

## Dalton (1766 - 1844)

1. All matter is made of tiny particles called atoms.
2. All atoms of a given element are identical in mass and properties.
3. Atoms of different elements combine in whole number ratios
4. Chemical reactions is the rearranging of atoms, but atoms cannot be created or destroyed.

## J. J. Thomson (1856-1940)

In 1897 Thomson conducted the cathode ray experiment.

<https://www.youtube.com/watch?v=UUpD62r2wq8>

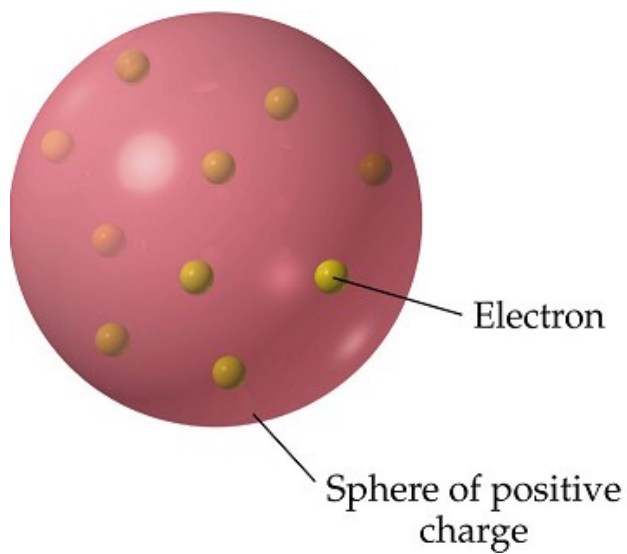
Two important discoveries from the cathode ray experiment.

1) electrons exist and they have a negative charge

2) ALL elements have electrons

# Thomson's Model of the Atom

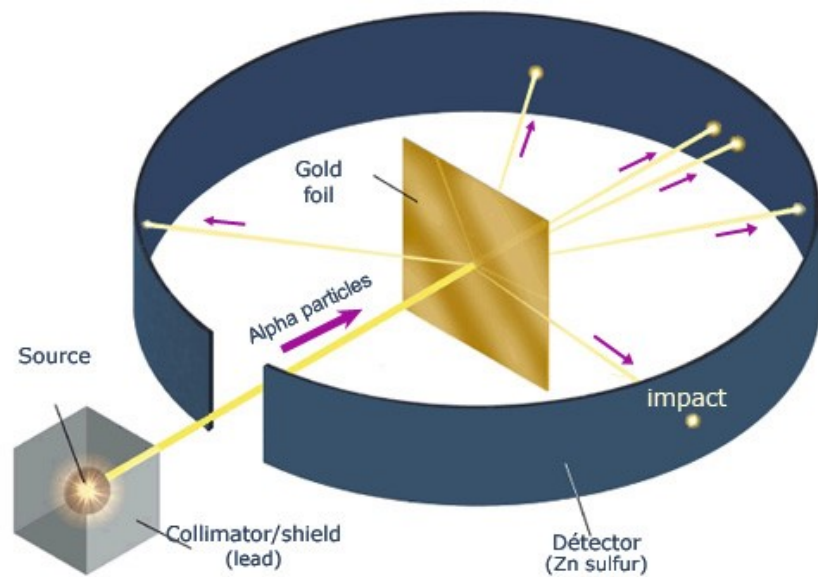
Plum Pudding



## Rutherford (1871-1937)

### Gold Foil Experiment - 1899

Expected vs  
Results?



## Things to know about the gold foil experiment

Alpha Particle

Atoms are mostly empty space

marble on a football field

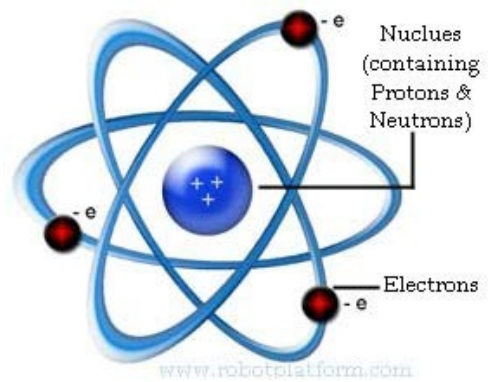
Atoms contain nucleus

"marble"

contain protons (and neutrons, not yet discovered)

