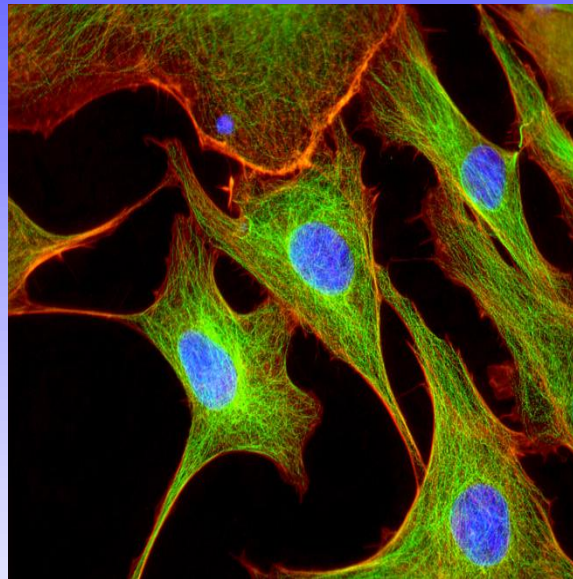
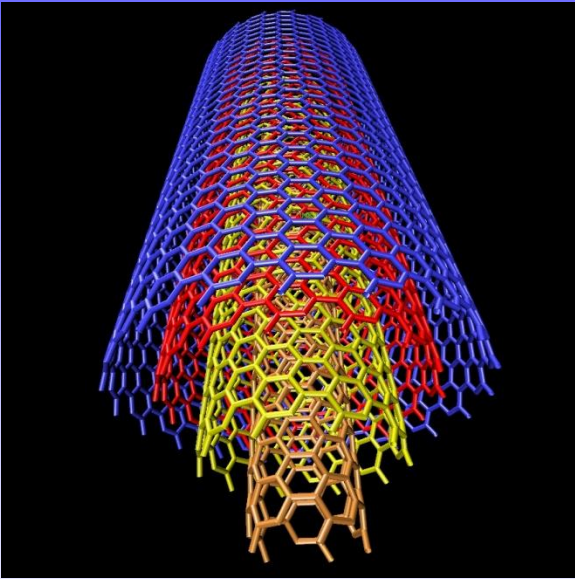


# Building a Universe



**Auburn Mountainview**

**Karl Steffin, 2001**

**8/14/2025**

# By end of this lesson, I can...

- **AS1: describe the differences between chemical and physical changes.**
- **AS3: calculate the charge of an element in order write an ion.**
- **AS4: use the atomic number and atomic mass number of an isotope, to draw and label a model of the isotope's atomic structure.**
- **AS5: use the relative mass and abundance of isotopes to calculate the atomic mass of an element.**
- **AS7: use the periodic table to find elements based on their properties...**

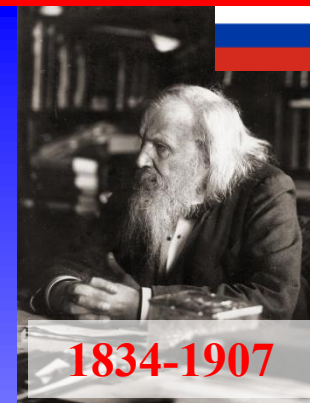
# The Subatomic Particles

- ‘All’ elements contain the same three particles:

Particle	Charge (q)	Mass (amu)
<b>Proton (<math>p^+</math>)</b>	<b>1</b>	<b>1</b>
<b>Electron (<math>e^-</math>)</b>	<b>-1</b>	<b>1/1900</b>
<b>Neutron (<math>n^0</math>)</b>	<b>0</b>	<b>1</b>



# The Periodic Table



1834-1907

- Contains data on all of the elements.
  - Credited to Dmitri Mendeleev in 1869.
- As of 2010 118 elements have been synthesized.
  - New elements can be named after a mythological concept, a mineral, a place or country, a property or a scientist (normally dead: **Seaborg, Oganessian**).































