Molecular Literacy for All

a lens to see the everyday molecules that intersect with our lives every day

As long as you live, keep learning how to live.
— Seneca

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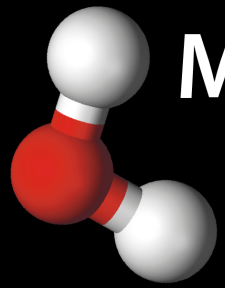
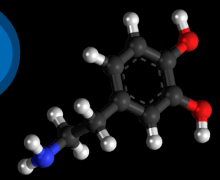
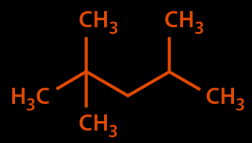
Molecules are



building blocks of LIFE

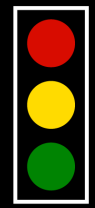
- nucleic acids
- monosaccharides
- amino acids





messengers in LIVING systems

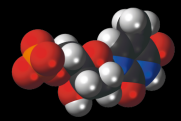
hormones & neurotransmitters



and SIGNALS for external COMMUNICATION

pheromones, chemoattractants, dyes, pigments, fragrances and flavors

they are chemical WEAPONS of *natural* defense



antibiotics, toxins & poisons

and nutrients that POWER LIFE

water, oxygen, proteins, fats, carbohydrates & vitamins

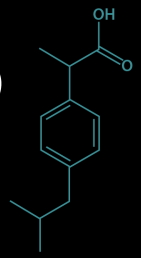
they are FUELS

for heat, transportation and electricity natural gas, petroleum, oil & coal

found throughout the universe because the chemical principles of the elements are UNIVERSAL

TOOLS

created by chemists



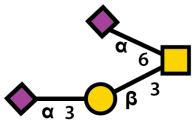
diagnostic reagents, molecular probes, contrast agents, fluorophores & markers

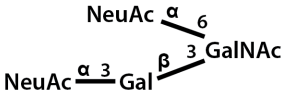
to study nature or to INFLUENCE it.

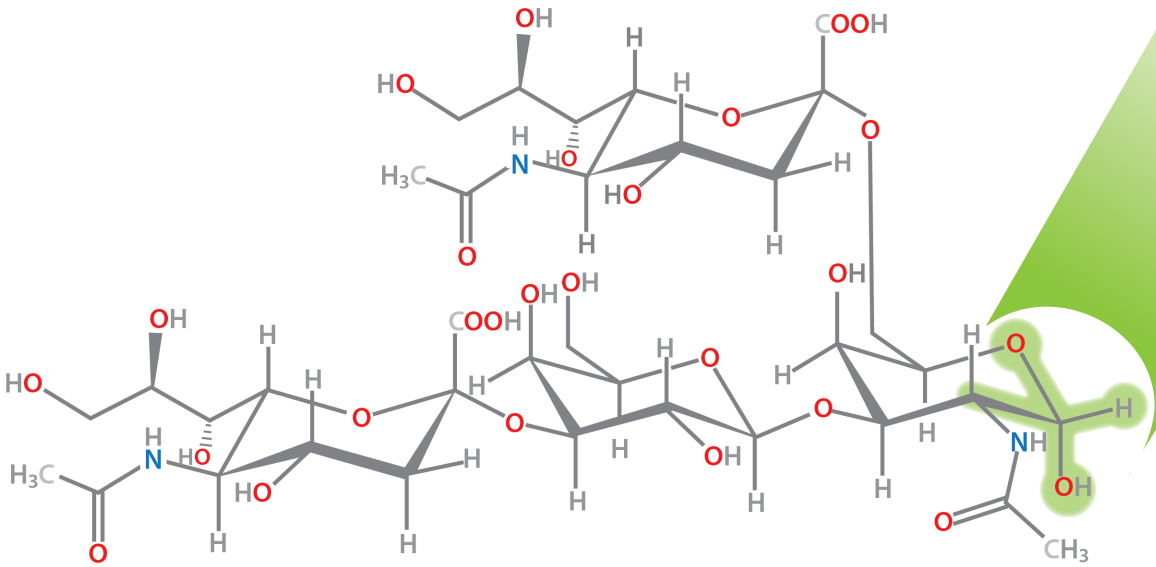
pharmaceuticals, pesticides & herbicides.

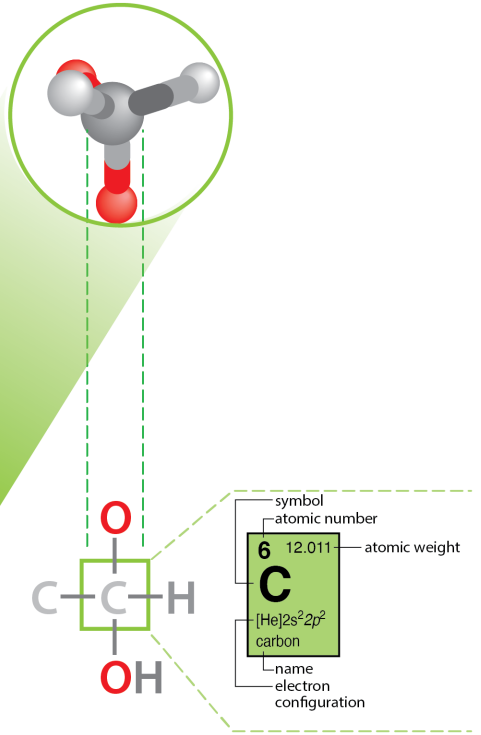
fabrics & TEXTILES plastics, WOOD & composites and the materials of clothing, packaging and CONSTRUCTION

