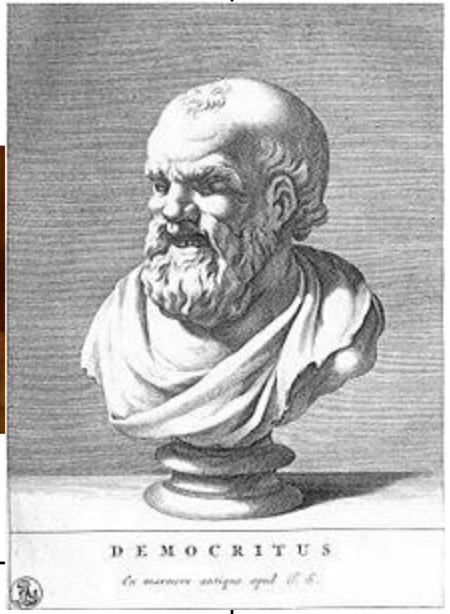
Subatomic Particles and Elements

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

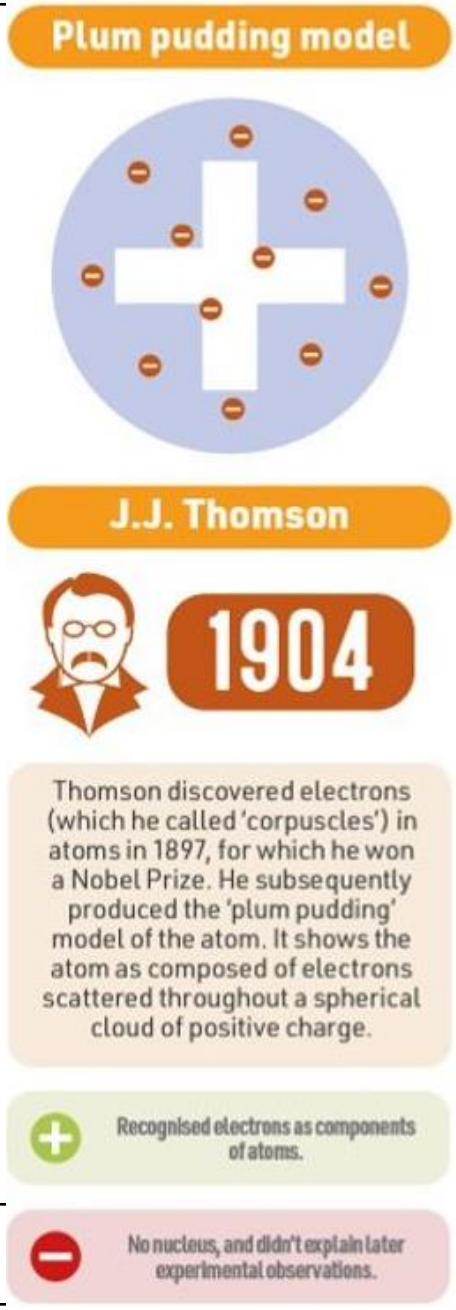
Dalton drew upon the Ancient Greek idea of atoms (the word 'atom' comes from the Greek '*atomos*' meaning indivisible). His theory stated that atoms are indivisible, those of a given element are identical, and compounds are combinations of different types of atoms.

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

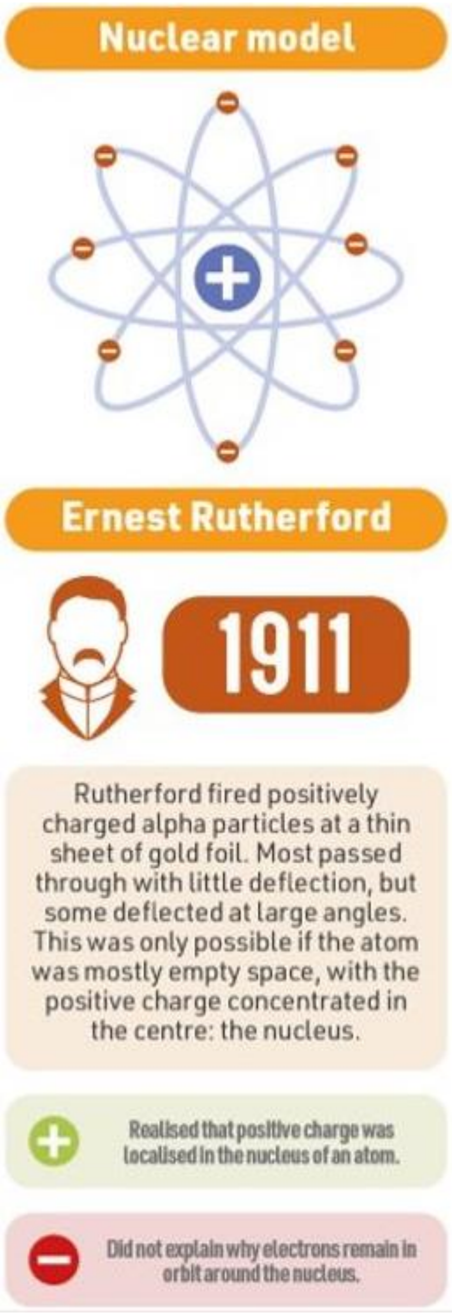
− Atoms aren't indivisible—they're composed from subatomic particles.

