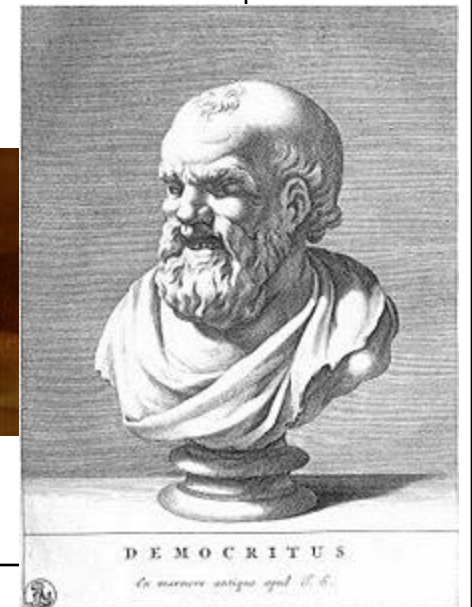




Subatomic Particles and Elements

The Atom

- The first ideas about what our world is made of came from Greece, and started by understanding the world in terms of 4 elements (water, earth, air, and fire)
- This idea lasted until 430-370 BC, when Democritus proposed that the world is made of an infinite number of units called atoms. Each element was made of different atoms.
- The word atom came from the word atomos "uncuttable". The idea came to him when he saw cheese being cut and thought that you can only cut cheese so many times before you are at the smallest it can be.



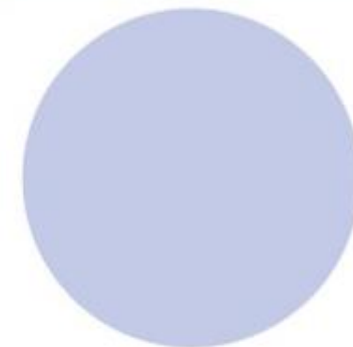
The Atom

- At the end of the 18th century, researcher John Dalton drew on what Democritus proposed, and came up with a model where the atoms are one solid sphere.
- Dalton again mentions that atoms of the same element are the same, but can also combine with other elements to create compounds.

Dalton's Atomic Theory

1. Elements are made of tiny particles called **atoms**.
2. All atoms of a given element are identical.
3. The atoms of a given element are different from those of any other element.
4. Atoms of one element can combine with atoms of other elements to form compounds. A given compound always has the same relative numbers and types of atoms.
5. Atoms are indivisible in chemical processes. That is, atoms are not created or destroyed in chemical reactions. A chemical reaction simply changes the way the atoms are grouped together.

Solid sphere model



John Dalton



1803

Dalton drew upon the Ancient Greek idea of atoms (the word 'atom' comes from the Greek 'atomos' meaning indivisible). His theory stated that atoms are indivisible, those of a given element are identical, and compounds are combinations of different types of atoms.



Recognised that atoms of a particular element differ from other elements.



Atoms aren't indivisible – they're composed from subatomic particles.

The Atom

- 19th century, J.J. Thomson proposed that the atom is actually divisible, and is made up of negative particles **electrons**, in a positive cloud.
- The model was called the plum pudding model
- Thomson called the **positive charges protons**

Plum pudding model



J.J. Thomson



1904

Thomson discovered electrons (which he called 'corpuscles') in atoms in 1897, for which he won a Nobel Prize. He subsequently produced the 'plum pudding' model of the atom. It shows the atom as composed of electrons scattered throughout a spherical cloud of positive charge.



Recognised electrons as components of atoms.



No nucleus, and didn't explain later experimental observations.

- This idea lasted until Ernest Rutherford shot positive particles at a sheet of gold foil.
- Ernest found the positive charge was located in the center, which he called the **nucleus** (different nucleus than the Biology/cell nucleus)



Nuclear model



Ernest Rutherford



1911

Rutherford fired positively charged alpha particles at a thin sheet of gold foil. Most passed through with little deflection, but some deflected at large angles. This was only possible if the atom was mostly empty space, with the positive charge concentrated in the centre: the nucleus.



Realised that positive charge was localised in the nucleus of an atom.