1912-1999



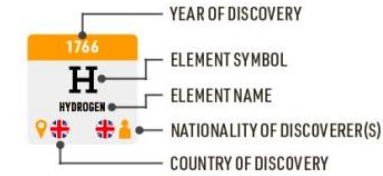
1933-



# PERIODIC TABLE OF ELEMENT DISCOVERIES

ANTIQUITY		1200-1700		1701-1800		1801-1850		1851-1900		1901-1950		1951-2000		2001-PRESENT			
<div>1766</div> <div>H</div> <div>HYDROGEN</div> <div></div>																	
<div>1817</div> <div>Li</div> <div>LITHIUM</div> <div></div>	<div>1797</div> <div>Be</div> <div>BERYLLIUM</div> <div></div>																
<div>1807</div> <div>Na</div> <div>SODIUM</div> <div></div>	<div>1755</div> <div>Mg</div> <div>MAGNESIUM</div> <div></div>																
<div>1807</div> <div>K</div> <div>POTASSIUM</div> <div></div>	<div>1808</div> <div>Ca</div> <div>CALCIUM</div> <div></div>	<div>1879</div> <div>Sc</div> <div>SCANDIUM</div> <div></div>	<div>1791</div> <div>Ti</div> <div>TITANIUM</div> <div></div>	<div>1801</div> <div>V</div> <div>VANADIUM</div> <div></div>	<div>1798</div> <div>Cr</div> <div>CHROMIUM</div> <div></div>	<div>1774</div> <div>Mn</div> <div>MANGANESE</div> <div></div>	ANTIQUITY	<div>1735</div> <div>Co</div> <div>COBALT</div> <div></div>	<div>1751</div> <div>Ni</div> <div>NICKEL</div> <div></div>	ANTIQUITY	<div>1746</div> <div>Zn</div> <div>ZINC</div> <div></div>	<div>1875</div> <div>Ga</div> <div>GALLIUM</div> <div></div>	<div>1886</div> <div>Ge</div> <div>GERMANIUM</div> <div></div>	<div>1250</div> <div>As</div> <div>ARSENIC</div> <div></div>	<div>1817</div> <div>Se</div> <div>SELENIUM</div> <div></div>	<div>1825</div> <div>Br</div> <div>BROMINE</div> <div></div>	<div>1898</div> <div>Kr</div> <div>KRYPTON</div> <div></div>
<div>1861</div> <div>Rb</div> <div>RUBIDIUM</div> <div></div>	<div>1790</div> <div>Sr</div> <div>STRONTIUM</div> <div></div>	<div>1794</div> <div>Y</div> <div>YTTRIUM</div> <div></div>	<div>1789</div> <div>Zr</div> <div>ZIRCONIUM</div> <div></div>	<div>1801</div> <div>Nb</div> <div>NIOBIUM</div> <div></div>	<div>1781</div> <div>Mo</div> <div>MOLYBDENUM</div> <div></div>	<div>1937</div> <div>Tc</div> <div>TECHNETIUM</div> <div></div>	<div>1844</div> <div>Ru</div> <div>RUTHENIUM</div> <div></div>	<div>1803</div> <div>Rh</div> <div>RHODIUM</div> <div></div>	<div>1803</div> <div>Pd</div> <div>PALLADIUM</div> <div></div>	ANTIQUITY	<div>1817</div> <div>Cd</div> <div>CADMIUM</div> <div></div>	<div>1863</div> <div>In</div> <div>INDIUM</div> <div></div>	ANTIQUITY	<div>1783</div> <div>Te</div> <div>TELLURIUM</div> <div></div>	<div>1811</div> <div>I</div> <div>IODINE</div> <div></div>	<div>1898</div> <div>Xe</div> <div>XENON</div> <div></div>	
<div>1860</div> <div>Cs</div> <div>CAESIUM</div> <div></div>	<div>1808</div> <div>Ba</div> <div>BARIUM</div> <div></div>	57-71	<div>1923</div> <div>Hf</div> <div>HAFNIUM</div> <div></div>	<div>1802</div> <div>Ta</div> <div>TANTALUM</div> <div></div>	<div>1783</div> <div>W</div> <div>TUNGSTEN</div> <div></div>	<div>1925</div> <div>Re</div> <div>RHENIUM</div> <div></div>	<div>1803</div> <div>Os</div> <div>OSMIUM</div> <div></div>	<div>1803</div> <div>Ir</div> <div>IRIDIUM</div> <div></div>	<div>1735</div> <div>Pt</div> <div>PLATINUM</div> <div></div>	ANTIQUITY	<div>1746</div> <div>Hg</div> <div>MERCURY</div> <div></div>	<div>1861</div> <div>Tl</div> <div>THALLIUM</div> <div></div>	ANTIQUITY	<div>1753</div> <div>Bi</div> <div>BISMUTH</div> <div></div>	<div>1898</div> <div>Po</div> <div>POLONIUM</div> <div></div>	<div>1940</div> <div>At</div> <div>ASTATINE</div> <div></div>	<div>1899</div> <div>Rn</div> <div>RADON</div> <div></div>
<div>1939</div> <div>Fr</div> <div>FRANCIUM</div> <div></div>	<div>1898</div> <div>Ra</div> <div>RADIUM</div> <div></div>		89-103	<div>1964</div> <div>Rf</div> <div>RUTHERFORDIUM</div> <div></div>	<div>1968</div> <div>Db</div> <div>DUBNIUM</div> <div></div>	<div>1974</div> <div>Sg</div> <div>SEABORGIUM</div> <div></div>	<div>1981</div> <div>Bh</div> <div>BOHRIUM</div> <div></div>	<div>1984</div> <div>Hs</div> <div>HASSIUM</div> <div></div>	<div>1982</div> <div>Mt</div> <div>MEITNERIUM</div> <div></div>	<div>1994</div> <div>Ds</div> <div>DARMSTADTIUM</div> <div></div>	<div>1994</div> <div>Rg</div> <div>ROENTGENIUM</div> <div></div>	<div>1996</div> <div>Cn</div> <div>COPERNICIUM</div> <div></div>	<div>2004</div> <div>Nh</div> <div>NIHONIUM</div> <div></div>	<div>1998</div> <div>Fl</div> <div>FLEROVIUM</div> <div></div>	<div>2004</div> <div>Mc</div> <div>MOSCOVIUM</div> <div></div>	<div>2000</div> <div>Lv</div> <div>LIVERMORIUM</div> <div></div>	<div>2010</div> <div>Ts</div> <div>TENNESSE</div> <div></div>
<div>1839</div> <div>La</div> <div>LANTHANUM</div> <div></div>	<div>1803</div> <div>Ce</div> <div>CERIUM</div> <div></div>	<div>1885</div> <div>Pr</div> <div>PRASEODYMIUM</div> <div></div>	<div>1885</div> <div>Nd</div> <div>NEODYMIUM</div> <div></div>	<div>1945</div> <div>Pm</div> <div>PROMETHIUM</div> <div></div>	<div>1879</div> <div>Sm</div> <div>SAMARIUM</div> <div></div>	<div>1901</div> <div>Eu</div> <div>EUROPIUM</div> <div></div>	<div>1880</div> <div>Gd</div> <div>GADOLINIUM</div> <div></div>	<div>1843</div> <div>Tb</div> <div>TERBIUM</div> <div></div>	<div>1886</div> <div>Dy</div> <div>DYSPROSIUM</div> <div></div>	<div>1878</div> <div>Ho</div> <div>HOLMIUM</div> <div></div>	<div>1843</div> <div>Er</div> <div>ERBIUM</div> <div></div>	<div>1879</div> <div>Tm</div> <div>THULIUM</div> <div></div>	<div>1878</div> <div>Yb</div> <div>YTTERBIUM</div> <div></div>	<div>1907</div> <div>Lu</div> <div>LUTETIUM</div> <div></div>			
<div>1899</div> <div>Ac</div> <div>ACTINIUM</div> <div></div>	<div>1829</div> <div>Th</div> <div>THORIUM</div> <div></div>	<div>1913</div> <div>Pa</div> <div>PROTACTINIUM</div> <div></div>	<div>1789</div> <div>U</div> <div>URANIUM</div> <div></div>	<div>1940</div> <div>Np</div> <div>NEPTUNIUM</div> <div></div>	<div>1940</div> <div>Pu</div> <div>PLUTONIUM</div> <div></div>	<div>1944</div> <div>Am</div> <div>AMERICIUM</div> <div></div>	<div>1944</div> <div>Cm</div> <div>CURIUM</div> <div></div>	<div>1949</div> <div>Bk</div> <div>BERKELIUM</div> <div></div>	<div>1950</div> <div>Cf</div> <div>CALIFORNIUM</div> <div></div>	<div>1952</div> <div>Es</div> <div>EINSTEINIUM</div> <div></div>	<div>1953</div> <div>Fm</div> <div>FERMIUM</div> <div></div>	<div>1955</div> <div>Md</div> <div>MENDELEVIUM</div> <div></div>	<div>1963</div> <div>No</div> <div>NOBELIUM</div> <div></div>	<div>1965</div> <div>Lr</div> <div>LAWRENCIUM</div> <div></div>			

## KEY



UK..... ♀ 22 ♂ 22  
 USA..... ♀ 20 ♂ 21  
 GERMANY..... ♀ 19 ♂ 19  
 SWEDEN..... ♀ 19 ♂ 18  
 FRANCE..... ♀ 16 ♂ 16  
 RUSSIA/USSR..... ♀ 9 ♂ 9  
 AUSTRIA..... ♀ 3 ♂ 4  
 SPAIN..... ♀ 2 ♂ 3  
 SWITZERLAND..... ♀ 2 ♂ 3  
 DENMARK..... ♀ 2 ♂ 1

FINLAND..... ♀ 1 ♂ 1  
 ITALY..... ♀ 1 ♂ 1  
 JAPAN..... ♀ 1 ♂ 1  
 MEXICO..... ♀ 1 ♂ 0  
 ROMANIA..... ♀ 1 ♂ 0  
 CANADA..... ♀ 1 ♂ 0  
 POLAND..... ♀ 0 ♂ 3  
 HUNGARY..... ♀ 0 ♂ 1  
 NETHERLANDS..... ♀ 0 ♂ 1  
 NEW ZEALAND..... ♀ 0 ♂ 1

# PERIODIC TABLE OF ELEMENT PRICES

## KEY

	£5-£10 per kilogram		£1000-£5000 per kilogram
	£10-£100 per kilogram		>£5000 per kilogram
	£100-£1000 per kilogram		Price unknown

Note: element prices can vary significantly with quantity and purity

<div>H HYDROGEN £18.14</div>																		<div>He HELIUM £30.99</div>												
<div>Li LITHIUM £88.76</div>	<div>Be BERYLLIUM £638</div>																	<div>B BORON £1831</div>	<div>C CARBON £18.41</div>	<div>N NITROGEN £2.13</div>	<div>O OXYGEN £0.49</div>	<div>F FLUORINE £1458</div>	<div>Ne NEON £483</div>							
<div>Na SODIUM £2.33</div>	<div>Mg MAGNESIUM £1.73</div>																	<div>Al ALUMINIUM £1.47</div>	<div>Si SILICON £1.47</div>	<div>P PHOSPHORUS £230</div>	<div>S SULFUR £0.08</div>	<div>Cl CHLORINE £1.15</div>	<div>Ar ARGON £1.96</div>							
<div>K POTASSIUM £9.99</div>	<div>Ca CALCIUM £4.55</div>	<div>Sc SCANDIUM £11508</div>	<div>Ti TITANIUM £2.89</div>	<div>V VANADIUM £17.34</div>	<div>Cr CHROMIUM £5.86</div>	<div>Mn MANGANESE £1.58</div>	<div>Fe IRON £0.06</div>	<div>Co COBALT £45.65</div>	<div>Ni NICKEL £7.05</div>	<div>Cu COPPER £4.53</div>	<div>Zn ZINC £2.17</div>	<div>Ga GALLIUM £213</div>	<div>Ge GERMANIUM £1407</div>	<div>As ARSENIC £1.33</div>	<div>Se SELENIUM £23.30</div>	<div>Br BROMINE £3.38</div>	<div>Kr KRYPTON £1.07</div>													
<div>Rb RUBIDIUM £11293</div>	<div>Sr STRONTIUM £4.14</div>	<div>Y YTTRIUM £26.85</div>	<div>Zr ZIRCONIUM £17.75</div>	<div>Nb NIOBIUM £32.22</div>	<div>Mo MOLYBDENUM £12.28</div>	<div>Tc TECHNETIUM No data</div>	<div>Ru RUTHENIUM £2343</div>	<div>Rh RHODIUM £58952</div>	<div>Pd PALLADIUM £26393</div>	<div>Ag SILVER £355</div>	<div>Cd CADMIUM £1.52</div>	<div>In INDIUM £262</div>	<div>Sn TIN £15.34</div>	<div>Sb ANTIMONY £5.41</div>	<div>Te TELLURIUM £42.72</div>	<div>I IODINE £21.48</div>	<div>Xe XENON £7.06</div>													
<div>Cs CAESIUM £56312</div>	<div>Ba BARIUM £422</div>	La-Lu	<div>Hf HAFNIUM £1085</div>	<div>Ta TANTALUM £183</div>	<div>W TUNGSTEN £19.58</div>	<div>Re RHENIUM £1255</div>	<div>Os OSMIUM £9866</div>	<div>Ir IRIDIUM £23926</div>	<div>Pt PLATINUM £20325</div>	<div>Au GOLD £29298</div>	<div>Hg MERCURY £29.49</div>	<div>Tl THALLIUM £5677</div>	<div>Pb LEAD £1.76</div>	<div>Bi BISMUTH £7.93</div>	<div>Po POLONIUM No data</div>	<div>At ASTATINE No data</div>	<div>Rn RADON No data</div>													
<div>Fr FRANCIUM No data</div>	<div>Ra RADIUM No data</div>		Ac-Lr	<div>Rf RUTHERFORDIUM No data</div>	<div>Db DUBNIUM No data</div>	<div>Sg SEABORGIUM No data</div>	<div>Bh BOHRNIUM No data</div>	<div>Hs HASSIUM No data</div>	<div>Mt MEITNERIUM No data</div>	<div>Ds DARMSTADTIUM No data</div>	<div>Rg ROENTGENIUM No data</div>	<div>Cn COPERNICIUM No data</div>	<div>Nh NIHONIUM No data</div>	<div>Fl FLEROVIUM No data</div>	<div>Mc MOSCOVIUM No data</div>	<div>Lv LIVERMORIUM No data</div>	<div>Ts TENNESSINE No data</div>	<div>Og OGANESSON No data</div>												