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**

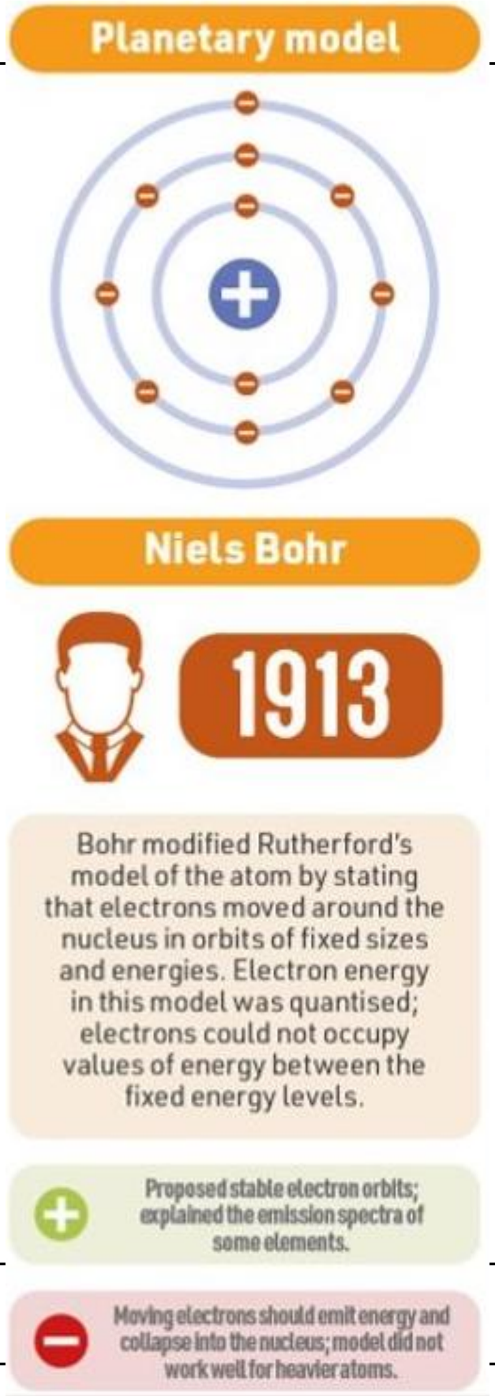


- This idea lasted until Ernest Rutherford shot positive lasers at a sheet of gold foil.
- Ernest found the positive charge was located in the center, which he called the **nucleus (different nucleus than the Biology/cell nucleus)**

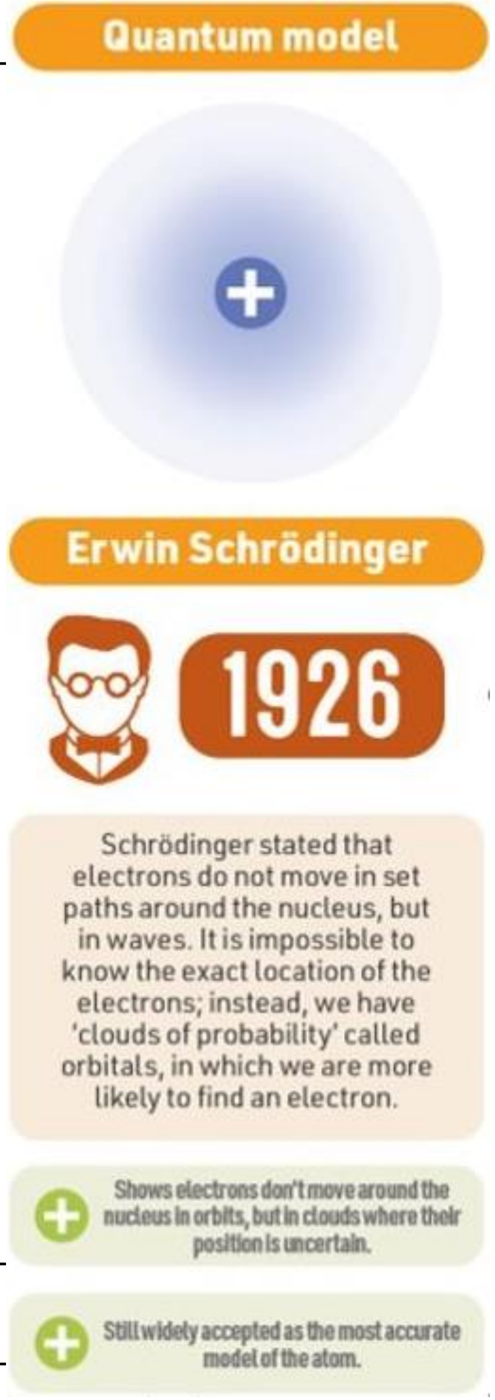


The Atom

- <u>The model we will be using</u>:
- 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.