SNFG	Abbr.	Systematic name
	GalNAc	2-Acetamido-2-deoxy-D-galactopyranose
	Gal	D-Galactopyranose
	NeuAc	5-Acetamido-3,5-dideoxy-D-glycero-D-galacto-non-2-ulopyranosonic acid



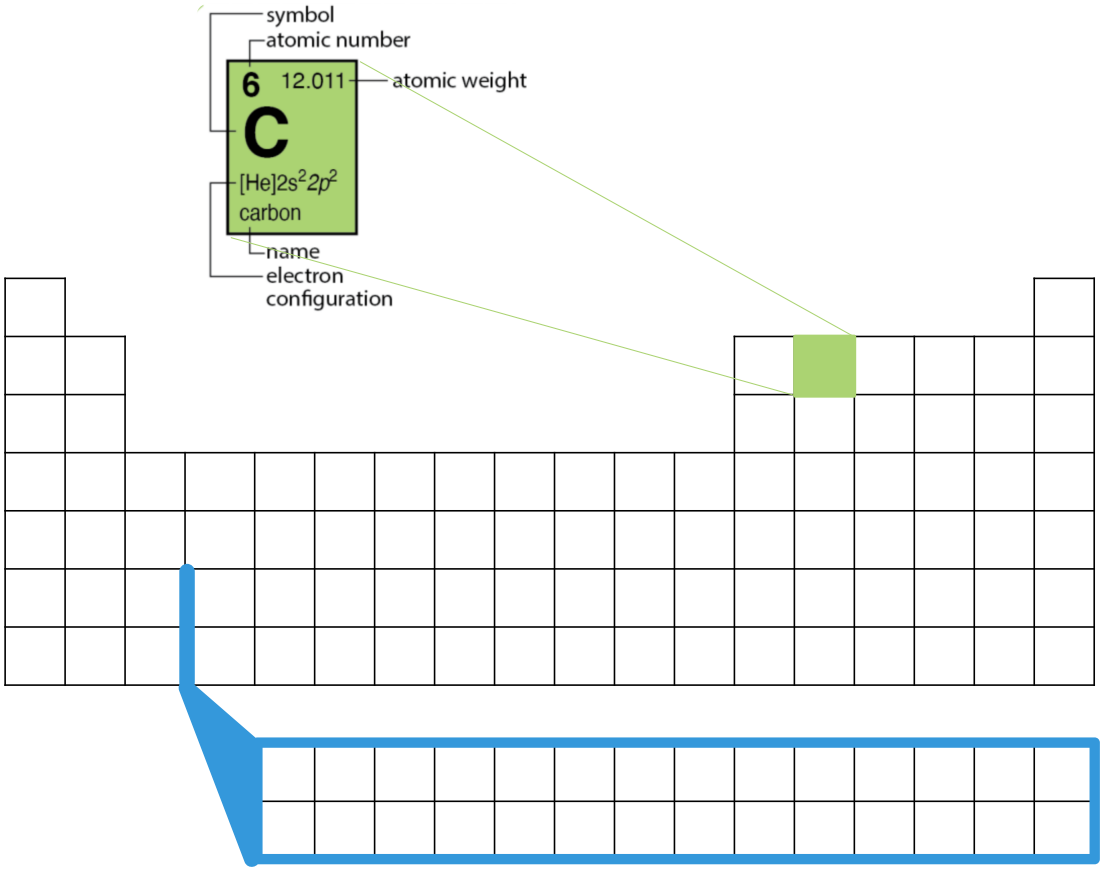




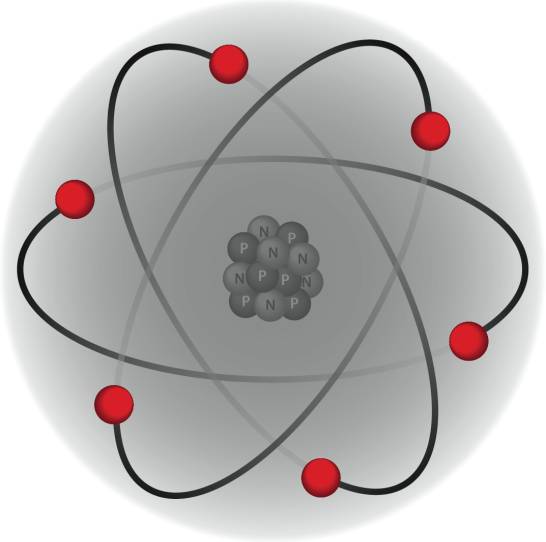


https://www.ncbi.nlm.nih.gov/glycans/snfg.html

The Periodic Table of the Elements: The Alphabet of the Molecular Language

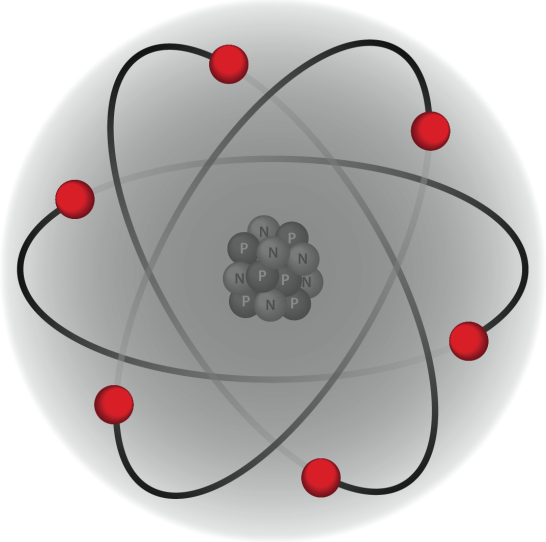


The atom and its subatomic particles



Subatomic Particle	Location	Charge	Mass
proton	nucleus	+	1,836
electron	cloud	-	1
neutron	nucleus	none	1,839

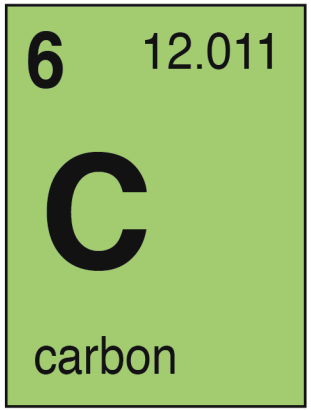