# Navigating the Periodic Table

- Rows ( $\leftrightarrow$ ) are called **periods** (7 total).
- Columns ( $\updownarrow$ ) are called **families** or **groups**.
- Electrons tell us when to start a new period.
- Elements are given a one or two letter symbol.
  - Ex: Li, He, Ne, C, V, W, Ti.
- Most of the time the name and symbol are the same
  - Li is Lithium, O is Oxygen

# Trivial: Names that do not follow set rules

Name	Symbol	Derivative	Meaning
Antimony	Sb	Stibium	Aribic/Egyptian: Eye Paint
Copper	Cu	Cuprum	Latin: From Cyprus
Gold	Au	Aurum	Latin: Glowing Dawn
Iron	Fe	Ferrum	Latin: Holy/Strong Metal (Sword)
Lead	Pb	Plumbum	Latin: Soft Metals
Mercury	Hg	Hydrargyros	Greek: Liquid Silver
Potassium	K	Kalium	Arabic: Plant Ashes
Silver	Ag	Argentum	Indo-European: White, Shining, Money
Sodium	Na	Natrium	Arabic/Egyptian: Soda
Tin	Sn	Stannum	Indo-European: Dripping
Tungsten	W	Wolfram	German: Wolf froth (Tin stealer)



# Protons

- **Elements are assigned an Atomic Number (Z) according to the number of protons in their nucleus.**
  - **Example: All Hydrogen atoms (H) have only 1  $p^+$ .**
  - **Example: All Carbon atoms (C) have only 6  $p^+$ .**
- **Elements are placed on the periodic table according to ascending proton number.**
  - **Example: Helium (He) has 2  $p^+$  so it is the second element to appear on the periodic table.**

# The Periodic Table (~2005)

GROUP 1										2									
<div>11.007941.1H1s1Hydrogen</div>										<div>24.002601.0He1s2Helium</div>									
3(6.941)11615453.7Li[He]2s1Lithium										49.012182227441560Be[He]2s2Beryllium									
1122.9897701156.1371.00.971Na[Ne]3s1Sodium										1224.305013639231.74Mg[Ne]3s2Magnesium									
1939.09831033336.80.862K[Ar]4s1Potassium										2040.078175711151.55Ca[Ar]4s2Calcium									
2144.95591310918142.99Sc[Ar]3d14s2Scandium										2247.86743.24.45Ti[Ar]3d24s2Titanium									
2350.94154.32.2183V[Ar]3d34s2Vanadium										2451.9963.627.19Cr[Ar]3d54s1Chromium									
2554.93802.34.67223415197.44Mn[Ar]3d54s2Manganese										2655.8453.627.874Fe[Ar]3d64s2Iron									
2758.93322.33131418117.874Co[Ar]3d74s2Cobalt										2858.93342.33131418117.874Ni[Ar]3d84s2Nickel									
2963.5462.131180692.688.96Cu[Ar]3d104s1Copper										3065.4092231180692.687.13Zn[Ar]3d104s2Zinc									
3169.7231.332773130692.686.095Ga[Ar]3d104s24p1Gallium										3272.644310692.685.32Ge[Ar]3d104s24p2Germanium									
3374.92164.6-2.3319581090208.105.73As[Ar]3d104s24p3Arsenic										3478.964.6-23319581090208.104.79Se[Ar]3d104s24p4Selenium									
3579.904±1.7,5.33319581090208.103.12Br[Ar]3d104s24p5Bromine										3683.800.23319581090208.103.73Kr[Ar]3d104s24p6Krypton									
3785.4678961312.461.532Rb[Kr]5s1Rubidium										3887.62165510502.54Sr[Kr]5s2Strontium									
3988.9059361817954.47Y[Kr]4d15s2Yttrium										4091.224468221286.51Zr[Kr]4d25s2Zirconium									
4192.90638501729308.57Nb[Kr]4d45s1Niobium										4295.944912289610.22Mo[Kr]4d55s1Molybdenum									
43(98)7.54432360711.5*Tc[Kr]4d55s2Technetium										44101.072.3,4,6,84423260712.37Ru[Kr]4d75s1Ruthenium									
45102.905503968223712.41Rh[Kr]4d85s1Rhodium										46106.422.44423260712.0Pd[Kr]4d10Palladium									
47107.86824351234.9310.50Ag[Kr]4d105s1Silver										48112.412435594.228.65Cd[Kr]4d105s2Cadmium									
49114.823245594.227.31In[Kr]4d105s25p1Indium										50118.7104.250.08Sn[Kr]4d105s25p2Tin									
51121.7601860903.78Sb[Kr]4d105s25p3Antimony										52127.604.6-21261722.666.69Te[Kr]4d105s25p4Tellurium									
53126.9047±1.5,7531261951.165.1I[Kr]4d105s25p5Iodine										54131.290.2,4,6,8165.11161.1Xe[Kr]4d105s25p6Xenon									
55132.905451217010003.5Cs[Xe]6s1Cesium										56137.327217010003.5Ba[Xe]6s2Barium									
57138.9055373711816.15La[Xe]5d16s2Lanthanum										58178.494876250613.31Hf[Xe]4f145d46s2Hafnium									
59180.94795730329016.65Ta[Xe]4f145d36s2Tantalum										60183.846.5,4,3,25828369519.3W[Xe]4f145d46s2Tungsten									
61186.2077.6,5,4,3,25870345921.0Re[Xe]4f145d56s2Rhenium										62190.234.6,5,3,25285330622.57Os[Xe]4f145d66s2Osmium									
63192.2174.2,6,34700272022.42Ir[Xe]4f145d76s2Iridium										64195.084.240982041.55Pt[Xe]4f145d96s1Platinum									
65196.966553.131303629.88234.3219.3Au[Xe]4f145d106s1Gold										66200.592.131303629.88234.3213.55Hg[Xe]4f145d106s2Mercury									
67204.3833.1174657711.85Tl[Xe]4f145d106s26p1Thallium										68207.22.42022600.615.77Pb[Xe]4f145d106s26p2Lead									
69208.98043.51837544.559.75Bi[Xe]4f145d106s26p3Bismuth										(209)4.625279.3Po[Xe]4f145d106s26p4Polonium									
(210)±1.7,5.3610*575At[Xe]4f145d106s26p5Astatine										(222)0.221.210.973Rn[Xe]4f145d106s26p6Radon									
87(223)Fr[Rn]7s1Francium										88(226)Ra[Rn]7s2Radium									
89(227)Ac3470*132410.07Rf[Rn]5f146d17s2Rutherfordium										(261)104[Rn]5f146d97s2Dubnium									
105(262)Db[Rn]5f146d97s2Dubnium										106(266)Sg[Rn]5f146d97s2Seaborgium									
107(264)Bh[Rn]5f146d97s2Bohrium										108(277)Hs[Rn]5f146d97s2Hassium									
109(268)Mt[Rn]5f146d97s2Meitnerium										110(269)Ds[Rn]5f146d97s2Darmstadtium									
111(272)Rg[Rn]5f146d97s2Roentgenium										112(285)Uub[Rn]5f146d97s2(Ununbium)									
113(284)Uut[Rn]5f146d97s27p1(Ununtrium)										114(289)Uuq[Rn]5f146d97s27p2(Ununquadium)									
115(288)Uup[Rn]5f146d97s27p3(Ununpentium)										116(289)Uuh[Rn]5f146d97s27p4(Ununhexium)									
117(290)Uus[Rn]5f146d97s27p5(Ununseptium)										118(292)Uuo[Rn]5f146d97s27p6(Ununoctium)									