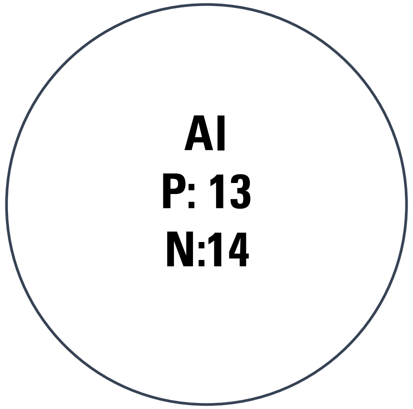


- This idea lasted until Erwin Schrodinger (famous for Schrodinger's cat) found the model does not work for heavy elements (past Calcium, #20)
- Schrodinger is <u>what is actually used today</u> and says that the electrons exist somewhere in clouds/orbitals around the nucleus.
- <u>We will not be using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



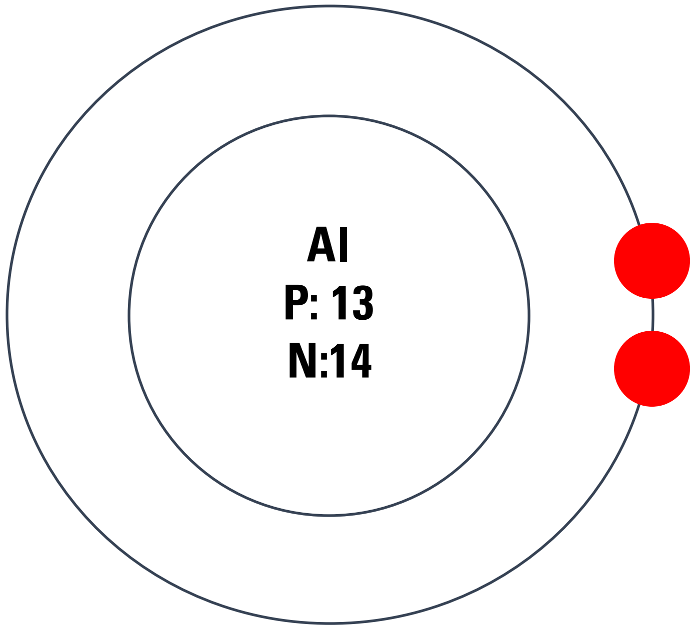
Bohr model example

- 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.