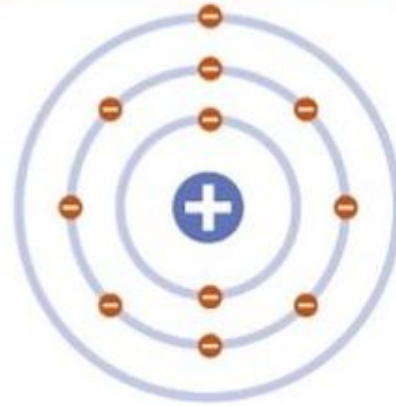


Did not explain why electrons remain in orbit around the nucleus.

The Atom

- The model we will be using:
- Niels **Bohr** found that the **negative electrons** rotate around the nucleus in circles called **shells**. The shells are filled up in this order: 2, 8, 8, 18, ...
- The nucleus is made up of **protons (positive) and neutrons (neutral)**. The number of neutrons can vary.
- **Compounds are overall neutral** in charge.

Planetary model



Niels Bohr



1913

Bohr modified Rutherford's model of the atom by stating that electrons moved around the nucleus in orbits of fixed sizes and energies. Electron energy in this model was quantised; electrons could not occupy values of energy between the fixed energy levels.



Proposed stable electron orbits; explained the emission spectra of some elements.



Moving electrons should emit energy and collapse into the nucleus; model did not work well for heavier atoms.

Quantum model



Erwin Schrödinger



1926

Schrödinger stated that electrons do not move in set paths around the nucleus, but in waves. It is impossible to know the exact location of the electrons; instead, we have 'clouds of probability' called orbitals, in which we are more likely to find an electron.



Shows electrons don't move around the nucleus in orbits, but in clouds where their position is uncertain.



Still widely accepted as the most accurate model of the atom.

- This idea lasted until Erwin Schrodinger (famous for Schrodinger's cat) found the model does not work for heavy elements (past Calcium, #20)
- Schrodinger is what is actually used today and says that the electrons exist somewhere in clouds/orbitals around the nucleus.
- We will not be using this model for Science 9.

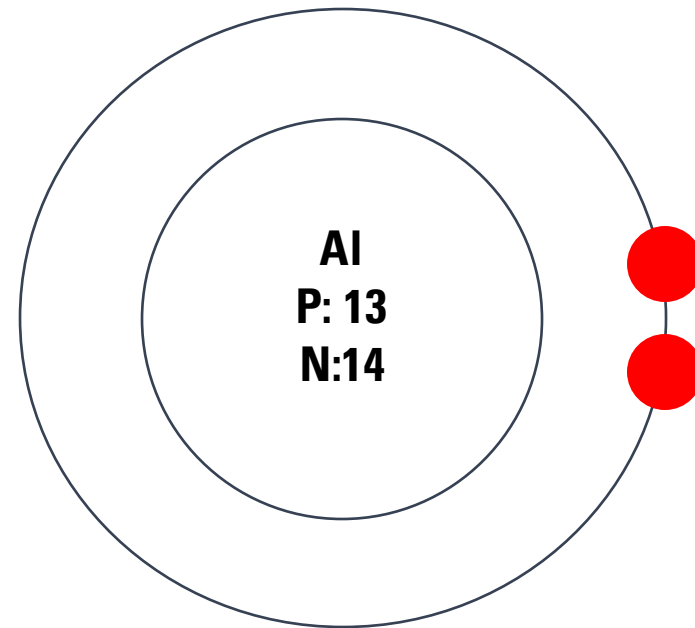
Bohr model example

- An atom of **aluminum** (symbol is Al) has **13 protons, 13 electrons, and 14 neutrons**.
- Start by drawing a circle and writing the **atomic symbol**, the **proton** number and **neutron** number.
- The circle represents the nucleus, which contains the protons and neutrons. Note that each particle is always vibrating inside the nucleus.