★	58140.116 3716 1071 6.77 Ce [Xe]4f <sup>1</sup> 5d <sup>1</sup> 6s <sup>2</sup> Cerium	59140.90765 3785 1204 6.77 Pr [Xe]4f <sup>3</sup> 6s <sup>2</sup> Praseodymium	60144.24 3347 1294 7.01 Nd [Xe]4f <sup>4</sup> 6s <sup>2</sup> Neodymium	61(145) 3273 1315 7.26 Pm [Xe]4f <sup>5</sup> 6s <sup>2</sup> Promethium	62150.36 2067 1347 7.52 Sm [Xe]4f <sup>6</sup> 6s <sup>2</sup> Samarium	63151.964 1869 1095 5.24 Eu [Xe]4f <sup>7</sup> 6s <sup>2</sup> Europium	64157.25 3546 1629 7.90 Gd [Xe]4f <sup>7</sup> 5d <sup>1</sup> 6s <sup>2</sup> Gadolinium	65158.92534 3503 1629 8.23 Tb [Xe]4f <sup>9</sup> 6s <sup>2</sup> Terbium	66162.50 2840 1685 8.55 Dy [Xe]4f <sup>10</sup> 6s <sup>2</sup> Dysprosium	67164.9303 2973 1747 8.795 Ho [Xe]4f <sup>11</sup> 6s <sup>2</sup> Holmium	68167.26 3140 1802 9.07 Er [Xe]4f <sup>12</sup> 6s <sup>2</sup> Erbium	69168.9342 2223 1818 9.32 Tm [Xe]4f <sup>13</sup> 6s <sup>2</sup> Thulium	70173.04 1499 1082 9.84 Yb [Xe]4f <sup>14</sup> 6s <sup>2</sup> Ytterbium	71174.967 3675 1936 9.84 Lu [Xe]4f <sup>14</sup> 5d <sup>1</sup> 6s <sup>2</sup> Lutetium
★★	90232.0381 5061 2023 11.72 Th [Rn]6d <sup>2</sup> 7s <sup>2</sup> Thorium	91231.0359 4300 <sup>1</sup> 1845 15.4 Pa [Rn]5f <sup>2</sup> 6d <sup>1</sup> 7s <sup>2</sup> Protactinium	92238.0289 4404 1408 18.95 U [Rn]5f <sup>3</sup> 6d <sup>1</sup> 7s <sup>2</sup> Uranium	93(237) 4175 <sup>1</sup> 917 20.2 Np [Rn]5f <sup>4</sup> 6d <sup>1</sup> 7s <sup>2</sup> Neptunium	94(244) 3505 913 19.84 Pu [Rn]5f <sup>6</sup> 7s <sup>2</sup> Plutonium	95(243) 2284 149 13.7 Am [Rn]5f <sup>7</sup> 7s <sup>2</sup> Americium	96(247) 1620 13.5 Cm [Rn]5f <sup>7</sup> 6d <sup>1</sup> 7s <sup>2</sup> Curium	97(247) 2340 14 <sup>1</sup> Bk [Rn]5f <sup>9</sup> 7s <sup>2</sup> Berkelium	98(251) 1170 <sup>1</sup> 1130 <sup>1</sup> Cf [Rn]5f <sup>10</sup> 7s <sup>2</sup> Californium	99(252) 1130 <sup>1</sup> 1130 <sup>1</sup> Es [Rn]5f <sup>11</sup> 7s <sup>2</sup> Einsteinium	100(257) 1800 <sup>1</sup> 1100 <sup>1</sup> Fm [Rn]5f <sup>12</sup> 7s <sup>2</sup> Fermium	101(258) 1100 <sup>1</sup> 1100 <sup>1</sup> Md [Rn]5f <sup>13</sup> 7s <sup>2</sup> Mendelevium	102(259) 1100 <sup>1</sup> 1100 <sup>1</sup> No [Rn]5f <sup>14</sup> 7s <sup>2</sup> Nobelium	103(262) 1900 <sup>1</sup> 1900 <sup>1</sup> Lr [Rn]5f <sup>14</sup> 6d <sup>1</sup> 7s <sup>2</sup> Lawrencium

# Families/Groups

- Columns share similar properties, and most are given a trivial name.