## Rutherford's Model of the Atom

<https://youtu.be/wzALbzTdnc8>



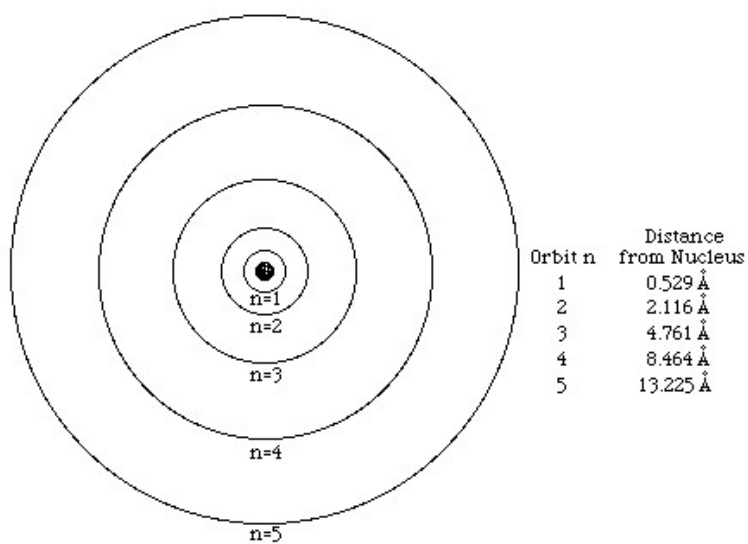
Niels Bohr (1885 - 1962)

In 1922 Bohr gets Nobel Prize in Physics for his work in atomic structure.

Quantized energy levels



# Bohr's Quantized Energy Levels



## The Bohr Model

- Like the rungs of the strange ladder, the energy levels in an atom are not equally spaced.
- The higher the energy level occupied by an electron, the less energy it takes to move from that energy level to the next higher energy level.



## Warm up

Without looking at your notes or asking someone, answer the following questions.

1) What two things did the cathode ray experiment determine.

2) What two things did the gold foil experiment determine?

## Periodic Table of Elements

Mendeleev (1834 - 1907)

created the modern version of the periodic table

Periodic = Recurring

The diagram shows a rectangular box representing an element's information in a periodic table. Inside the box, from top to bottom, are: the element name "molybdenum", the atomic number "42", the atomic symbol "Mo" in blue, and the atomic mass "95.94". Four arrows point from text labels on the right to these elements: "element name" points to "molybdenum", "atomic number" (with "number of protons (Z)" below it) points to "42", "atomic symbol" points to "Mo", and "atomic mass" (with "A (this is an average mass)" below it) points to "95.94".

\*Atomic mass is equal to the number of protons and neutrons

Protons - define the element

Neutrons - add mass

Electrons - responsible for chemical reactions

	Location	Mass	Charge
Proton	nucleus	1 amu	positive
Neutron	nucleus	1 amu	none
Electron	around the nucleus	$1/1837$ amu	negative

# Periodic Table

**Periodic Table of the Elements**

Atomic Number      Boiling Point  
**Symbol**  
 Name  
 Atomic Mass

Normal boiling points are in °C.  
 SP = Triple Point  
 Pressure is listed if not 1 atm.  
 Allotrope is listed if more than one allotrope.