The atom and its subatomic particles



Subatomic Particle	Location	Charge	Mass	Change subatomic particle	
				What changes?	What stays the same?
proton	nucleus	+	1,836		
electron	cloud	-	1		
neutron	nucleus	none	1,839		

Atomic Number

Every element has a unique number of protons.



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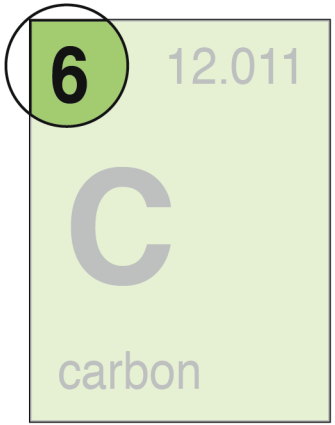
The number of protons is the element's atomic number.



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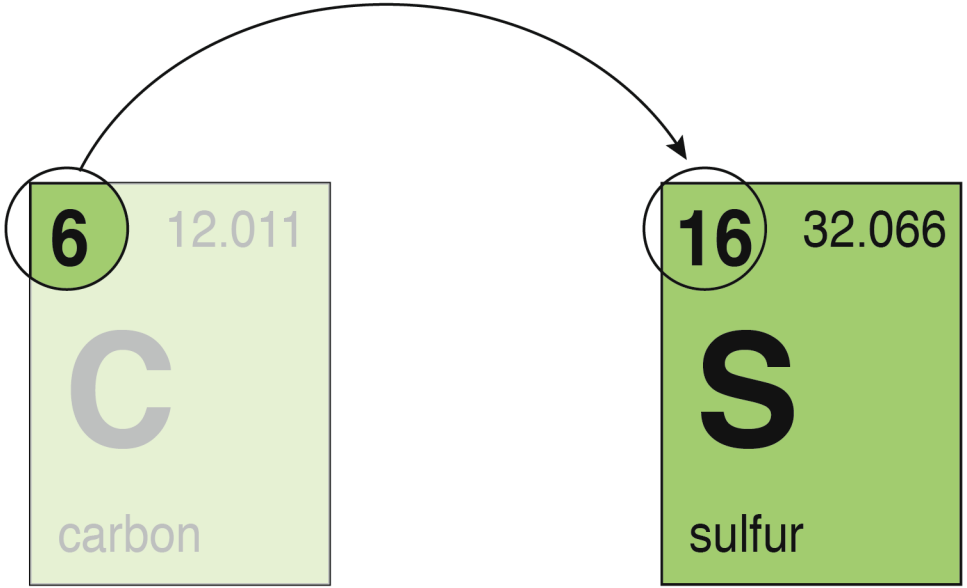
Any change in the number of protons changes the element.