1: Alkali Metals

2: Alkaline Earth Metals

7: Halogens

8: Noble Gasses

5: Pnictogen

6: Chalcogens

3: Boron

4: Carbon

S: Coinage

<div>11.00794</div> <div>20.28 13.81</div> <div>1</div> <div>0.0899†</div> <div>1s<sup>1</sup></div> <div>H</div> <div>Hydrogen</div>	<div>24.00260</div> <div>4.216 0.95 0.1785†</div> <div>2</div> <div>1s<sup>2</sup></div> <div>He</div> <div>Helium</div>																
<div>36.941</div> <div>1615 453.7 0.53</div> <div>3</div> <div>1s<sup>2</sup>2s<sup>1</sup></div> <div>Li</div> <div>Lithium</div>	<div>9.01218</div> <div>3243 1560</div> <div>4</div> <div>1s<sup>2</sup>2s<sup>2</sup></div> <div>Be</div> <div>Beryllium</div>	<div>10.811</div> <div>4275 2365</div> <div>5</div> <div>1s<sup>2</sup>2s<sup>2</sup>p<sup>1</sup></div> <div>B</div> <div>Boron</div>	<div>12.011</div> <div>5100* 3825*</div> <div>6</div> <div>1s<sup>2</sup>2s<sup>2</sup>p<sup>2</sup></div> <div>C</div> <div>Carbon</div>	<div>14.0067</div> <div>77.344 63.15</div> <div>7</div> <div>1s<sup>2</sup>2s<sup>2</sup>p<sup>3</sup></div> <div>N</div> <div>Nitrogen</div>	<div>15.9994</div> <div>90.188 54.8</div> <div>8</div> <div>1s<sup>2</sup>2s<sup>2</sup>p<sup>4</sup></div> <div>O</div> <div>Oxygen</div>	<div>18.99840</div> <div>85.0 53.55</div> <div>9</div> <div>1s<sup>2</sup>2s<sup>2</sup>p<sup>5</sup></div> <div>F</div> <div>Fluorine</div>	<div>20.1797</div> <div>27.10 24.55</div> <div>10</div> <div>1s<sup>2</sup>2s<sup>2</sup>p<sup>6</sup></div> <div>Ne</div> <div>Neon</div>										
<div>22.98977</div> <div>1156 371.0 0.97</div> <div>11</div> <div>[Ne]3s<sup>1</sup></div> <div>Na</div> <div>Sodium</div>	<div>24.305</div> <div>1380 922</div> <div>12</div> <div>[Ne]3s<sup>2</sup></div> <div>Mg</div> <div>Magnesium</div>	<div>26.98154</div> <div>2740 933.5 2.70</div> <div>13</div> <div>[Ne]3s<sup>2</sup>p<sup>1</sup></div> <div>Al</div> <div>Aluminum</div>	<div>28.0855</div> <div>2630 1683</div> <div>14</div> <div>[Ne]3s<sup>2</sup>p<sup>2</sup></div> <div>Si</div> <div>Silicon</div>	<div>30.97376</div> <div>553 317.3</div> <div>15</div> <div>[Ne]3s<sup>2</sup>p<sup>3</sup></div> <div>P</div> <div>Phosphorus</div>	<div>32.066</div> <div>717.82 392.2</div> <div>16</div> <div>[Ne]3s<sup>2</sup>p<sup>4</sup></div> <div>S</div> <div>Sulfur</div>	<div>35.4527</div> <div>239.18 172.17</div> <div>17</div> <div>[Ne]3s<sup>2</sup>p<sup>5</sup></div> <div>Cl</div> <div>Chlorine</div>	<div>39.948</div> <div>74.45 33.95</div> <div>18</div> <div>[Ne]3s<sup>2</sup>p<sup>6</sup></div> <div>Ar</div> <div>Argon</div>										
<div>39.0983</div> <div>1033 336.8 0.86</div> <div>19</div> <div>[Ar] 4s<sup>1</sup></div> <div>K</div> <div>Potassium</div>	<div>40.078</div> <div>1757 1112</div> <div>20</div> <div>[Ar]4s<sup>2</sup></div> <div>Ca</div> <div>Calcium</div>	<div>44.9559</div> <div>3109 1814</div> <div>21</div> <div>[Ar]3d<sup>1</sup>4s<sup>2</sup></div> <div>Sc</div> <div>Scandium</div>	<div>47.88</div> <div>3560 1935</div> <div>22</div> <div>[Ar]3d<sup>2</sup>4s<sup>2</sup></div> <div>Ti</div> <div>Titanium</div>	<div>50.9415</div> <div>2945 2130</div> <div>23</div> <div>[Ar]3d<sup>3</sup>4s<sup>2</sup></div> <div>V</div> <div>Vanadium</div>	<div>51.996</div> <div>2235 1518</div> <div>24</div> <div>[Ar]3d<sup>4</sup>4s<sup>1</sup></div> <div>Cr</div> <div>Chromium</div>	<div>54.9380</div> <div>2945 2130</div> <div>25</div> <div>[Ar]3d<sup>5</sup>4s<sup>2</sup></div> <div>Mn</div> <div>Manganese</div>	<div>55.847</div> <div>3023 1808</div> <div>26</div> <div>[Ar]3d<sup>6</sup>4s<sup>2</sup></div> <div>Fe</div> <div>Iron</div>	<div>58.9332</div> <div>3143 1768</div> <div>27</div> <div>[Ar]3d<sup>7</sup>4s<sup>2</sup></div> <div>Co</div> <div>Cobalt</div>	<div>58.9334</div> <div>3005 1726</div> <div>28</div> <div>[Ar]3d<sup>8</sup>4s<sup>2</sup></div> <div>Ni</div> <div>Nickel</div>	<div>63.546</div> <div>2840 1356.6</div> <div>29</div> <div>[Ar]3d<sup>9</sup>4s<sup>1</sup></div> <div>Cu</div> <div>Copper</div>	<div>65.39</div> <div>1180 692.73</div> <div>30</div> <div>[Ar]3d<sup>10</sup>4s<sup>2</sup></div> <div>Zn</div> <div>Zinc</div>	<div>69.723</div> <div>2478 302.92</div> <div>31</div> <div>[Ar]3d<sup>10</sup>4s<sup>2</sup>p<sup>1</sup></div> <div>Ga</div> <div>Gallium</div>	<div>72.61</div> <div>3107 211.5</div> <div>32</div> <div>[Ar]3d<sup>10</sup>4s<sup>2</sup>p<sup>2</sup></div> <div>Ge</div> <div>Germanium</div>	<div>74.9216</div> <div>876(mel) 1090</div> <div>33</div> <div>[Ar]3d<sup>10</sup>4s<sup>2</sup>p<sup>3</sup></div> <div>As</div> <div>Arsenic</div>	<div>78.96</div> <div>958 494</div> <div>34</div> <div>[Ar]3d<sup>10</sup>4s<sup>2</sup>p<sup>4</sup></div> <div>Se</div> <div>Selenium</div>	<div>79.904</div> <div>331.85 265.95</div> <div>35</div> <div>[Ar]3d<sup>10</sup>4s<sup>2</sup>p<sup>5</sup></div> <div>Br</div> <div>Bromine</div>	<div>83.80</div> <div>120.85 116</div> <div>36</div> <div>[Ar]3d<sup>10</sup>4s<sup>2</sup>p<sup>6</sup></div> <div>Kr</div> <div>Krypton</div>



# Out of Place

- Most of the columns in the middle don't have family names.
- Due to spacing some elements have been moved from their middle spot to the bottom.