1 1A 1A 1 H Hydrogen 1.008 -252.902	2 IIA 2A 4 Be Beryllium 9.012 2473																	18 VIIIA 8A 2 He Helium 4.003 -268.93																													
3 IIIA 3A 3 Li Lithium 6.941 1342	4 IIIA 3A 4 B Boron 10.811 4000	5 IIIA 3A 5 Al Aluminum 26.982 2519	6 IVA 4A 6 C Carbon 12.011 3642	7 VA 5A 7 N Nitrogen 14.007 -195.78	8 VIA 6A 8 O Oxygen 15.999 -182.955	9 VIIA 7A 9 F Fluorine 18.998 -188.12	10 VIIA 7A 10 Ne Neon 20.180 -246.053																																								
11 IA 1A 11 Na Sodium 22.990 882.940	12 IIA 2A 12 Mg Magnesium 24.305 1090	13 IIIA 3B 13 Al Aluminum 26.982 2519	14 IIIA 3B 14 Si Silicon 28.086 2355	15 VA 5A 15 P Phosphorus 30.974 280.5	16 VIA 6A 16 S Sulfur 32.065 444.61	17 VIIA 7A 17 Cl Chlorine 35.453 -101.5	18 VIIA 7A 18 Ar Argon 39.948 -185.847																																								
19 IA 1A 19 K Potassium 39.098 759	20 IIA 2A 20 Ca Calcium 40.078 1484	21 IIIB 3B 21 Sc Scandium 44.956 2836	22 IIIB 3B 22 Ti Titanium 47.88 3287	23 IIIB 3B 23 V Vanadium 50.942 3407	24 IIIB 3B 24 Cr Chromium 51.996 2671	25 IIIB 3B 25 Mn Manganese 54.938 2091	26 IIIB 3B 26 Fe Iron 55.845 2861	27 IIIB 3B 27 Co Cobalt 58.933 2707	28 IIIB 3B 28 Ni Nickel 58.693 2913	29 IIIB 3B 29 Cu Copper 63.546 2562	30 IIIB 3B 30 Zn Zinc 65.39 907	31 IIIB 3B 31 Ga Gallium 69.723 2204	32 IIIB 3B 32 Ge Germanium 72.63 2833	33 IIIB 3B 33 As Arsenic 74.922 616 SP	34 IIIB 3B 34 Se Selenium 78.972 685	35 IIIB 3B 35 Br Bromine 79.904 58.8	36 IIIB 3B 36 Kr Krypton 83.80 -153.34																														
37 IA 1A 37 Rb Rubidium 84.468 688	38 IIA 2A 38 Sr Strontium 87.62 1382	39 IIIB 3B 39 Y Yttrium 88.906 3345	40 IIIB 3B 40 Zr Zirconium 91.224 4409	41 IIIB 3B 41 Nb Niobium 92.906 4744	42 IIIB 3B 42 Mo Molybdenum 95.95 4639	43 IIIB 3B 43 Tc Technetium 98.907 4535	44 IIIB 3B 44 Ru Ruthenium 101.07 4150	45 IIIB 3B 45 Rh Rhodium 102.905 3695	46 IIIB 3B 46 Pd Palladium 106.42 3963	47 IIIB 3B 47 Ag Silver 107.868 2142	48 IIIB 3B 48 Cd Cadmium 112.411 907	49 IIIB 3B 49 In Indium 114.818 2012	50 IIIB 3B 50 Sn Tin 118.71 2602	51 IIIB 3B 51 Sb Antimony 121.760 1587	52 IIIB 3B 52 Te Tellurium 127.6 988	53 IIIB 3B 53 I Iodine 126.904 184.4	54 IIIB 3B 54 Xe Xenon 131.29 -108.09																														
55 IA 1A 55 Cs Cesium 132.905 673	56 IIA 2A 56 Ba Barium 137.327 1897	57-71 IIIB 3B 57-71 Lanthanide Series	72 IIIB 3B 72 Hf Hafnium 178.49 4603	73 IIIB 3B 73 Ta Tantalum 180.948 3498	74 IIIB 3B 74 W Tungsten 183.85 5555	75 IIIB 3B 75 Re Rhenium 186.207 5596	76 IIIB 3B 76 Os Osmium 190.23 5012	77 IIIB 3B 77 Ir Iridium 192.22 5628	78 IIIB 3B 78 Pt Platinum 195.08 3825	79 IIIB 3B 79 Au Gold 196.967 2856	80 IIIB 3B 80 Hg Mercury 200.59 356.62	81 IIIB 3B 81 Tl Thallium 204.383 1473	82 IIIB 3B 82 Pb Lead 207.2 1749	83 IIIB 3B 83 Bi Bismuth 208.980 1564	84 IIIB 3B 84 Po Polonium 209 1682	85 IIIB 3B 85 At Astatine 209 337	86 IIIB 3B 86 Rn Radon 222.018 -61.7																														
87 IA 1A 87 Fr Francium 223.020 677	88 IIA 2A 88 Ra Radium 226.025 1717	89-103 IIIB 3B 89-103 Actinide Series	104 IIIB 3B 104 Rf Rutherfordium [261]	105 IIIB 3B 105 Db Dubnium [262]	106 IIIB 3B 106 Sg Seaborgium [266]	107 IIIB 3B 107 Bh Bohrium [264]	108 IIIB 3B 108 Hs Hassium [265]	109 IIIB 3B 109 Mt Meitnerium [268]	110 IIIB 3B 110 Ds Darmstadtium [269]	111 IIIB 3B 111 Rg Roentgenium [272]	112 IIIB 3B 112 Cn Copernicium [277]	113 IIIB 3B 113 Uut Ununtrium [278]	114 IIIB 3B 114 Fl Flerovium [289]	115 IIIB 3B 115 Uup Ununpentium [288]	116 IIIB 3B 116 Lv Livermorium [293]	117 IIIB 3B 117 Uus Ununseptium [294]	118 IIIB 3B 118 Uuo Ununoctium [294]																														
<table border="1"> <tr> <td>57 Lanthanide Series La Lanthanum 138.906 3444</td> <td>58 Ce Cerium 140.115 3443</td> <td>59 Pr Praseodymium 140.908 3520</td> <td>60 Nd Neodymium 144.24 3074</td> <td>61 Pm Promethium 144.913 3000</td> <td>62 Sm Samarium 150.36 1794</td> <td>63 Eu Europium 151.966 1529</td> <td>64 Gd Gadolinium 157.25 3273</td> <td>65 Tb Terbium 158.925 3230</td> <td>66 Dy Dysprosium 162.50 2567</td> <td>67 Ho Holmium 164.930 2700</td> <td>68 Er Erbium 167.26 2868</td> <td>69 Tm Thulium 168.934 1950</td> <td>70 Yb Ytterbium 173.04 1196</td> <td>71 Lu Lutetium 174.967 3402</td> </tr> <tr> <td>89 Actinide Series Ac Actinium 227.028 3198</td> <td>90 Th Thorium 232.038 4768</td> <td>91 Pa Protactinium 231.036 4027</td> <td>92 U Uranium 238.029 4131</td> <td>93 Np Neptunium 237.048 4174</td> <td>94 Pu Plutonium 244.064 3228</td> <td>95 Am Americium 243.061 2011</td> <td>96 Cm Curium 247.070 3100</td> <td>97 Bk Berkelium 247.070 2627</td> <td>98 Cf Californium 251.080 2567</td> <td>99 Es Einsteinium [252]</td> <td>100 Fm Fermium [257]</td> <td>101 Md Mendelevium [258]</td> <td>102 No Nobelium [259]</td> <td>103 Lr Lawrencium [260]</td> </tr> </table>																		57 Lanthanide Series La Lanthanum 138.906 3444	58 Ce Cerium 140.115 3443	59 Pr Praseodymium 140.908 3520	60 Nd Neodymium 144.24 3074	61 Pm Promethium 144.913 3000	62 Sm Samarium 150.36 1794	63 Eu Europium 151.966 1529	64 Gd Gadolinium 157.25 3273	65 Tb Terbium 158.925 3230	66 Dy Dysprosium 162.50 2567	67 Ho Holmium 164.930 2700	68 Er Erbium 167.26 2868	69 Tm Thulium 168.934 1950	70 Yb Ytterbium 173.04 1196	71 Lu Lutetium 174.967 3402	89 Actinide Series Ac Actinium 227.028 3198	90 Th Thorium 232.038 4768	91 Pa Protactinium 231.036 4027	92 U Uranium 238.029 4131	93 Np Neptunium 237.048 4174	94 Pu Plutonium 244.064 3228	95 Am Americium 243.061 2011	96 Cm Curium 247.070 3100	97 Bk Berkelium 247.070 2627	98 Cf Californium 251.080 2567	99 Es Einsteinium [252]	100 Fm Fermium [257]	101 Md Mendelevium [258]	102 No Nobelium [259]	103 Lr Lawrencium [260]
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Isotope - same element different mass