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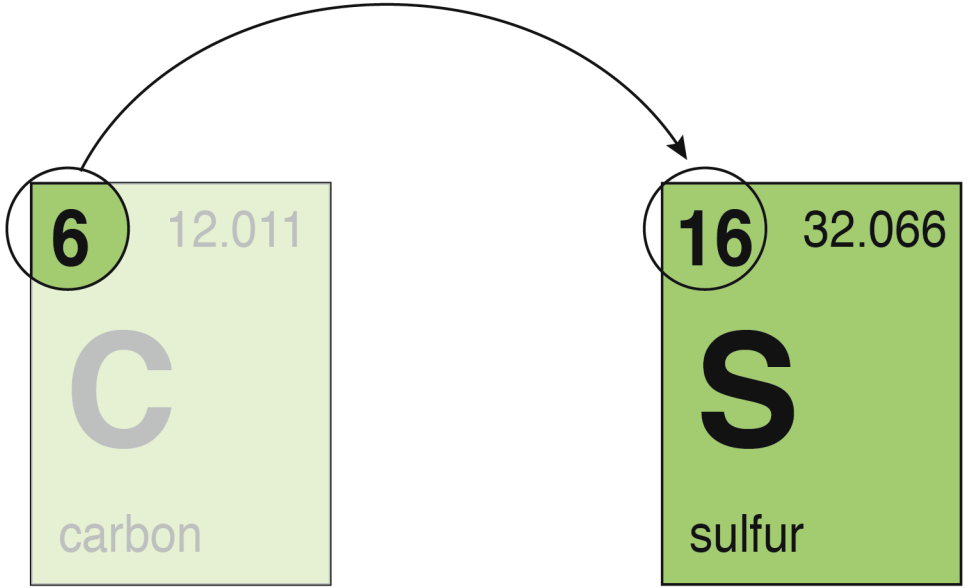


The elements of the periodic table begin with atomic number 1 and increase by 1 proton from left to right.

Chemical reactions conserve the elemental identity of every atom.

Nuclear reactions involve changes in the number of protons in an atom, and thus change the element.

Isotopes

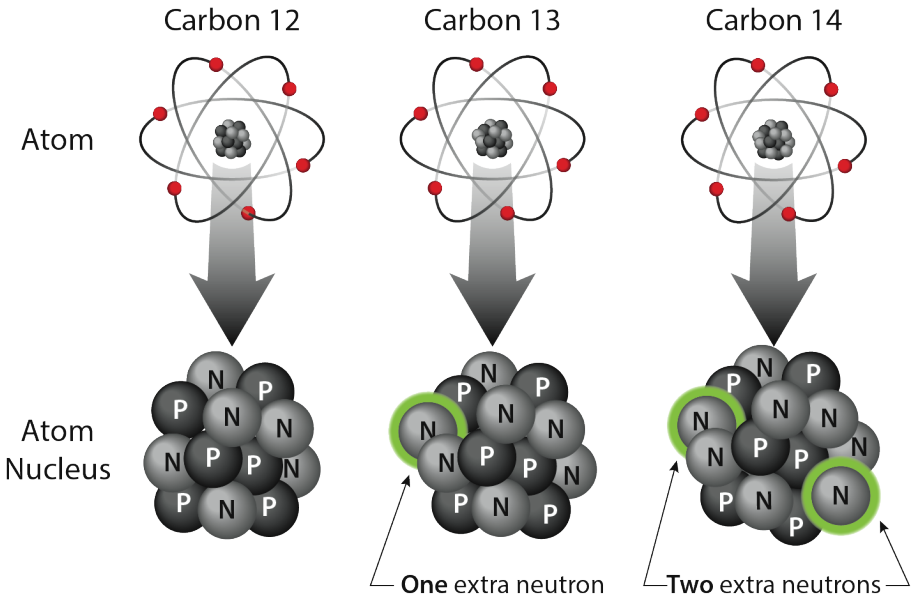
atomic variants of a chemical element

Isotopes are variants of a particular chemical element which differ in neutron number.

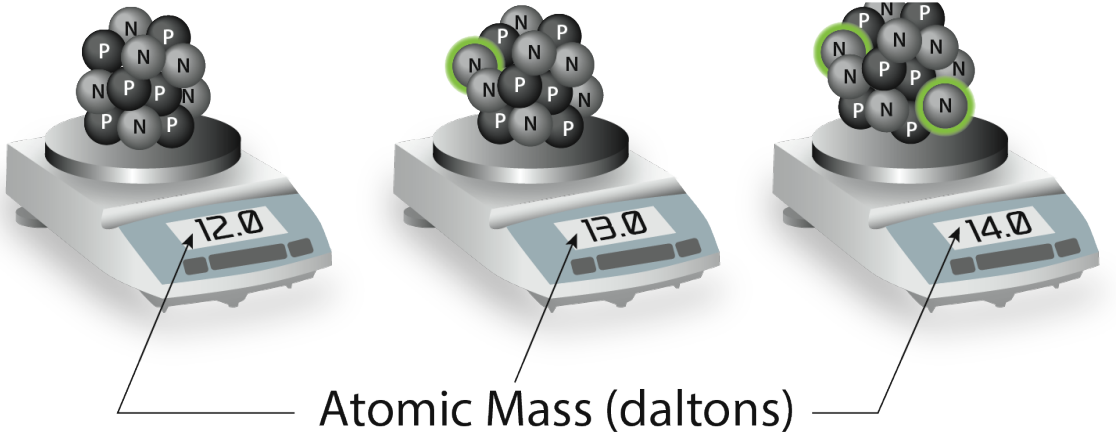
Each atomic number identifies a specific element, but not the isotope.