<div>11.007941 20.28 13.81 0.0899 1s H Hydrogen</div>																		<div>24.002602 4.216 0.95 0.1783 1s He Helium</div>																																																																																																																																																																																																																																																																													
<div>36.9413 1815 453.7 0.53 1s2s Li Lithium</div>									<div>49.012184 3105 1560 1.85 1s2s Be Beryllium</div>									<div>510.8111 4275 2369 2.34 1s2s2p B Boron</div>									<div>612.0111 5100 3825 2.26 1s2s2p C Carbon</div>									<div>714.0067 5100 3825 1.251 1s2s2p N Nitrogen</div>									<div>815.9994 5100 3825 1.429 1s2s2p O Oxygen</div>									<div>918.9984 85.0 53.55 1.696 1s2s2p F Fluorine</div>									<div>1020.1797 27.10 24.55 0.900 1s2s2p Ne Neon</div>																																																																																																																																																																																																																																
<div>122.989771 1156 371.0 0.97 [Ne]3s Na Sodium</div>									<div>24.30512 1380 222 1.74 [Ne]3s Mg Magnesium</div>									<div>26.9815413 2740 933.5 2.70 [Ne]3s3p Al Aluminum</div>									<div>28.085514 2830 962.2 2.33 [Ne]3s3p Si Silicon</div>									<div>30.9737615 2630 962.2 2.33 [Ne]3s3p P Phosphorus</div>									<div>32.06616 2710 962.2 2.07 [Ne]3s3p S Sulfur</div>									<div>35.452717 238.10 172.17 3.214 [Ne]3s3p Cl Chlorine</div>									<div>39.94818 37.45 83.95 1.784 [Ne]3s3p Ar Argon</div>																																																																																																																																																																																																																																
<div>39.098319 1033 336.8 0.86 [Ar]4s K Potassium</div>									<div>40.07820 1757 1014 1.55 [Ar]4s Ca Calcium</div>									<div>44.955921 3109 1560 2.26 [Ar]3d4s Sc Scandium</div>									<div>47.8822 3680 1935 4.54 [Ar]3d4s Ti Titanium</div>									<div>50.941523 3660 1935 5.11 [Ar]3d4s V Vanadium</div>									<div>51.99624 2945 2130 7.19 [Ar]3d4s Cr Chromium</div>									<div>54.938025 2235 1518 7.44 [Ar]3d4s Mn Manganese</div>									<div>55.84726 3003 1908 7.874 [Ar]3d4s Fe Iron</div>									<div>58.933227 3005 1908 8.90 [Ar]3d4s Co Cobalt</div>									<div>58.933428 3005 1908 8.90 [Ar]3d4s Ni Nickel</div>									<div>63.54629 2840 1356.6 8.96 [Ar]3d4s Cu Copper</div>									<div>65.3930 2890 1356.6 7.13 [Ar]3d4s Zn Zinc</div>									<div>69.72331 2478 962.2 5.91 [Ar]3d4s Ga Gallium</div>									<div>72.6132 2478 962.2 5.91 [Ar]3d4s Ge Germanium</div>									<div>74.921633 276.8 962.2 5.78 [Ar]3d4s As Arsenic</div>									<div>78.9634 958 962.2 4.79 [Ar]3d4s Se Selenium</div>									<div>79.90435 958 962.2 4.79 [Ar]3d4s Br Bromine</div>									<div>83.8036 102.85 116 3.12 [Ar]3d4s Kr Krypton</div>																																																																																																																																						
<div>85.467837 961 312.63 1.532 [Kr]5s Rb Rubidium</div>									<div>87.6238 1655 1042 2.54 [Kr]5s Sr Strontium</div>									<div>86.905939 1611 1795 4.47 [Kr]4d5s Y Yttrium</div>									<div>91.22440 4682 2128 6.51 [Kr]4d5s Zr Zirconium</div>									<div>92.906441 5015 2742 6.57 [Kr]4d5s Nb Niobium</div>									<div>95.9442 4912 2896 10.22 [Kr]4d5s Mo Molybdenum</div>									<div>95.9443 4912 2896 10.22 [Kr]4d5s Tc Technetium</div>									<div>101.0744 4425 2610 12.37 [Kr]4d5s Ru Ruthenium</div>									<div>102.905545 4425 2610 12.37 [Kr]4d5s Rh Rhodium</div>									<div>106.4246 4425 2610 12.37 [Kr]4d5s Pd Palladium</div>									<div>107.86847 4425 2610 12.37 [Kr]4d5s Ag Silver</div>									<div>112.4148 4425 2610 12.37 [Kr]4d5s Cd Cadmium</div>									<div>114.8249 4425 2610 12.37 [Kr]4d5s In Indium</div>									<div>118.71050 4425 2610 12.37 [Kr]4d5s Sn Tin</div>									<div>121.75751 4425 2610 12.37 [Kr]4d5s Sb Antimony</div>									<div>127.6052 4425 2610 12.37 [Kr]4d5s Te Tellurium</div>									<div>126.904553 4425 2610 12.37 [Kr]4d5s I Iodine</div>									<div>131.2954 4425 2610 12.37 [Kr]4d5s Xe Xenon</div>																																																																																																																																						
<div>132.905455 944 301.54 1.87 [Xe]6s Cs Cesium</div>									<div>137.3356 1071 3204 3.4 [Xe]6s Ba Barium</div>									<div>138.905557 1071 3204 3.4 [Xe]5d6s La Lanthanum</div>									<div>140.1258 1071 3204 3.4 [Xe]5d6s Ce Cerium</div>									<div>140.907759 1071 3204 3.4 [Xe]5d6s Pr Praseodymium</div>									<div>144.2460 1071 3204 3.4 [Xe]5d6s Nd Neodymium</div>									<div>145145 1071 3204 3.4 [Xe]5d6s Pm Promethium</div>									<div>150.3662 1071 3204 3.4 [Xe]5d6s Sm Samarium</div>									<div>151.96563 1071 3204 3.4 [Xe]5d6s Eu Europium</div>									<div>157.2564 1071 3204 3.4 [Xe]5d6s Gd Gadolinium</div>									<div>158.925365 1071 3204 3.4 [Xe]5d6s Tb Terbium</div>									<div>162.5066 1071 3204 3.4 [Xe]5d6s Dy Dysprosium</div>									<div>164.930367 1071 3204 3.4 [Xe]5d6s Ho Holmium</div>									<div>167.2668 1071 3204 3.4 [Xe]5d6s Er Erbium</div>									<div>168.934269 1071 3204 3.4 [Xe]5d6s Tm Thulium</div>									<div>173.0470 1071 3204 3.4 [Xe]5d6s Yb Ytterbium</div>									<div>174.9671 1071 3204 3.4 [Xe]5d6s Lu Lutetium</div>									<div>176.4872 1071 3204 3.4 [Xe]5d6s Hf Hafnium</div>									<div>180.947973 1071 3204 3.4 [Xe]5d6s Ta Tantalum</div>									<div>183.8574 1071 3204 3.4 [Xe]5d6s W Tungsten</div>									<div>186.2075 1071 3204 3.4 [Xe]5d6s Re Rhenium</div>									<div>190.276 1071 3204 3.4 [Xe]5d6s Os Osmium</div>									<div>192.2277 1071 3204 3.4 [Xe]5d6s Ir Iridium</div>									<div>195.0879 1071 3204 3.4 [Xe]5d6s Pt Platinum</div>									<div>196.966579 1071 3204 3.4 [Xe]5d6s Au Gold</div>									<div>200.5980 1071 3204 3.4 [Xe]5d6s Hg Mercury</div>									<div>204.38381 1071 3204 3.4 [Xe]5d6s Tl Thallium</div>									<div>207.282 1071 3204 3.4 [Xe]5d6s Pb Lead</div>									<div>208.980483 1071 3204 3.4 [Xe]5d6s Bi Bismuth</div>									<div>209209 1071 3204 3.4 [Xe]5d6s Po Polonium</div>									<div>210210 1071 3204 3.4 [Xe]5d6s At Astatine</div>									<div>222222 1071 3204 3.4 [Xe]5d6s Rn Radon</div>								
<div>22387 950 300 [Rn]7s Fr Francium</div>									<div>22688 950 300 [Rn]7s Ra Radium</div>									<div>22789 950 300 [Rn]5d7s Ac Actinium</div>									<div>23290 950 300 [Rn]5d7s Th Thorium</div>									<div>23191 950 300 [Rn]5d7s Pa Protactinium</div>									<div>23892 950 300 [Rn]5d7s U Uranium</div>									<div>23793 950 300 [Rn]5d7s Np Neptunium</div>									<div>24494 950 300 [Rn]5d7s Pu Plutonium</div>									<div>24395 950 300 [Rn]5d7s Am Americium</div>									<div>24796 950 300 [Rn]5d7s Cm Curium</div>									<div>24797 950 300 [Rn]5d7s Bk Berkelium</div>									<div>25198 950 300 [Rn]5d7s Cf Californium</div>									<div>25299 950 300 [Rn]5d7s Es Einsteinium</div>									<div>257100 950 300 [Rn]5d7s Fm Fermium</div>									<div>258101 950 300 [Rn]5d7s Md Mendelevium</div>									<div>259102 950 300 [Rn]5d7s No Nobelium</div>									<div>260103 950 300 [Rn]5d7s Lr Lawrencium</div>									<div>261104 950 300 [Rn]5f6d7s Rf Rutherfordium</div>									<div>262105 950 300 [Rn]5f6d7s Ha Hahnium</div>									<div>263106 950 300 [Rn]5f6d7s Sg Seaborgium</div>									<div>262107 950 300 [Rn]5f6d7s Uns (Unnilseptium)</div>									<div>265108 950 300 [Rn]5f6d7s Uno (Unniloctium)</div>									<div>268109 950 300 [Rn]5f6d7s Une (Unnilnonium)</div>																																																																																									

# General Trends

Elements have three main groups: Metal, Metalloids, and Nonmetals.