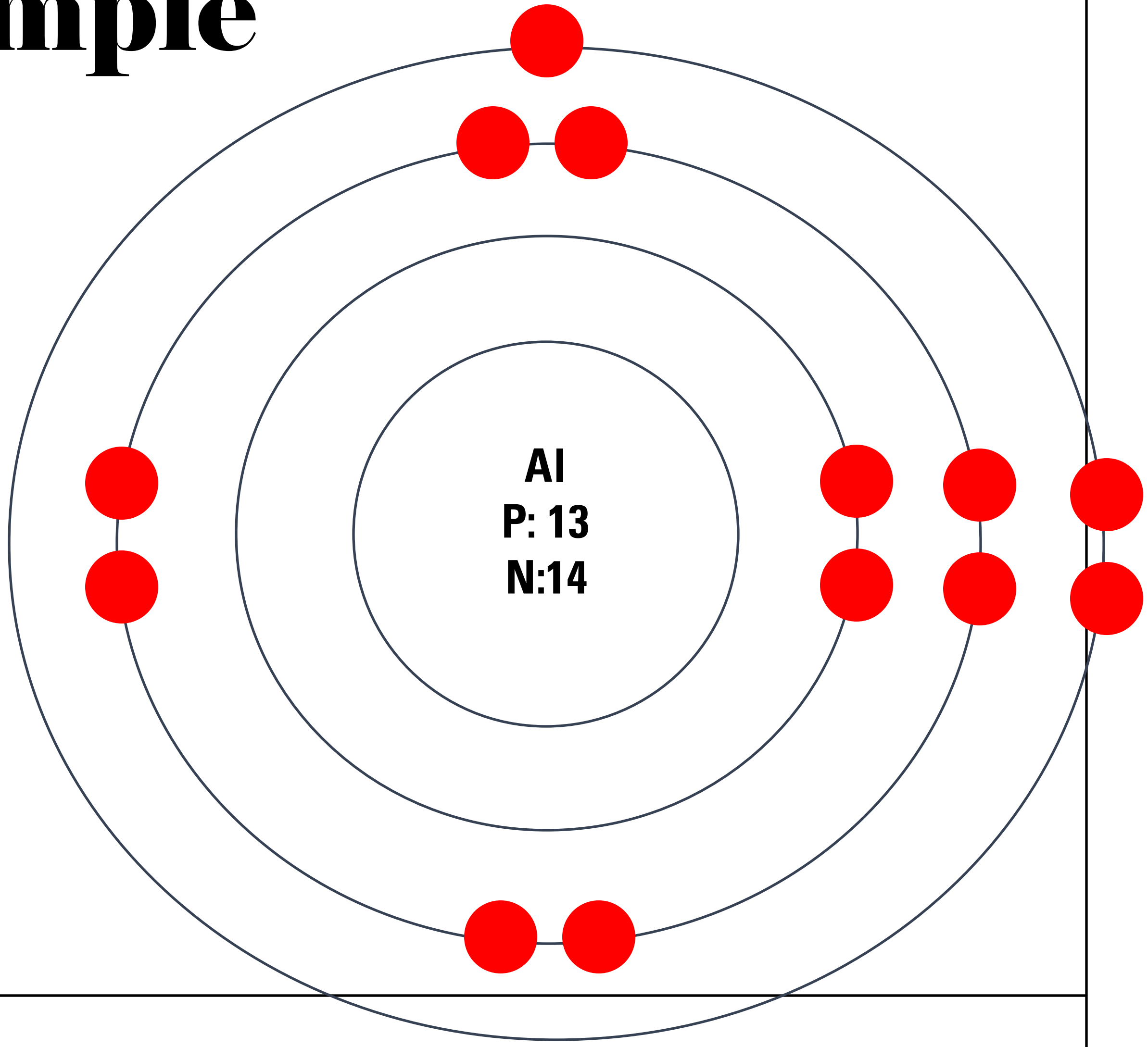
Bohr model example

- 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 :)