An atom of a given element may have a wide range in its number of neutrons.

Explore: The isotopes of hydrogen			
Isotope	Common name	Abundance	Decay?
^{1}H			
^{2}H			
^{3}H			



^{12}C	^{13}C	^{14}C
Carbon-12	Carbon-13	Carbon-14
98.9%	1.1%	<0.1%
6 protons	__ protons	__ protons
6 neutrons	__ neutrons	__ neutrons



The atomic mass is defined as the mass of a single atom, which can only be one isotope at a time, and is not an abundance-weighted average, as in the case of atomic weight.

Atomic Mass

- The protons and neutrons of the nucleus account for nearly all of the total mass of atoms, with the electrons and nuclear binding energy making minor contributions.
- The atomic mass is often expressed in the unit dalton (symbol: Da, or u) where 1 dalton is defined as $^{1}/_{12}$ of the mass of a single carbon-12 atom, at rest.
- The **atomic mass** of a carbon-12 atom is exactly 12 Da.

Atomic Weight

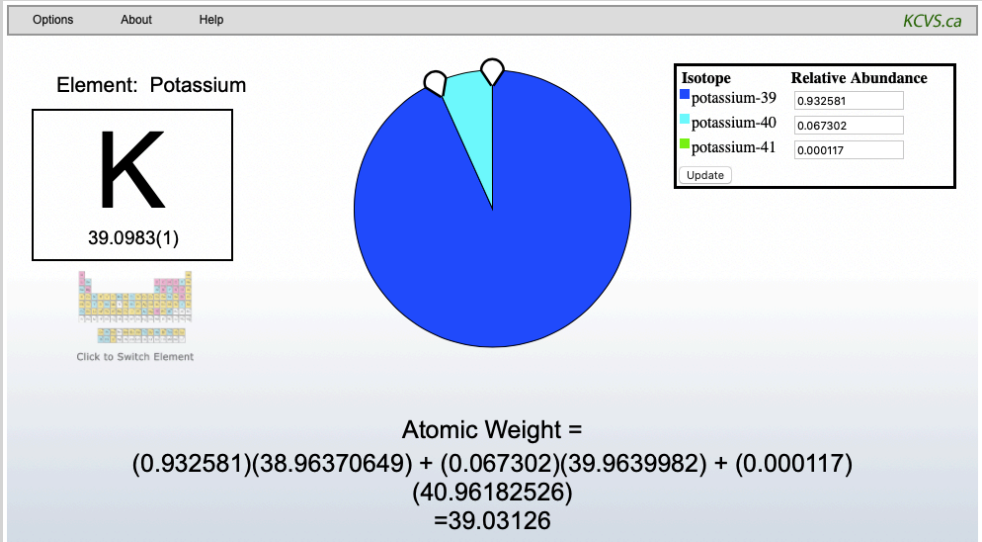
Why is atomic weight important?

- To count by weighing

How are the **atomic weight** values on the periodic table calculated?