1		2						8	
1 1.00794 20.28 13.81 0.0899 ↑ 1s <sup>1</sup> Hydrogen		3 (6.941) 6.941 453.7 0.51 2s <sup>1</sup> Lithium	4 9.012182 9.012 1500 1.85 [He]2s <sup>2</sup> Beryllium	<b>SEMI-METALS (METALLOIDS)</b>				10 20.1797 20.18 24.56 0.900† [He]2s <sup>2</sup> 2p <sup>6</sup> Neon	2 4.00260 4.01 0.95 at 20 atm 0.1785† 1s <sup>2</sup> Helium
11 22.989770 22.99 37.45 0.55 [Ne]3s <sup>1</sup> Sodium	12 24.3050 24.31 39.95 0.55 [Ne]3s <sup>2</sup> Magnesium	<b>POOR METALS (POST TRANSITION)</b>				15 28.0855 28.09 93.5 2.6989 [Ne]3s <sup>2</sup> 3p <sup>1</sup> Aluminum	16 28.0855 28.09 93.5 2.6989 [Ne]3s <sup>2</sup> 3p <sup>2</sup> Silicon	17 35.453 35.45 171.65 3.214† [Ne]3s <sup>2</sup> 3p <sup>5</sup> Chlorine	18 39.948 39.95 15.8 3.73† [Ne]3s <sup>2</sup> 3p <sup>6</sup> Argon
19 39.0983 39.10 79.904 2.99 [Ar]4s <sup>1</sup> Potassium	20 40.078 40.08 79.904 2.99 [Ar]4s <sup>2</sup> Calcium	21 44.95591 44.96 3109 2.99 [Ar]3d <sup>1</sup> 4s <sup>2</sup> Scandium	22 47.867 47.87 3500 4.54 [Ar]3d <sup>2</sup> 4s <sup>2</sup> Titanium	23 50.9415 50.94 3680 6.11 [Ar]3d <sup>3</sup> 4s <sup>2</sup> Vanadium	24 51.996 51.99 3680 7.19 [Ar]3d <sup>4</sup> 4s <sup>1</sup> Chromium	25 54.9380 54.94 3680 7.44 [Ar]3d <sup>5</sup> 4s <sup>1</sup> Manganese	26 55.845 55.85 3680 7.874 [Ar]3d <sup>5</sup> 4s <sup>2</sup> Iron	27 58.9332 58.93 3680 8.90 [Ar]3d <sup>6</sup> 4s <sup>2</sup> Cobalt	28 58.9332 58.93 3680 8.90 [Ar]3d <sup>7</sup> 4s <sup>2</sup> Nickel
37 79.904 79.90 15.8 3.73† [Ne]3s <sup>2</sup> 3p <sup>6</sup> Argon	38 79.904 79.90 15.8 3.73† [Ne]3s <sup>2</sup> 3p <sup>6</sup> Argon	39 88.9059 88.91 3109 2.99 [Ar]3d <sup>1</sup> 4s <sup>2</sup> Scandium	40 87.62 87.62 3109 2.99 [Ar]3d <sup>1</sup> 4s <sup>2</sup> Scandium	41 88.9059 88.91 3109 2.99 [Ar]3d <sup>1</sup> 4s <sup>2</sup> Scandium	42 88.9059 88.91 3109 2.99 [Ar]3d <sup>1</sup> 4s <sup>2</sup> Scandium	43 88.9059 88.91 3109 2.99 [Ar]3d <sup>1</sup> 4s <sup>2</sup> Scandium	44 88.9059 88.91 3109 2.99 [Ar]3d <sup>1</sup> 4s <sup>2</sup> Scandium	45 88.9059 88.91 3109 2.99 [Ar]3d <sup>1</sup> 4s <sup>2</sup> Scandium	46 88.9059 88.91 3109 2.99 [Ar]3d <sup>1</sup> 4s <sup>2</sup> Scandium
55 132.9054 132.91 1000 6.51 [Xe]6s <sup>1</sup> Cesium	56 137.327 137.33 1000 6.51 [Xe]6s <sup>2</sup> Barium	57 138.9055 138.91 3109 2.99 [Ar]3d <sup>1</sup> 4s <sup>2</sup> Scandium	58 137.327 137.33 1000 6.51 [Xe]6s <sup>2</sup> Barium	59 140.90765 140.91 3109 2.99 [Ar]3d <sup>1</sup> 4s <sup>2</sup> Scandium	60 144.24 144.24 3109 2.99 [Ar]3d <sup>1</sup> 4s <sup>2</sup> Scandium	61 144.24 144.24 3109 2.99 [Ar]3d <sup>1</sup> 4s <sup>2</sup> Scandium	62 150.36 150.36 3109 2.99 [Ar]3d <sup>1</sup> 4s <sup>2</sup> Scandium	63 151.964 151.96 3109 2.99 [Ar]3d <sup>1</sup> 4s <sup>2</sup> Scandium	64 157.25 157.25 3109 2.99 [Ar]3d <sup>1</sup> 4s <sup>2</sup> Scandium
87 223 223 1000 6.51 [Xe]6s <sup>1</sup> Francium	88 226 226 1000 6.51 [Xe]6s <sup>2</sup> Radium	89 227 227 1000 6.51 [Xe]6s <sup>2</sup> Actinium	90 232.0375 232.04 1000 6.51 [Xe]6s <sup>2</sup> Thorium	91 231.0359 231.04 1000 6.51 [Xe]6s <sup>2</sup> Protactinium	92 238.0289 238.03 1000 6.51 [Xe]6s <sup>2</sup> Uranium	93 237 237 1000 6.51 [Xe]6s <sup>2</sup> Neptunium	94 244 244 1000 6.51 [Xe]6s <sup>2</sup> Plutonium	95 243 243 1000 6.51 [Xe]6s <sup>2</sup> Americium	96 247 247 1000 6.51 [Xe]6s <sup>2</sup> Curium
<b>TRANSITION METALS</b>		<b>TRANSITION METALS</b>		<b>TRANSITION METALS</b>		<b>TRANSITION METALS</b>		<b>TRANSITION METALS</b>	
58 140.116 140.12 3109 2.99 [Xe]4f <sup>1</sup> 5d <sup>1</sup> 6s <sup>2</sup> Cerium	59 140.90765 140.91 3109 2.99 [Xe]4f <sup>3</sup> 6s <sup>2</sup> Praseodymium	60 144.24 144.24 3109 2.99 [Xe]4f <sup>5</sup> 6s <sup>2</sup> Neodymium	61 144.24 144.24 3109 2.99 [Xe]4f <sup>5</sup> 6s <sup>2</sup> Neodymium	62 150.36 150.36 3109 2.99 [Xe]4f <sup>6</sup> 6s <sup>2</sup> Promethium	63 151.964 151.96 3109 2.99 [Xe]4f <sup>7</sup> 6s <sup>2</sup> Samarium	64 157.25 157.25 3109 2.99 [Xe]4f <sup>7</sup> 6s <sup>2</sup> Europium	65 158.92534 158.93 3109 2.99 [Xe]4f <sup>7</sup> 6s <sup>2</sup> Gadolinium	66 162.50 162.50 3109 2.99 [Xe]4f <sup>7</sup> 6s <sup>2</sup> Terbium	67 164.9303 164.93 3109 2.99 [Xe]4f <sup>7</sup> 6s <sup>2</sup> Dysprosium
89 227 227 1000 6.51 [Xe]6s <sup>2</sup> Actinium	90 232.0375 232.04 1000 6.51 [Xe]6s <sup>2</sup> Thorium	91 231.0359 231.04 1000 6.51 [Xe]6s <sup>2</sup> Protactinium	92 238.0289 238.03 1000 6.51 [Xe]6s <sup>2</sup> Uranium	93 237 237 1000 6.51 [Xe]6s <sup>2</sup> Neptunium	94 244 244 1000 6.51 [Xe]6s <sup>2</sup> Plutonium	95 243 243 1000 6.51 [Xe]6s <sup>2</sup> Americium	96 247 247 1000 6.51 [Xe]6s <sup>2</sup> Curium	97 247 247 1000 6.51 [Xe]6s <sup>2</sup> Berkelium	98 251 251 1000 6.51 [Xe]6s <sup>2</sup> Californium
<b>INNER TRANSITION METALS</b>		<b>INNER TRANSITION METALS</b>		<b>INNER TRANSITION METALS</b>		<b>INNER TRANSITION METALS</b>		<b>INNER TRANSITION METALS</b>	
71 174.967 174.97 3109 2.99 [Xe]4f <sup>1</sup> 5d <sup>1</sup> 6s <sup>2</sup> Lutetium	72 173.04 173.04 3109 2.99 [Xe]4f <sup>1</sup> 5d <sup>1</sup> 6s <sup>2</sup> Ytterbium	73 174.967 174.97 3109 2.99 [Xe]4f <sup>1</sup> 5d <sup>1</sup> 6s <sup>2</sup> Lutetium	74 173.04 173.04 3109 2.99 [Xe]4f <sup>1</sup> 5d <sup>1</sup> 6s <sup>2</sup> Ytterbium	75 174.967 174.97 3109 2.99 [Xe]4f <sup>1</sup> 5d <sup>1</sup> 6s <sup>2</sup> Lutetium	76 173.04 173.04 3109 2.99 [Xe]4f <sup>1</sup> 5d <sup>1</sup> 6s <sup>2</sup> Ytterbium	77 174.967 174.97 3109 2.99 [Xe]4f <sup>1</sup> 5d <sup>1</sup> 6s <sup>2</sup> Lutetium	78 173.04 173.04 3109 2.99 [Xe]4f <sup>1</sup> 5d <sup>1</sup> 6s <sup>2</sup> Ytterbium	79 174.967 174.97 3109 2.99 [Xe]4f <sup>1</sup> 5d <sup>1</sup> 6s <sup>2</sup> Lutetium	80 173.04 173.04 3109 2.99 [Xe]4f <sup>1</sup> 5d <sup>1</sup> 6s <sup>2</sup> Ytterbium
101 258 258 1000 6.51 [Xe]6s <sup>2</sup> Mendelevium	102 259 259 1000 6.51 [Xe]6s <sup>2</sup> Nobelium	103 262 262 1000 6.51 [Xe]6s <sup>2</sup> Lawrencium	104 261 261 1000 6.51 [Xe]6s <sup>2</sup> Rutherfordium	105 262 262 1000 6.51 [Xe]6s <sup>2</sup> Dubnium	106 266 266 1000 6.51 [Xe]6s <sup>2</sup> Seaborgium	107 264 264 1000 6.51 [Xe]6s <sup>2</sup> Bohrium	108 277 277 1000 6.51 [Xe]6s <sup>2</sup> Hassium	109 268 268 1000 6.51 [Xe]6s <sup>2</sup> Meitnerium	110 269 269 1000 6.51 [Xe]6s <sup>2</sup> Darmstadtium
<b>TRANSITION METALS</b>		<b>TRANSITION METALS</b>		<b>TRANSITION METALS</b>		<b>TRANSITION METALS</b>		<b>TRANSITION METALS</b>	
113 284 284 1000 6.51 [Xe]6s <sup>2</sup> Nh	114 289 289 1000 6.51 [Xe]6s <sup>2</sup> Fl	115 288 288 1000 6.51 [Xe]6s <sup>2</sup> Mc	116 289 289 1000 6.51 [Xe]6s <sup>2</sup> Lv	117 289 289 1000 6.51 [Xe]6s <sup>2</sup> Ts	118 289 289 1000 6.51 [Xe]6s <sup>2</sup> Og	119 289 289 1000 6.51 [Xe]6s <sup>2</sup> Og	120 289 289 1000 6.51 [Xe]6s <sup>2</sup> Og	121 289 289 1000 6.51 [Xe]6s <sup>2</sup> Og	122 289 289 1000 6.51 [Xe]6s <sup>2</sup> Og



# Tip of the Periodic Iceberg

- A periodic table contains a great deal of information.
- Find the key and make use of it.