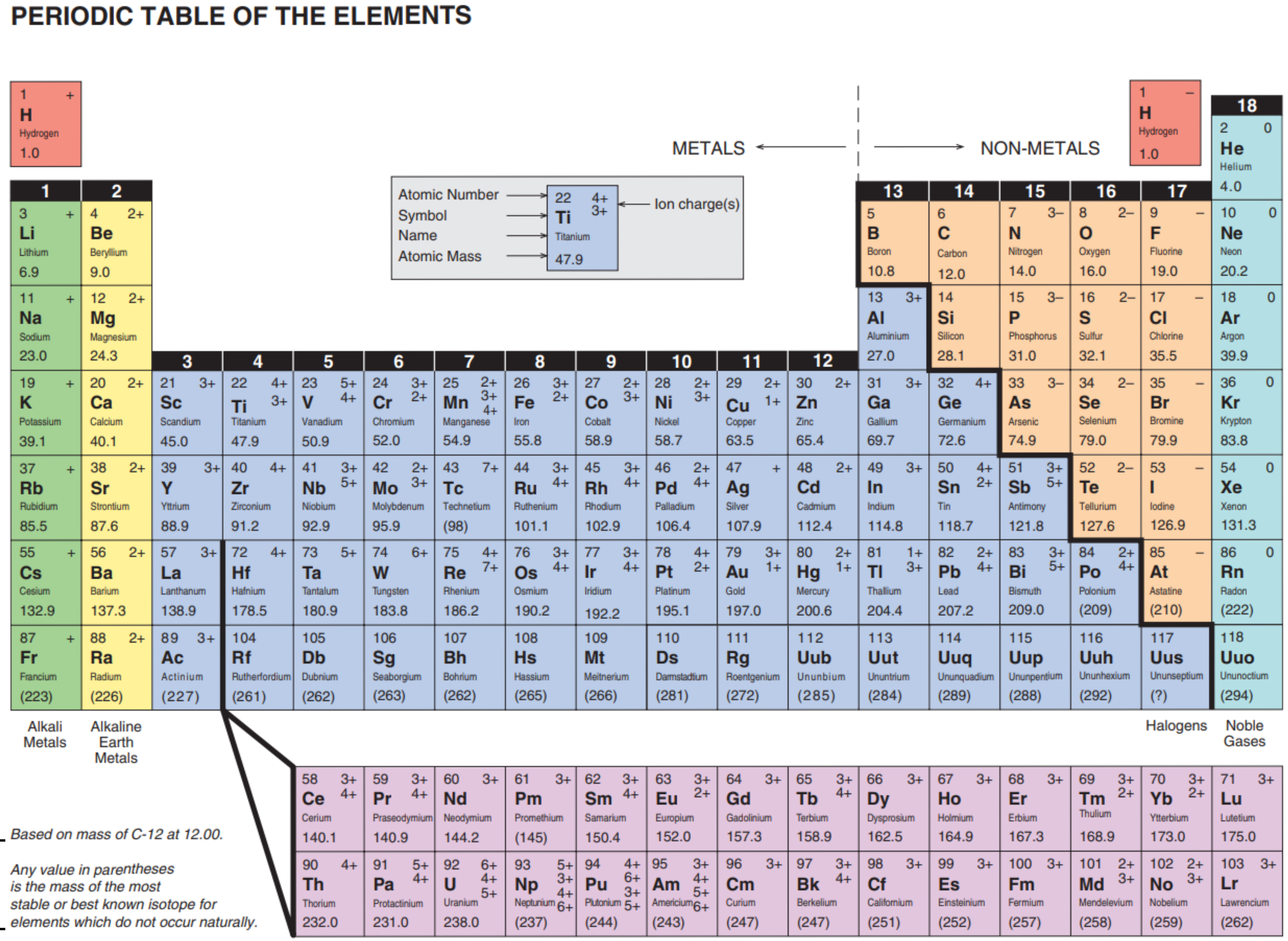
Bohr model example

- 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 (<u>except Hydrogen</u>) are **metals**.
    - **All elements on the right** of the line are **non-metals**.



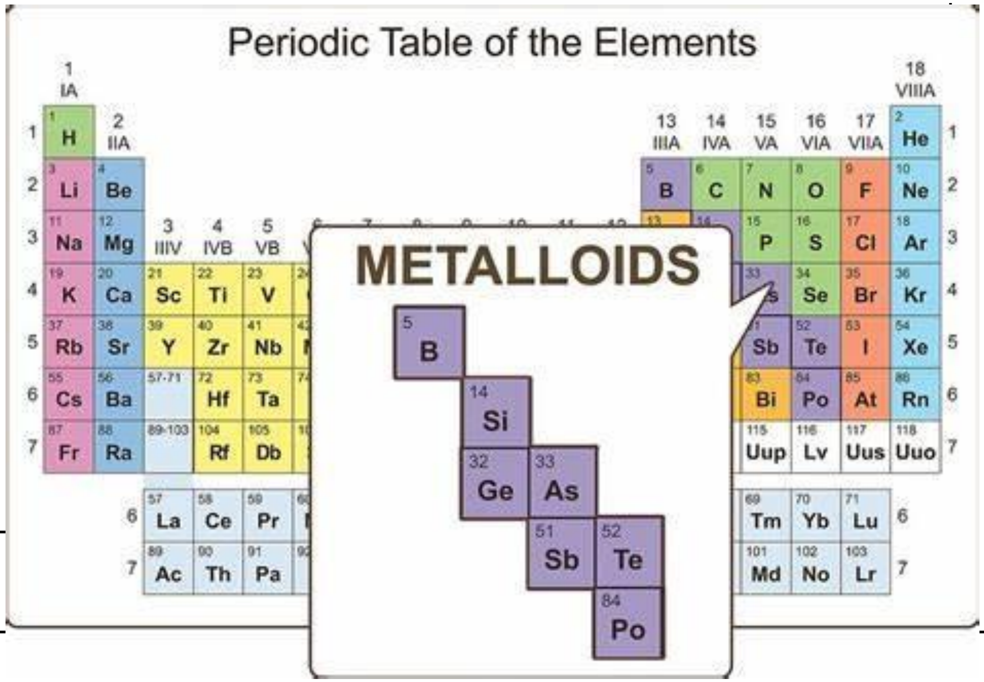
Metals vs. Non-metals

- **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)

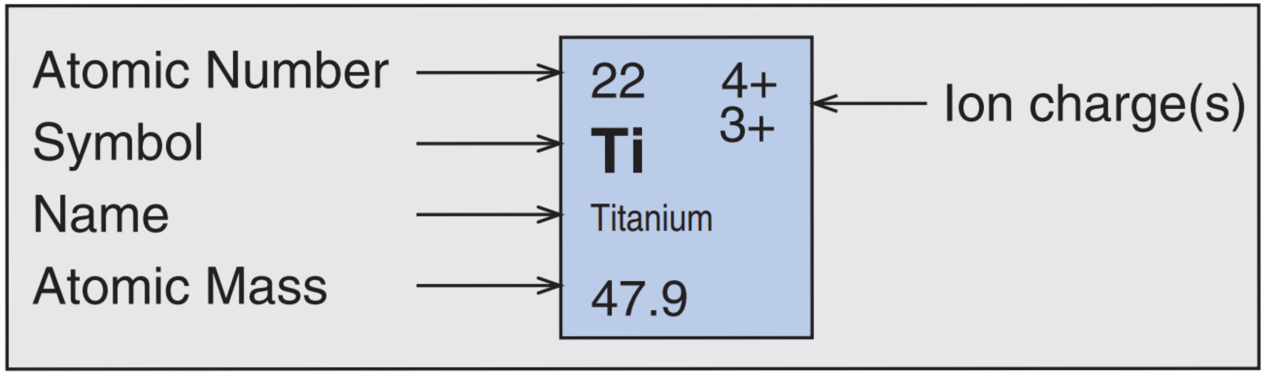
Metalloids (Semi-metals)