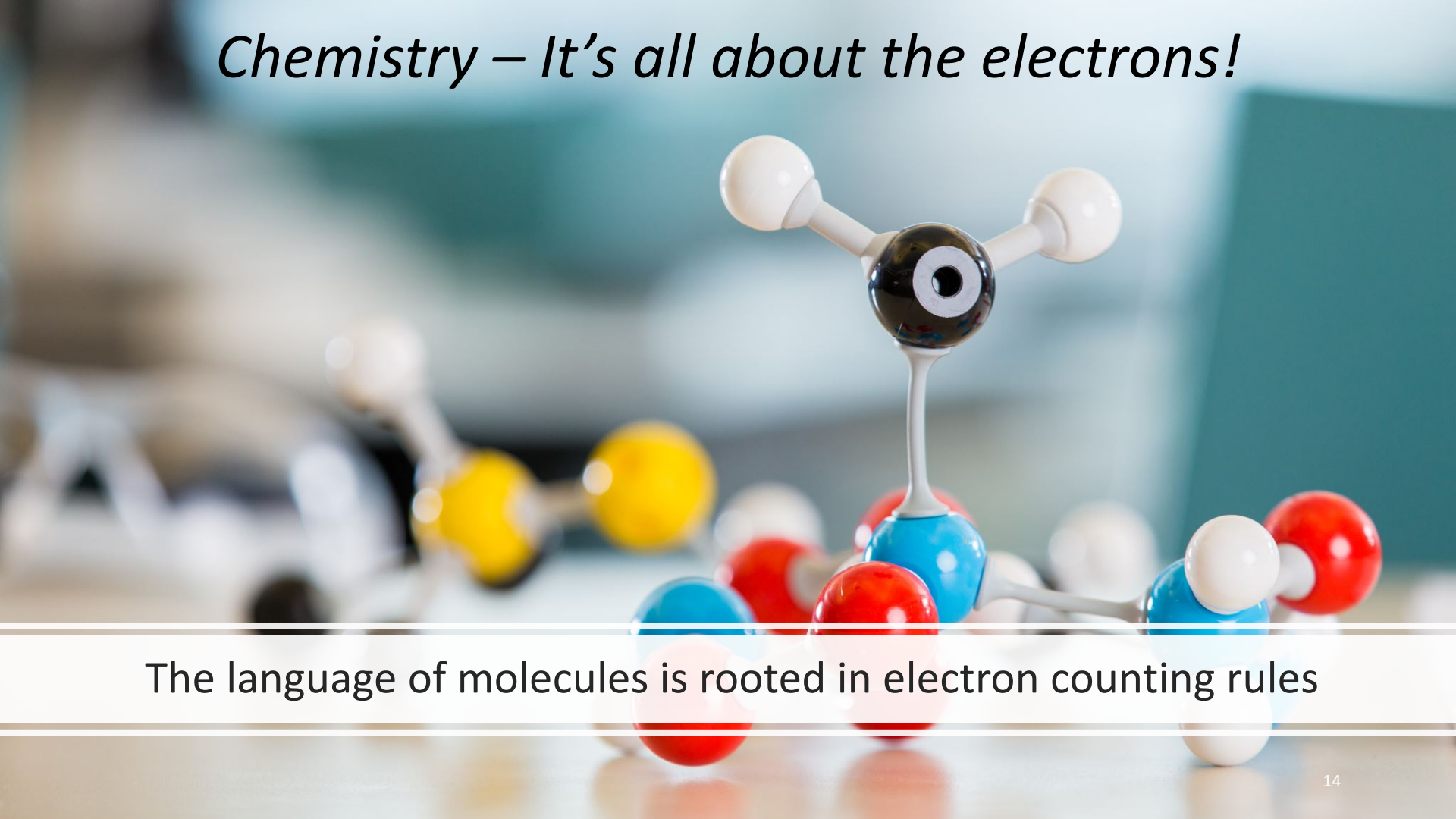
- Isotopes are atoms of the same element with different numbers of neutrons.

- **Atomic weight** of an element takes into account:
  - The **atomic mass** of each isotope in a sample of that element
  - The **relative abundance** of each contributing isotope in the sample



Link to the calculator

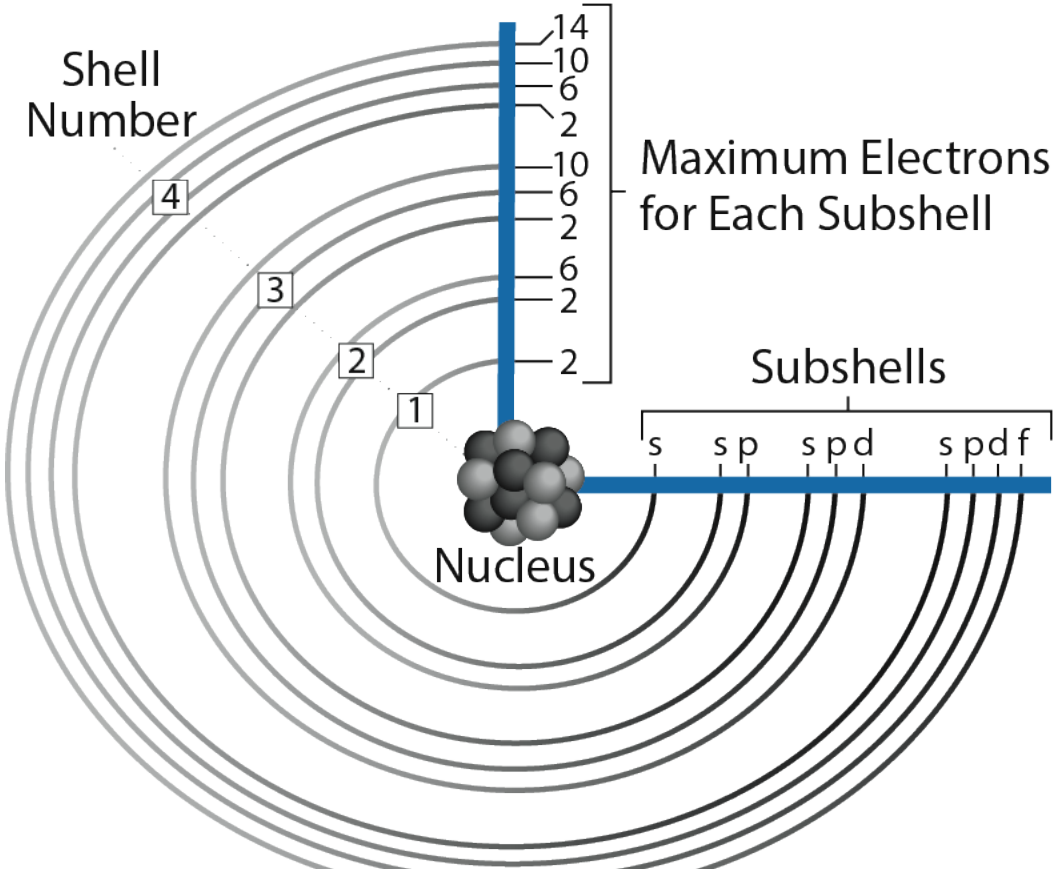
Chemistry – It's all about the electrons!