Electron Configuration	
Atomic Number	3
Symbol	Li
Name	Lithium
Average Atomic Mass	6.941
Density (g/mL) (Gases given in g/L at STP)	0.54
$T_f$ (freezing point) (K)	453.7
$T_b$ (boiling point) (K)	1614
$\Delta H_f$ (heat of fusion) (kJ/mol)	3.0
$\Delta H_v$ (heat of vaporization) (kJ/mol)	147.1
Oxidation States (most common in bold)	1

# Electrons: Making Ions

- On the periodic table or unless specifically told, protons equal electrons.
- **Ion**: when an element's  $p^+ \neq e^-$ .
- An ion is considered electrically charged.



# Ionic Example: Is Al with 16 e<sup>-</sup> an ion?

- Al always has 13 p<sup>+</sup>.
- Solve by subtracting e<sup>-</sup> from p<sup>+</sup>.  
–  $13 - 16 = -3$
- $x < 0$  so yes, it is an Ion and called an **Anion**.
- If  $x > 0$  then it would be an Ion called a **Cation**.
- If  $x = 0$  (e<sup>-</sup> = p<sup>+</sup>) then it would not be an Ion (Neutral).

# Ions: Symbolic

- To write an Ion two pieces of information are needed
  - The element's symbol
  - The charge (both mag and + or -)
- Write the element and then the charge in the **upper right-hand** corner.
- For 1+ or 1-: you may drop the '1'
- Examples:  $\text{Al}^{3+}$ ,  $\text{Li}^{+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Cl}^{-}$ ,  $\text{O}^{2-}$ .

# Be Careful

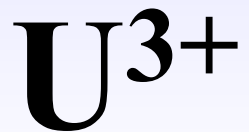
- Common errors and things to look out for.
  - You **CAN NEVER** remove protons!
    - Adding  $e^-$  means increasing the negative charge.
    - Removing  $e^-$  means increasing the positive charge.
  - Don't take away more  $e^-$  than there are to start.
    - Ex:  $\text{Li}^{4+}$  (Lithium only has 3 protons so max is  $\text{Li}^{3+}$ )
  - **Oxidation States** tell which ions are possible.

Electron Configuration	
Atomic Number	3
Symbol	Li
Name	Lithium
Average Atomic Mass	6.941
Density (g/mL) (Gases given in g/L at STP)	0.54
$T_f$ (freezing point) (K)	453.7
$T_b$ (boiling point) (K)	1614
$\Delta H_f$ (heat of fusion) (kJ/mol)	3.0
$\Delta H_v$ (heat of vaporization) (kJ/mol)	147.1
Oxidation States (most common in bold)	<b>1</b>



# Write Symbolically

- Uranium of charge +3.
- Oxygen with 10 electrons.
- Iron with 29 electrons.
- The most common form of element 9.



$Z = 92$



8-10



26-29

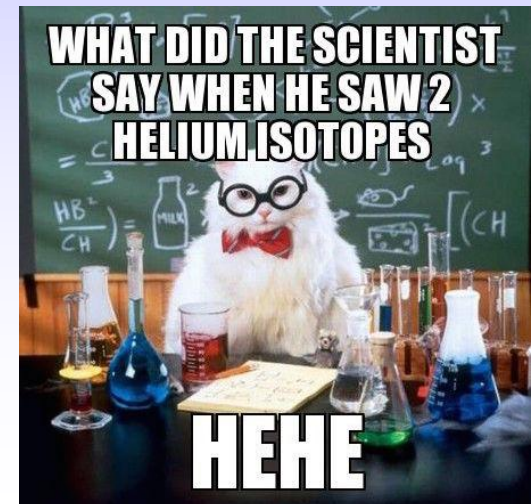


P Table

# Neutrons: Making Isotopes

- While a  $n^0$  has no charge to contribute, its mass is almost the same as a  $p^+$ .
- By adding or subtracting  $n^0$  subtle changes must occur in an element's properties.
- When two or more elements have the same number of  $p^+$  but different  $n^0$  this is called an...

**Isotope**



# Symbolic Form

- Symbolic Form was mentioned with ions.
- Symbolic Form can also be used to describe an atom on the Periodic Table.

$$p^{+} + n^{0} = w$$

$$p^{+} = Z \text{ X } n^{0}$$

**w:** Atomic Weight. Unless specifically told look this up on the Periodic Table.

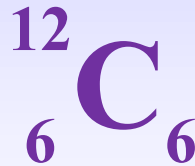
**For Isotopes:** Always rounded to a whole number

**Notes:** Writing the  $n^0$  is redundant: KISS.

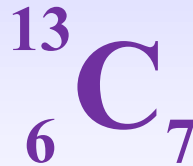
This form is not mixed with the Ion Symbolic Form.

# Writing Isotopes

- Isotopes can be shown two ways; **symbolic** and **written**. There are three Carbon's; They have 6 n<sup>o</sup>, 7 n<sup>o</sup> and 8 n<sup>o</sup> respectively.



**Carbon-12**



**Carbon-13**



**Carbon-14**

# Periodic Table

- The atomic weight is listed on most periodic tables.
- **Atomic Weight:** Mass of the element.
- Here is information on Boron
- Its atomic weight is 10.8?
- How is this possible?
  - Remember:  $p^+ = 1$ ,  $n^0 = 1$ ,  $e^- = .005$
  - $Z = 5$  so  $n^0$  has to be either 5 or 6 not 5.8?

<b>5</b>	<b>10.811</b>
4275	<sup>3</sup>
2348	<b>B</b>
<b>2.37</b>	
[He]2s <sup>2</sup> 2p <sup>1</sup>	
<b>Boron</b>	



# Weighted Average

- The number appearing on the periodic table is called a **Weighted Average**.
- Let's look at the isotopes of Boron.

Written	Symbolic	Weight	Abundance
Boron-10	$^{10}_5B$	10.0	19.4%
Boron-11	$^{11}_5B$	11.0	80.6%

# Calculating Weighted Ave.

To calculate:  $(AW_1)(ab\%_1) + (AW_2)(ab\%_2) + (AW_3)(ab\%_3) = W_a$

AW: Atomic Weight of Isotope

ab%: Abundance of Isotope (as a decimal)

Ex: Boron

$$W_a = 10.0 (.194) + 11.0 (.806)$$

$$W_a = 1.94 + 8.866$$

$$W_a = 10.806$$

**10.8**

# Wrap Up

Proton (p <sup>+</sup> )	Electron (e <sup>-</sup> )	Neutron (n <sup>0</sup> )
Big particle in Nucleus	Small particle orbits Nucleus	Big particle in Nucleus
Equals the atomic number	Ion: p <sup>+</sup> ≠ e <sup>-</sup>	Isotope: same p <sup>+</sup> , different n <sup>0</sup>
Defines the element (DNA)	Cation: more p <sup>+</sup> than e <sup>-</sup>	Unstable: α/β/γ
Can not be added or removed	Anion: less p <sup>+</sup> than e <sup>-</sup>	Half Life: Probability of decay

## Ions

Symbol:  $X^{p^+ - e^-}$  Example: Phosphorus with 17 electrons.  $P^{-2}$

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## Isotopes

Symbol:  ${}_Z^W X$  Example: Phosphorus with 16 neutrons.  ${}_{15}^{31}P$

Written: Element-w Phosphorus-31