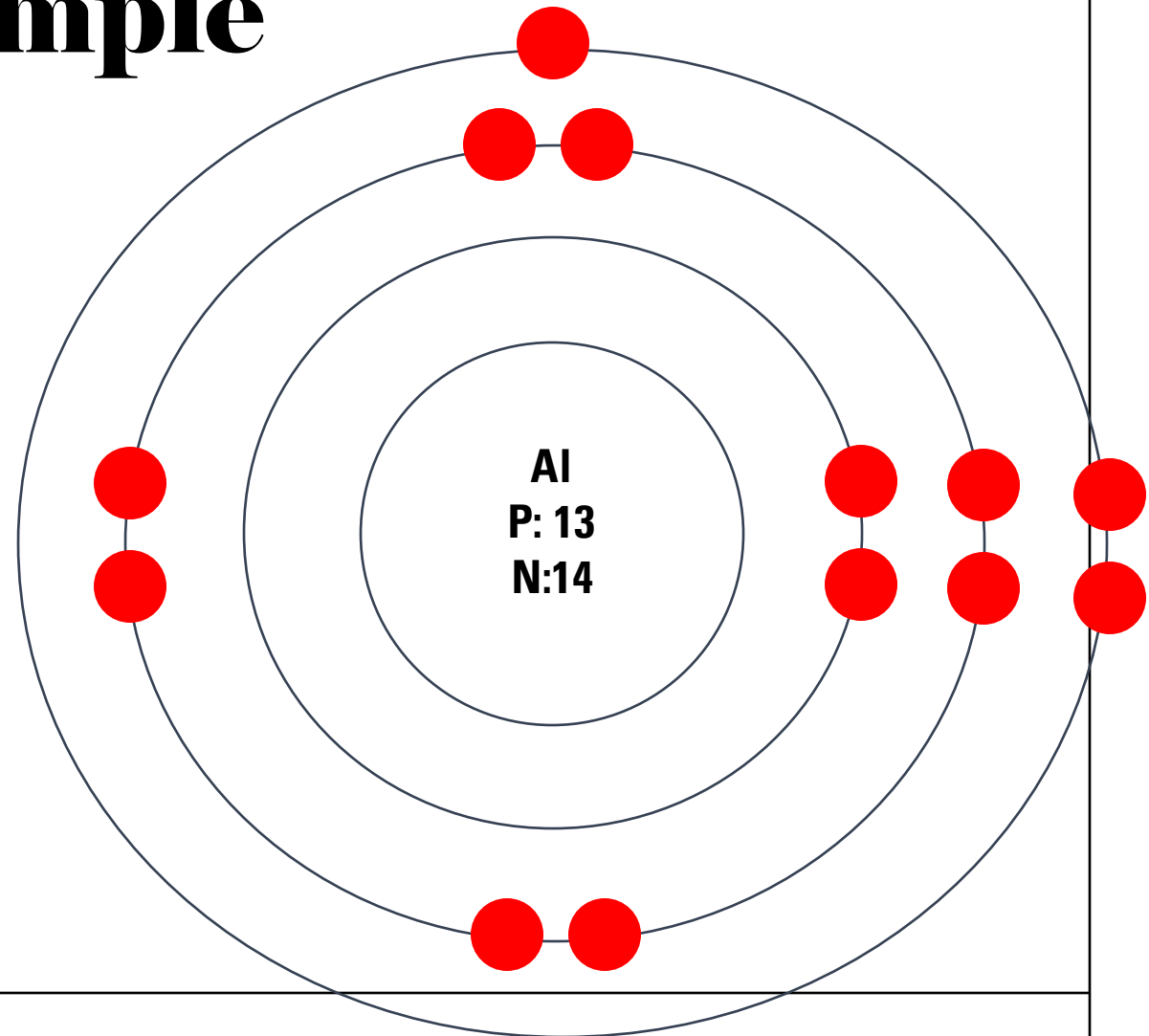
Bohr model example

- Draw the first circle around the nucleus and **add 2** of our 13 electrons.
- The first shell can only hold a **maximum of 2** electrons.
- If you want to be really accurate, draw the electrons in pairs, they like a friend :)



Bohr model example

- We still have **11 more electrons** to place. Draw in another circle. The **second circle can hold 8** of our remaining 11 electrons.
- Then, we draw in 1 more circle that can hold up to 8 more electrons. Place **the remaining 3 three in the last circle.**
- If you needed a fourth circle, draw in a fourth circle and place the remaining electrons.
- **Note:** electrons constantly jump between shells, but there will always be 2 in the first, 8 in the second,...