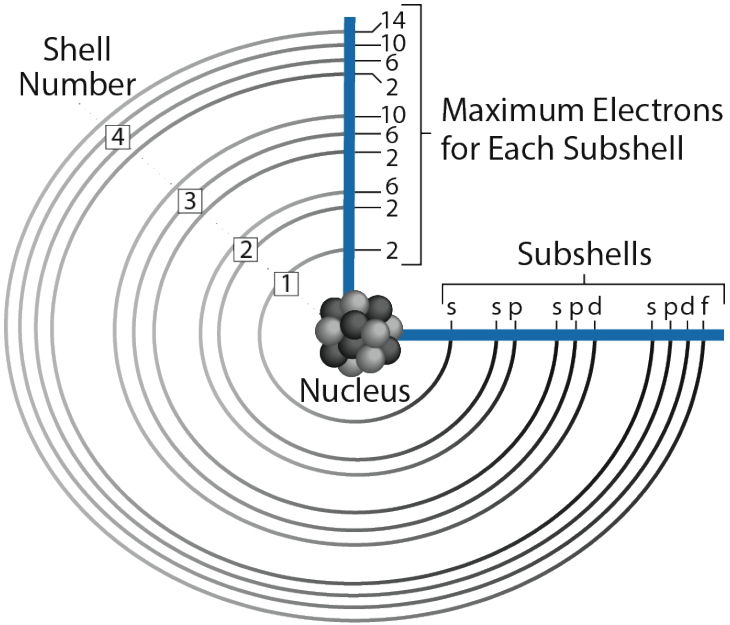
The language of molecules is rooted in electron counting rules

Given…this graphic. It's the primary postulate on which we will base our understanding of molecular structure and bonding. Atoms seek to bond to other atoms in order to fill their electron shells to maximum capacity. Accept this and you will have a conceptual framework to predict the patterns of bonding exhibited by atoms in molecules.

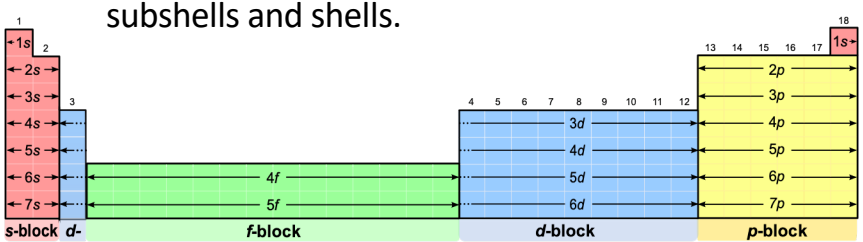
- The shells and their subshells are models to approximate the arrangement of electrons around the nucleus.
- Each subshell has a maximum capacity i.e., an upper limit, as to the number of electrons that it can accommodate.
- A shell's electron capacity is the sum of the maximum capacity of each of its subshell.
- The maximum electron capacity of a shell determines its chemical properties.
- Shell number 2, has a capacity of eight electrons giving rise to the octet rule.
- A shell at capacity is said to be filled.
- Electrons in the outermost shell are valence electrons.
- Electrons in the inner shells are core electrons.
- The chemistry of atoms and molecules is understood by the giving or receiving of electrons (electron sharing) to bring about filled shells.



The periodic table and electron count



The shape of the periodic table follows the order with which electrons are added to subshells and shells.

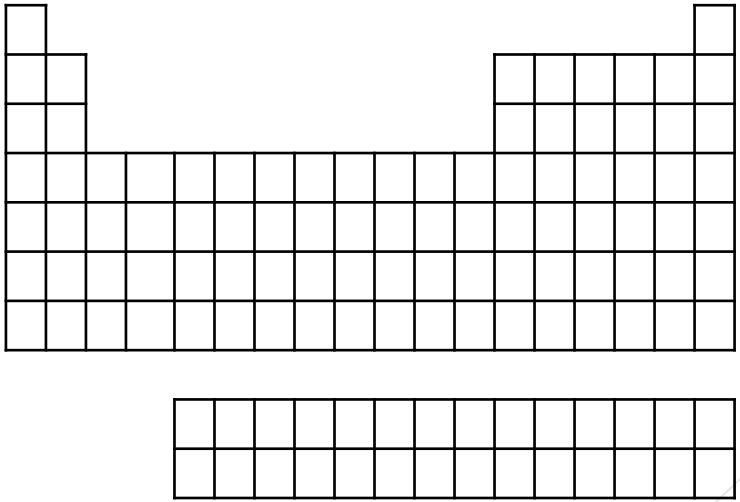


Valency is the combining power of an atom

- Consider an atom in isolation. The outermost electron shell of that atom is known as the valence shell, and the electrons in that shell are called valence electrons.
- The no. of valence electrons (i.e., electron count) determines the atom's ability to bond with other atoms.
- No. core electrons that carbon (C) has: _____
- No. valence electrons that carbon has: _____
- No. electrons to fill carbon's valence shell: ____
- We usually show the valence electrons and ignore the core electrons. Draw the valence electrons around (C).