Calculating Weighted Averages for Atomic Mass  
based on natural abundance....

Left to right are called periods

Up and down are called groups

Group 1A - Alkali Metals

Group 2A - Alkaline Earth Metals

Group 7A - Halogens

Group 8A - Noble Gases

Groups 1A - 7A = Representative Elements

Groups 3B - 2B = Transition Metals

Periods on the Bottom = Inner Transition Metals

### Working in pairs

Determine the name, how many protons, electrons, and neutrons each of these have. Also, state what group and period they are in and give the group name if it has one.

1) F      2) C      3) Rb      4) Au      5) K

6) B      7) Kr      8) N      9) Ni      10) Ca

- 1) Flourine, 9, 9, 10, 2, VIIA, Halogen
- 2) Carbon, 6, 6, 6, 2, IVA, Representative
- 3) Rubidium, 37, 37, 48, 5, IA, Alkali Metal
- 4) Gold, 79, 79, 118, 6, IB, transition metal
- 5) Potassium, 19, 19, 20, 4, IA, Alkalie Metal
- 6) Boron, 5, 5, 6, 2, IIIA, representative
- 7) Krypton, 36, 36, 48, 4, VIIIA, Nobel Gas
- 8) Nitrogen, 7, 7, 7, 2, VA, Representative
- 9) Nickel, 28, 28, 31, 4, VIIIB, transition metal
- 10) Calcium, 20, 20, 20, 4, IIA, Earth Metal