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



Reading the periodic table

- The **atomic number** is always the same has 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



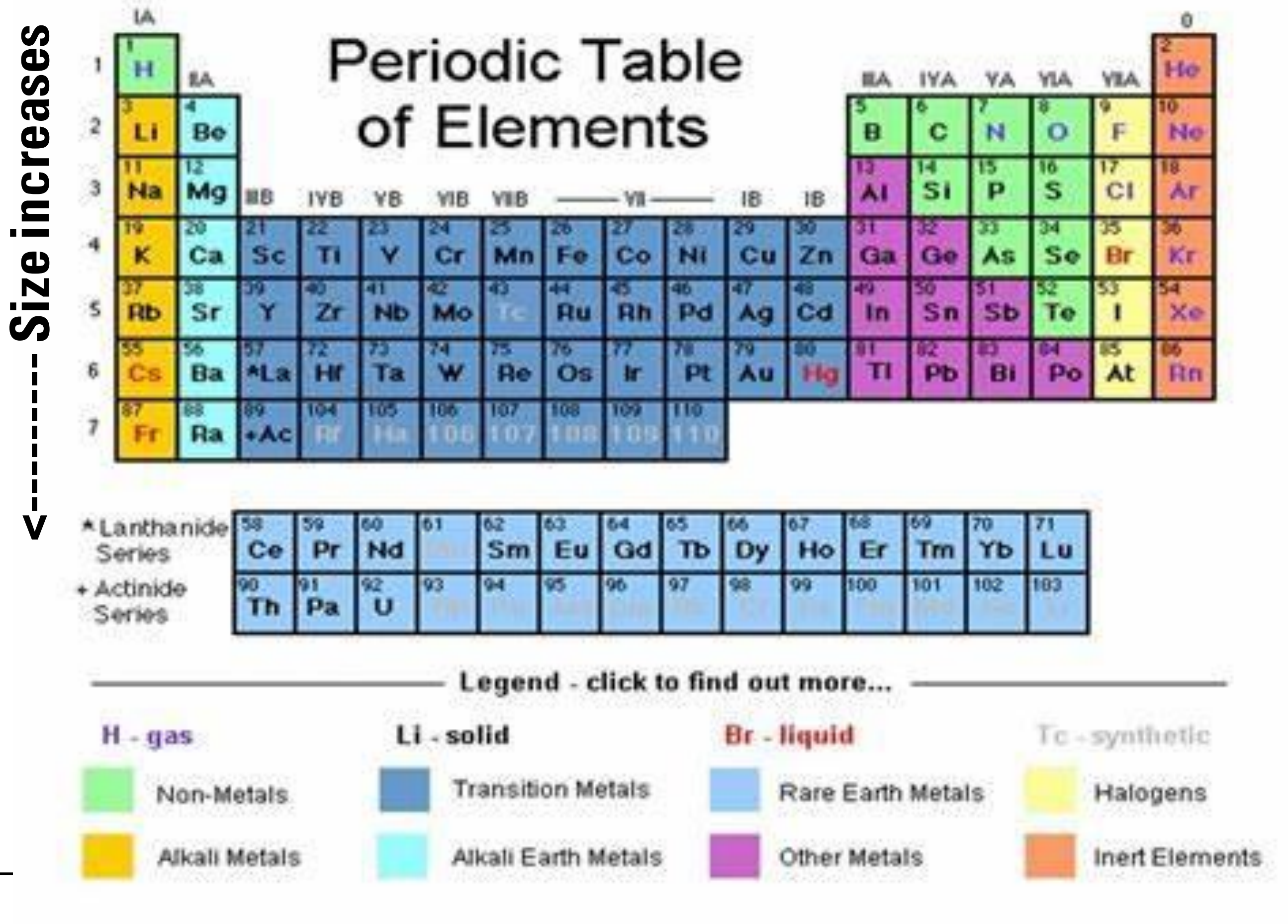
Each element has 1 or 2 letters. For 2 letter elements, the first letter is always capitalized, and the second letter is always lowercase. Yes, it matters!