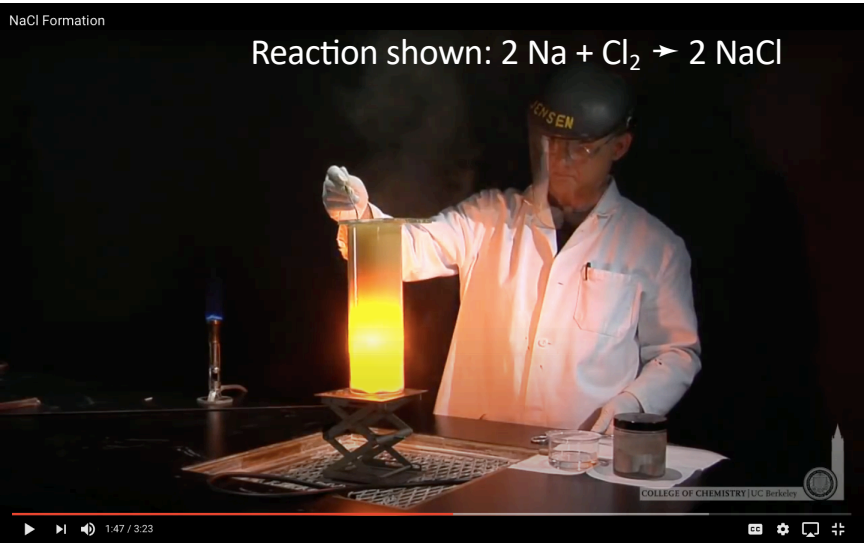
C

For hydrogen through chlorine, indicate the number of valence electrons in the atoms of each element



Transferring electrons to fill shells

Electrons transfer from one atom to another during chemical reactions. In the process, some atoms gain or lose electrons. Electron transfer is favorable when atoms, initially with incomplete shells, attain filled shells. A reaction that is favorable releases energy.



1. Show the valence electrons for sodium and chlorine atoms

Na + **Cl**

↓

NaCl

2. Which atom is the electron donor, and which is the electron acceptor?

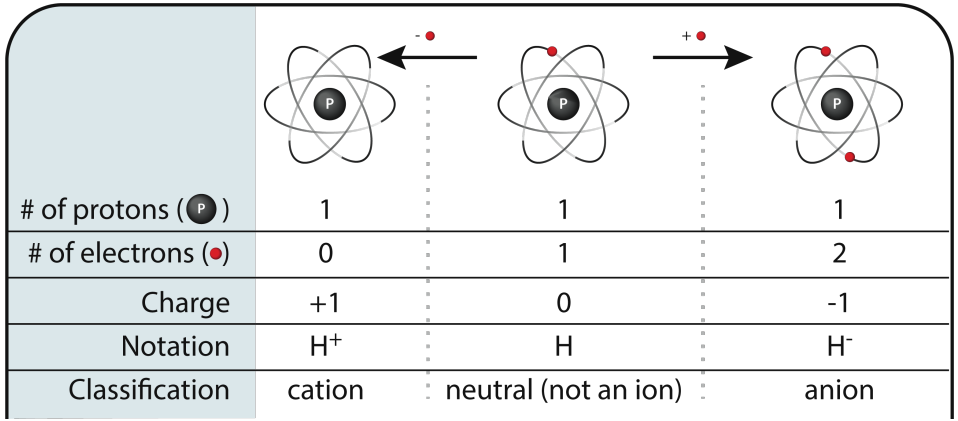
3. Use an arrow to show the electron transfer from the donor to the acceptor

4. Both atoms in NaCl now have filled shells

Chemical reactions are understood as the transfer of electrons from a donor to an acceptor atom

Ions and charge

- Since the electric charge on a proton is equal and opposite to the charge on an electron, the net charge on an ion is equal to the number of protons in the ion minus the number of electrons.
- If the number of electrons is different from the nucleus' electrical charge, such an atom is called an ion.
- Ions are formed by the gain or loss of electrons to an atom’s valence shell.
- An anion (−), from the Greek word, meaning "up", is an ion with more electrons than protons, giving it a net negative charge
- A cation (+), from the Greek word, meaning "down", is an ion with fewer electrons than protons, giving it a positive charge.



# of protons (P)	1	1	1
# of electrons (•)	0	1	2
Charge	+1	0	-1
Notation	H^+	H	H^-
Classification	cation	neutral (not an ion)	anion

Optional Reading

- *The Same and Not the Same* by Roald Hoffmann
- *Organic Chemistry: Principles in Context* by Mark Green
- *Nature's Robots* by Tanford and Reynolds