The periodic table of elements

- Humans have made a table of all the known elements (found on Earth or human made)
- There are 7 **periods** (rows) and 18 **groups/families** (columns)
- Note the **black "staircase"** pattern on the right side of the periodic table.
 - All elements on the left** of the line (except Hydrogen) are **metals**.
 - All elements on the right** of the line are **non-metals**.

PERIODIC TABLE OF THE ELEMENTS

										METALS ←									
1 + H Hydrogen 1.0																		1 - H Hydrogen 1.0	18 He Helium 4.0
3 + Li Lithium 6.9	4 2+ Be Beryllium 9.0											5 B Boron 10.8	6 C Carbon 12.0	7 3- N Nitrogen 14.0	8 2- O Oxygen 16.0	9 - F Fluorine 19.0	10 0 Ne Neon 20.2		
11 + Na Sodium 23.0	12 2+ Mg Magnesium 24.3	13 3+ Al Aluminium 27.0	14 Si Silicon 28.1	15 3- P Phosphorus 31.0	16 2- S Sulfur 32.1	17 - Cl Chlorine 35.5	18 0 Ar Argon 39.9												
19 + K Potassium 39.1	20 2+ Ca Calcium 40.1	21 3+ Sc Scandium 45.0	22 4+ Ti Titanium 47.9	23 5+ V Vanadium 50.9	24 3+ Cr Chromium 52.0	25 2+ Mn Manganese 54.9	26 3+ Fe Iron 55.8	27 2+ Co Cobalt 58.9	28 2+ Ni Nickel 58.7	29 2+ Cu Copper 63.5	30 2+ Zn Zinc 65.4	31 3+ Ga Gallium 69.7	32 4+ Ge Germanium 72.6	33 3- As Arsenic 74.9	34 2- Se Selenium 79.0	35 - Br Bromine 79.9	36 0 Kr Krypton 83.8		
37 + Rb Rubidium 85.5	38 2+ Sr Strontium 87.6	39 3+ Y Yttrium 88.9	40 4+ Zr Zirconium 91.2	41 3+ Nb Niobium 92.9	42 2+ Mo Molybdenum 95.9	43 7+ Tc Technetium (98)	44 3+ Ru Ruthenium 101.1	45 3+ Rh Rhodium 102.9	46 2+ Pd Palladium 106.4	47 + Ag Silver 107.9	48 2+ Cd Cadmium 112.4	49 3+ In Indium 114.8	50 4+ Sn Tin 118.7	51 3+ Sb Antimony 121.8	52 2- Te Tellurium 127.6	53 - I Iodine 126.9	54 0 Xe Xenon 131.3		
55 + Cs Cesium 132.9	56 2+ Ba Barium 137.3	57 3+ La Lanthanum 138.9	72 4+ Hf Hafnium 178.5	73 5+ Ta Tantalum 180.9	74 6+ W Tungsten 183.8	75 4+ Re Rhenium 186.2	76 3+ Os Osmium 190.2	77 3+ Ir Iridium 192.2	78 4+ Pt Platinum 195.1	79 3+ Au Gold 197.0	80 2+ Hg Mercury 200.6	81 1+ Tl Thallium 204.4	82 2+ Pb Lead 207.2	83 3+ Bi Bismuth 209.0	84 2+ Po Polonium (209)	85 - At Astatine (210)	86 0 Rn Radon (222)		
87 + Fr Francium (223)	88 2+ Ra Radium (226)	89 3+ Ac Actinium (227)	104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (263)	107 Bh Bohrium (262)	108 Hs Hassium (265)	109 Mt Meitnerium (266)	110 Ds Darmstadtium (281)	111 Rg Roentgenium (272)	112 Uub Ununbium (285)	113 Uut Ununtrium (284)	114 Uuq Ununquadium (289)	115 Uup Ununpentium (288)	116 Uuh Ununhexium (292)	117 Uus Ununseptium (?)	118 Uuo Ununoctium (294)		
Alkali Metals		Alkaline Earth Metals												Halogens		Noble Gases			
58 3+ Ce Cerium 140.1	59 3+ Pr Praseodymium 140.9	60 3+ Nd Neodymium 144.2	61 3+ Pm Promethium (145)	62 3+ Sm Samarium 150.4	63 3+ Eu Europium 152.0	64 3+ Gd Gadolinium 157.3	65 3+ Tb Terbium 158.9	66 3+ Dy Dysprosium 162.5	67 3+ Ho Holmium 164.9	68 3+ Er Erbium 167.3	69 3+ Tm Thulium 168.9	70 3+ Yb Ytterbium 173.0	71 3+ Lu Lutetium 175.0						
90 4+ Th Thorium 232.0	91 5+ Pa Protactinium 231.0	92 6+ U Uranium 238.0	93 5+ Np Neptunium (237)	94 4+ Pu Plutonium (244)	95 3+ Am Americium (243)	96 3+ Cm Curium (247)	97 3+ Bk Berkelium (247)	98 3+ Cf Californium (251)	99 3+ Es Einsteinium (252)	100 3+ Fm Fermium (257)	101 2+ Md Mendelevium (258)	102 2+ No Nobelium (259)	103 3+ Lr Lawrencium (262)						