Exploring the periodic table

- The periodic table is organized in many ways: by atomic number, by metals and non-metals, by how reactive the elements are, by size of the elements, and more!

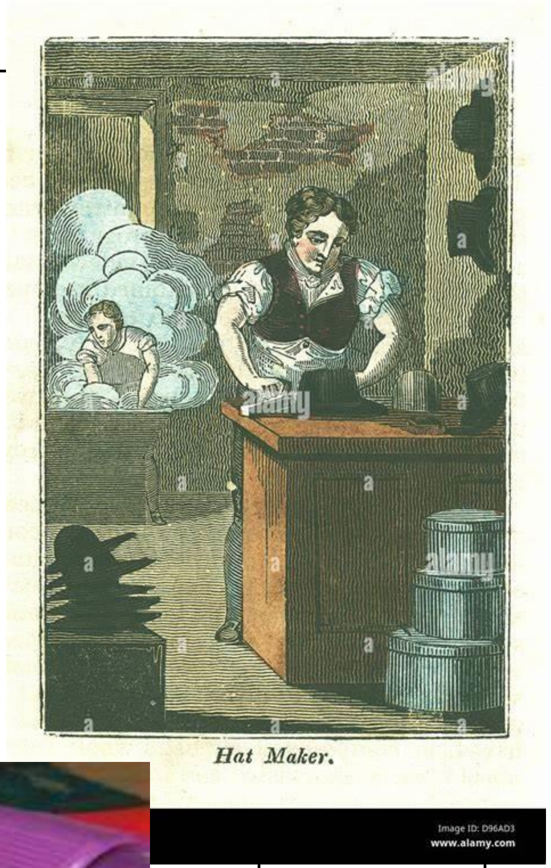
Useful exploration resources:

- Periodic Table - Ptable - Properties an interactive periodic table
- The Periodic Table of Videos - University of Nottingham (periodicvideos.com) - shows a video on every element in the periodic table



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.



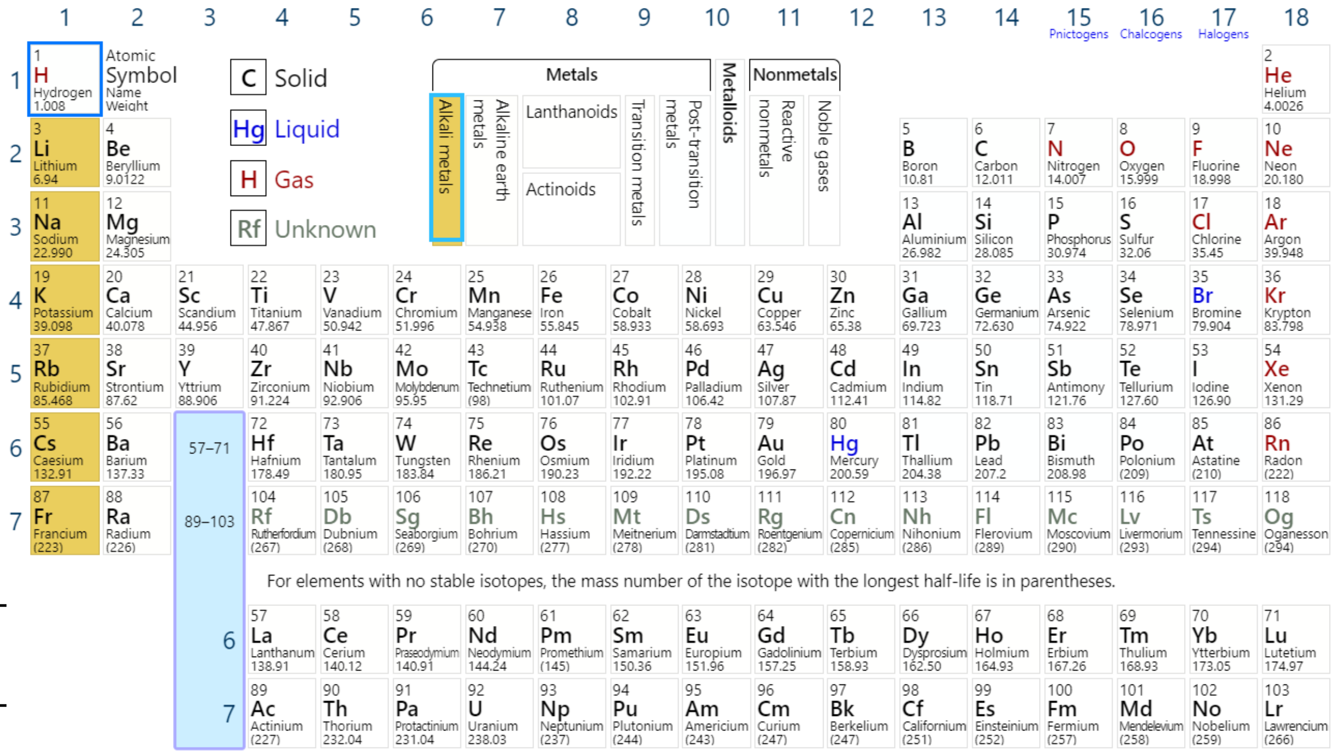
Families of the periodic table: The Alkali Metals

- 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 **<u>extremely reactive metals.</u>** They react in water, sometimes air, and many other substances violently.

