 Fl (260)	116 Lv (260)	124 Lv (260)	132 Lv (260)	140 Lv (260)	148 Lv (260)	156 Lv (260)	164 Lv (260)	166 Lv (260)	168 Lv (260)
55 Cs 132.91	56 Ba 137.33	78 Pt 195.08	92 U 238.03	100 Fm (260)	100 Fm (260)	100 Fm (260)	108 Lv (260)	116 Lv (260)	124 Lv (260)	77 Ir 192.22	106 Lv (260)	118 Og (289)	126 Lv (260)	134 Lv (260)	142 Lv (260)	150 Lv (260)	158 Lv (260)	166 Lv (260)	168 Lv (260)	170 Lv (260)
57 La 138.91	58 Ce 140.12	82 Pb 207.2	90 Th 232.04	98 Cf (251)	98 Cf (251)	98 Cf (251)	106 Lv (260)	114 Fl (289)	122 Lv (260)	79 Au 196.97	108 Lv (260)	120 Dn (289)	132 Lv (260)	144 Lv (260)	156 Lv (260)	168 Lv (260)	180 Lv (260)	192 Lv (260)	204 Lv (260)	216 Lv (260)
59 Pr 140.91	60 Nd 144.24	86 Rn (222)	94 Pu (242)	102 No (259)	102 No (259)	102 No (259)	110 Dn (289)	118 Og (289)	126 Lv (260)	80 Hg 200.59	110 Dn (289)	122 Lv (260)	134 Lv (260)	146 Lv (260)	158 Lv (260)	170 Lv (260)	182 Lv (260)	194 Lv (260)	206 Lv (260)	218 Lv (260)
61 Pm (145)	62 Sm 150.36	90 Th 232.04	98 Cf (251)	106 Lv (260)	106 Lv (260)	106 Lv (260)	114 Fl (289)	122 Lv (260)	130 Lv (260)	81 Tl 204.38	112 Cn (277)	124 Lv (260)	136 Lv (260)	148 Lv (260)	160 Lv (260)	172 Lv (260)	184 Lv (260)	196 Lv (260)	208 Lv (260)	220 Lv (260)
63 Eu 151.96	64 Gd 157.25	94 Pu (242)	102 No (259)	110 Dn (289)	110 Dn (289)	110 Dn (289)	118 Og (289)	126 Lv (260)	134 Lv (260)	82 Pb 207.2	114 Fl (289)	126 Lv (260)	138 Lv (260)	150 Lv (260)	162 Lv (260)	174 Lv (260)	186 Lv (260)	198 Lv (260)	210 Lv (260)	222 Lv (260)
65 Tb 158.93	66 Dy 162.50	96 Cm (248)	104 Fl (260)	112 Cn (277)	112 Cn (277)	112 Cn (277)	120 Dn (289)	128 Lv (260)	136 Lv (260)	83 Bi 208.98	116 Lv (260)									