Atomic Number	22	4+	← Ion charge(s)
Symbol	Ti	3+	
Name	Titanium		
Atomic Mass	47.9		

Based on mass of C-12 at 12.00.

Any value in parentheses is the mass of the most stable or best known isotope for elements which do not occur naturally.

Metals vs. Non-metals

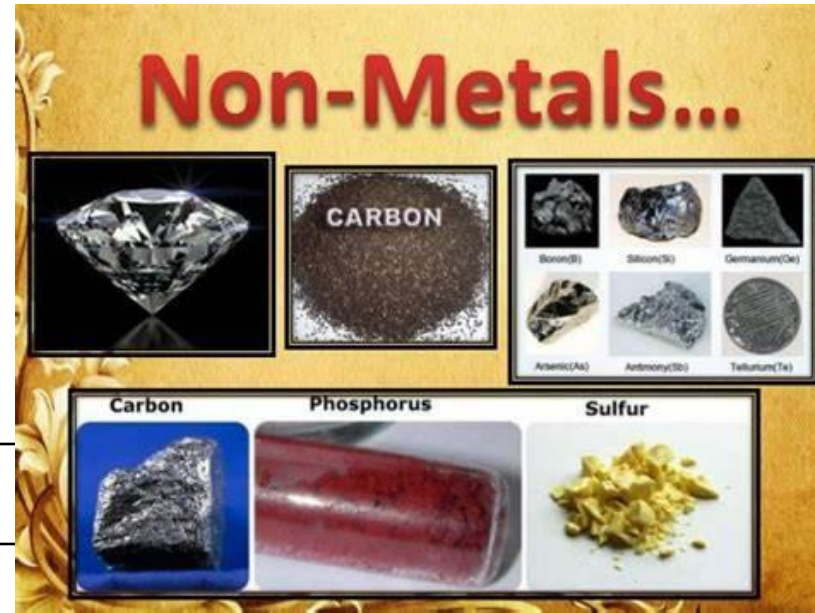
- **Metals are:**

- Usually shiny
- Ductile/Malleable - Can be easily deformed/shaped without breaking
- Conductive of electricity
- Usually high melting and boiling temperatures
- Usually have a high density (feel heavy)



- **Non-metals are:**

- Usually dull looking
- Brittle. Not ductile or malleable.
- Usually do not conduct of electricity well
- Usually low melting and boiling temperatures
- Usually have a low density (feel light)



Metalloids (Semi-metals)



Silicon



Germanium



Arsenic

- **Metalloids** are the elements that are along on the black staircase on the right side of the periodic table
- Metalloids have some properties of metals and some properties of non-metals
 - Example: Germanium can conduct electricity well and is shiny, but Germanium is very brittle and has a medium density