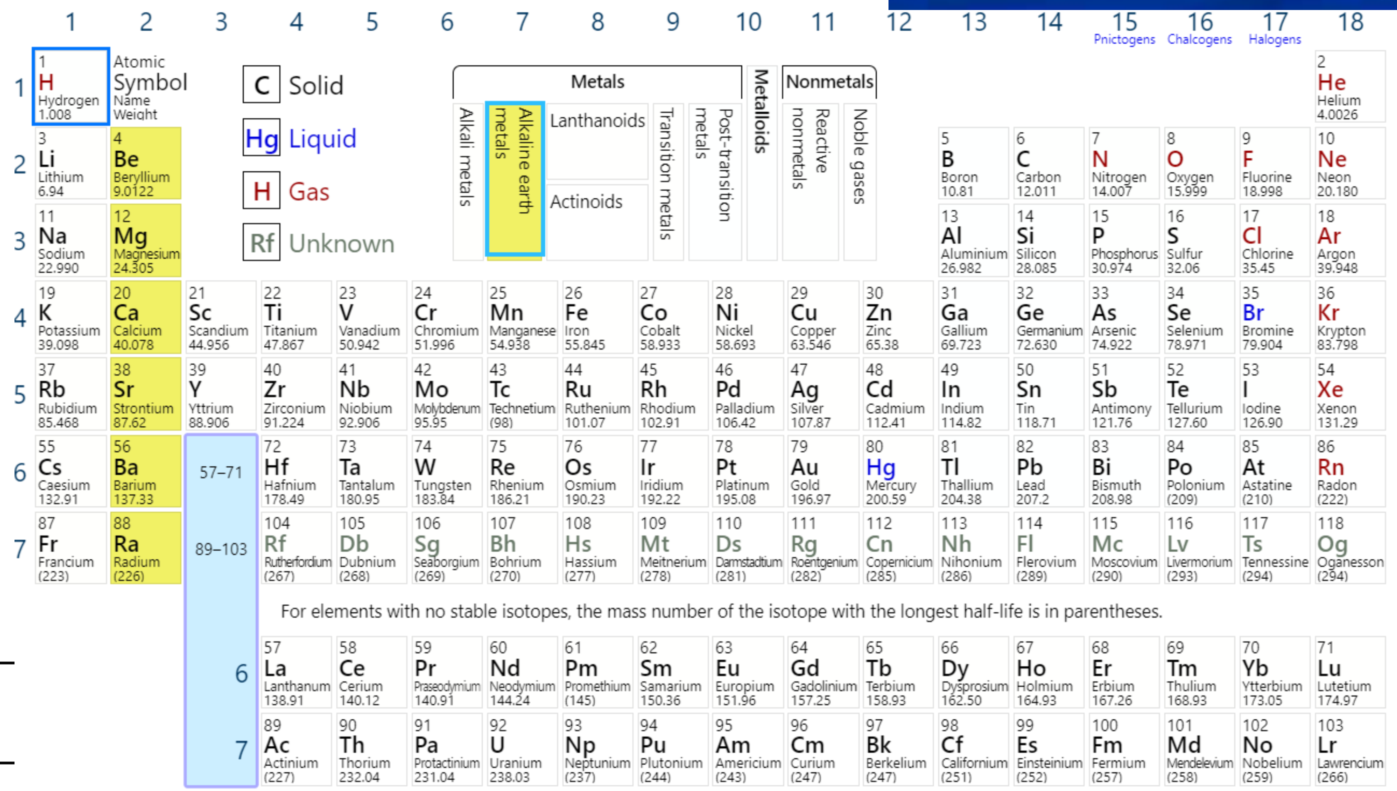
Rubidium in water ->



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 <u>**react violently**</u>, but not as much as the alkali metals.



Families of the periodic table: The Halogens

- The **Halogens** are found in **second to last column** on the right of the periodic table.
- Halogens are **really reactive** non-metals. This can react with many different materials, in a **non-explosive manner**.
- Examples of uses for halogens are disinfecting things (example: chlorine in pools)

Bromine Vapors that are reactive ->

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17 Halogens	18
H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La-Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac-No															

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 a neutral gases to fill space, since they are not flammable or explosive.
- Also they can glow!

Noble gases in glass ->