Periodic Table of the Elements

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
IA	IIA	IIIB	IVB	VB	VIB	VIIA	VIIIA	VIIIA	VIIIA	VIIIA	VIIIA	IIIA	IVA	VA	VIA	VIIA	VIIIA
1 H	2 He											3 B	4 C	5 N	6 O	7 F	8 Ne
3 Li	4 Be											9 Al	10 Si	11 P	12 S	13 Cl	14 Ar
5 Na	6 Mg	7 Sc	8 Ti	9 V	10 Cr	11 Mn	12 Fe	13 Co	14 Ni	15 Cu	16 Zn	17 Ga	18 Ge	19 As	20 Se	21 Br	22 Kr
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57-71 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89-103 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Uup	116 Lv	117 Uus	118 Uuo
		6 La	7 Ce	8 Pr	9 Nd	10 Pm	11 Sm	12 Eu	13 Gd	14 Tb	15 Dy	16 Ho	17 Er	18 Tm	19 Yb	20 Lu	
		7 Ac	8 Th	9 Pa	10 U	11 Np	12 Pu	13 Am	14 Cm	15 Bk	16 Cf	17 Es	18 Fm	19 Md	20 No	21 Lr	

METALLOIDS

Reading the periodic table

- The **atomic number** is always the same as the **number of protons**.
- In a neutral atom, if there are **22** positive **protons**, then there must be **22** negative **electrons**.
- The atomic mass is the protons + the neutrons.
- To find the number of neutrons:
 1. Round the atomic mass
 2. Subtract the proton number from the rounded atomic mass
- Example for Titanium: 47.9 is close to 48. $48 - 22 = 26$ neutrons

Atomic Number	→	22	4+	← Ion charge(s)
Symbol	→	Ti	3+	
Name	→	Titanium		
Atomic Mass	→	47.9		

Each element has 1 or 2 letters. For 2 letter elements, the first letter is always capitalized, and the second letter is always lowercase. Yes, it matters!

Cool Example: Mercury

- Mercury (nicknamed liquid silver) is one of two elements on the periodic table that is a liquid at room temperature.
- It has all the same properties as most metals (other than its melting and boiling point).
- It has been used for electronics, hat making, barometers and thermometers extensively
- It is very toxic, so we do not use it much anymore.



Hat Maker.



Families of the periodic table: The Alkali Metals

- Note: **Hydrogen is not a metal**, so even though it is in the same column, **it is not part of the alkali metals**
- Alkali metals** are located in the **first column** of the periodic table
- Alkali metals are **extremely reactive metals**. They react in water, sometimes air, and many other substances violently.

Rubidium in water ->



1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18					
													Prictogens	Chalcogens	Halogens							
1 H Hydrogen 1.008	Atomic Symbol Name Weight																	2 He Helium 4.0026				
3 Li Lithium 6.94	4 Be Beryllium 9.0122																5 B Boron 10.81	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180
11 Na Sodium 22.990	12 Mg Magnesium 24.305																13 Al Aluminium 26.982	14 Si Silicon 28.085	15 P Phosphorus 30.974	16 S Sulfur 32.06	17 Cl Chlorine 35.45	18 Ar Argon 39.948
19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.867	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.630	33 As Arsenic 74.922	34 Se Selenium 78.971	35 Br Bromine 79.904	36 Kr Krypton 83.798					
37 Rb Rubidium 85.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.95	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.91	46 Pd Palladium 106.42	47 Ag Silver 107.87	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.71	51 Sb Antimony 121.76	52 Te Tellurium 127.60	53 I Iodine 126.90	54 Xe Xenon 131.29					
55 Cs Caesium 132.91	56 Ba Barium 137.33	57-71	72 Hf Hafnium 178.49	73 Ta Tantalum 180.95	74 W Tungsten 183.84	75 Re Rhenium 186.21	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.97	80 Hg Mercury 200.59	81 Tl Thallium 204.38	82 Pb Lead 207.2	83 Bi Bismuth 208.98	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)					
87 Fr Francium (223)	88 Ra Radium (226)	89-103	104 Rf Rutherfordium (267)	105 Db Dubnium (268)	106 Sg Seaborgium (269)	107 Bh Bohrium (270)	108 Hs Hassium (277)	109 Mt Meitnerium (278)	110 Ds Darmstadtium (281)	111 Rg Roentgenium (282)	112 Cn Copernicium (285)	113 Nh Nihonium (286)	114 Fl Flerovium (289)	115 Mc Moscovium (290)	116 Lv Livermorium (293)	117 Ts Tennessine (294)	118 Og Oganesson (294)					
For elements with no stable isotopes, the mass number of the isotope with the longest half-life is in parentheses.																						
57 La Lanthanum 138.91	58 Ce Cerium 140.12	59 Pr Praseodymium 140.91	60 Nd Neodymium 144.24	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.96	64 Gd Gadolinium 157.25	65 Tb Terbium 158.93	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93	68 Er Erbium 167.26	69 Tm Thulium 168.93	70 Yb Ytterbium 173.05	71 Lu Lutetium 174.97								
89 Ac Actinium (227)	90 Th Thorium 232.04	91 Pa Protactinium 231.04	92 U Uranium 238.03	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (266)								

Families of the periodic table: The Alkaline Earth Metals



Magnesium in water ->

- The **alkaline earth metals** are located in the **second column** of the periodic table.
- The alkaline earth metals also **react violently**, but not as much as the alkali metals.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18																																																													
		Atomic Symbol Name Weight																																																																														
1	H	Hydrogen	1.008																	2	He	Helium	4.0026																																																									
3	Li	Lithium	6.94	4	Be	Beryllium	9.0122													5	B	Boron	10.81	6	C	Carbon	12.011	7	N	Nitrogen	14.007	8	O	Oxygen	15.999	9	F	Fluorine	18.998	10	Ne	Neon	20.180																																					
11	Na	Sodium	22.990	12	Mg	Magnesium	24.305													13	Al	Aluminium	26.982	14	Si	Silicon	28.085	15	P	Phosphorus	30.974	16	S	Sulfur	32.06	17	Cl	Chlorine	35.45	18	Ar	Argon	39.948																																					
19	K	Potassium	39.098	20	Ca	Calcium	40.078	21	Sc	Scandium	44.956	22	Ti	Titanium	47.867	23	V	Vanadium	50.942	24	Cr	Chromium	51.996	25	Mn	Manganese	54.938	26	Fe	Iron	55.845	27	Co	Cobalt	58.933	28	Ni	Nickel	58.693	29	Cu	Copper	63.546	30	Zn	Zinc	65.38	31	Ga	Gallium	69.723	32	Ge	Germanium	72.630	33	As	Arsenic	74.922	34	Se	Selenium	78.971	35	Br	Bromine	79.904	36	Kr	Krypton	83.798									
37	Rb	Rubidium	85.468	38	Sr	Strontium	87.62	39	Y	Yttrium	88.906	40	Zr	Zirconium	91.224	41	Nb	Niobium	92.906	42	Mo	Molybdenum	95.95	43	Tc	Technetium	(98)	44	Ru	Ruthenium	101.07	45	Rh	Rhodium	102.91	46	Pd	Palladium	106.42	47	Ag	Silver	107.87	48	Cd	Cadmium	112.41	49	In	Indium	114.82	50	Sn	Tin	118.71	51	Sb	Antimony	121.76	52	Te	Tellurium	127.60	53	I	Iodine	126.90	54	Xe	Xenon	131.29									
55	Cs	Caesium	132.91	56	Ba	Barium	137.33	57-71													72	Hf	Hafnium	178.49	73	Ta	Tantalum	180.95	74	W	Tungsten	183.84	75	Re	Rhenium	186.21	76	Os	Osmium	190.23	77	Ir	Iridium	192.22	78	Pt	Platinum	195.08	79	Au	Gold	196.97	80	Hg	Mercury	200.59	81	Tl	Thallium	204.38	82	Pb	Lead	207.2	83	Bi	Bismuth	208.98	84	Po	Polonium	(209)	85	At	Astatine	(210)	86	Rn	Radon	(222)
87	Fr	Francium	(223)	88	Ra	Radium	(226)	89-103													104	Rf	Rutherfordium	(267)	105	Db	Dubnium	(268)	106	Sg	Seaborgium	(269)	107	Bh	Bohrium	(270)	108	Hs	Hassium	(277)	109	Mt	Mitnherium	(278)	110	Ds	Darmstadtium	(281)	111	Rg	Roentgenium	(282)	112	Cn	Copernicium	(285)	113	Nh	Nihonium	(286)	114	Fl	Flerovium	(289)	115	Mc	Moscovium	(290)	116	Lv	Livermorium	(293)	117	Ts	Tennesine	(294)	118	Og	Oganesson	(294)
For elements with no stable isotopes, the mass number of the isotope with the longest half-life is in parentheses.																																																																																
57	La	Lanthanum	138.91	58	Ce	Cerium	140.12	59	Pr	Praseodymium	140.91	60	Nd	Neodymium	144.24	61	Pm	Promethium	(145)	62	Sm	Samarium	150.36	63	Eu	Europium	151.96	64	Gd	Gadolinium	157.25	65	Tb	Terbium	158.93	66	Dy	Dysprosium	162.50	67	Ho	Holmium	164.93	68	Er	Erbium	167.26	69	Tm	Thulium	168.93	70	Yb	Ytterbium	173.05	71	Lu	Lutetium	174.97																					
89	Ac	Actinium	(227)	90	Th	Thorium	232.04	91	Pa	Protactinium	231.04	92	U	Uranium	238.03	93	Np	Neptunium	(237)	94	Pu	Plutonium	(244)	95	Am	Americium	(243)	96	Cm	Curium	(247)	97	Bk	Berkelium	(247)	98	Cf	Californium	(251)	99	Es	Einsteinium	(252)	100	Fm	Fermium	(257)	101	Md	Mendelevium	(258)	102	No	Nobelium	(259)	103	Lr	Lawrencium	(266)																					

Families of the periodic table: The Noble Gases

- The **noble gases** are a group of elements in the **right most column** that are gases at room temperature.
- The **noble gases do not want to react with anything** and can only react when forced.
- They are often used as neutral gases to fill space, since they are not flammable or explosive.
- Also they can glow!

Noble gases in glass ->



1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H Hydrogen 1.008	2 He Helium 4.0026																
3 Li Lithium 6.94	4 Be Beryllium 9.0122											5 B Boron 10.81	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 18.998
11 Na Sodium 22.990	12 Mg Magnesium 24.305											13 Al Aluminium 26.982	14 Si Silicon 28.085	15 P Phosphorus 30.974	16 S Sulfur 32.06	17 Cl Chlorine 35.45	18 Ar Argon 39.948
19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.867	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.630	33 As Arsenic 74.922	34 Se Selenium 78.971	35 Br Bromine 79.904	36 Kr Krypton 83.798
37 Rb Rubidium 85.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.95	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.91	46 Pd Palladium 106.42	47 Ag Silver 107.87	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.71	51 Sb Antimony 121.76	52 Te Tellurium 127.60	53 I Iodine 126.90	54 Xe Xenon 131.29
55 Cs Caesium 132.91	56 Ba Barium 137.33	57-71 Lanthanoids	72 Hf Hafnium 178.49	73 Ta Tantalum 180.95	74 W Tungsten 183.84	75 Re Rhenium 186.21	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.97	80 Hg Mercury 200.59	81 Tl Thallium 204.38	82 Pb Lead 207.2	83 Bi Bismuth 208.98	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
87 Fr Francium (223)	88 Ra Radium (226)	89-103 Actinoids	104 Rf Rutherfordium (267)	105 Db Dubnium (268)	106 Sg Seaborgium (269)	107 Bh Bohrium (270)	108 Hs Hassium (277)	109 Mt Meitnerium (278)	110 Ds Darmstadtium (281)	111 Rg Roentgenium (282)	112 Cn Copernicium (285)	113 Nh Nihonium (286)	114 Fl Flerovium (289)	115 Mc Moscovium (290)	116 Lv Livermorium (293)	117 Ts Tennessine (294)	118 Og Oganesson (294)
For elements with no stable isotopes, the mass number of the isotope with the longest half-life is in parentheses.																	
		6	57 La Lanthanum 138.91	58 Ce Cerium 140.12	59 Pr Praseodymium 140.91	60 Nd Neodymium 144.24	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.96	64 Gd Gadolinium 157.25	65 Tb Terbium 158.93	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93	68 Er Erbium 167.26	69 Tm Thulium 168.93	70 Yb Ytterbium 173.05	71 Lu Lutetium 174.97
		7	89 Ac Actinium (227)	90 Th Thorium 232.04	91 Pa Protactinium 231.04	92 U Uranium 238.03	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (266)