Introducing....

The chemistry of life

And the periodic table....
Atoms are represented by single spheres. Spheres of the same size and colour represent atoms of the same element.

Molecules are represented by two or more spheres joined together.

Molecules of Elements are represented by two or more spheres of the same size and colour joined together.

Molecules of Compounds are represented by two or more spheres of different sizes and colours joined together.
The radius of a typical atom is one tenth of a billionth of a meter (0.1 nm). A string of atoms one meter (about 3 ft) long contains an atom for every person in the world. A cube of sugar contains as many atoms as there are stars in the Universe.
How big is an atom?

Scale in m:

- $10^{-10}$ m
- $10^{-14}$ m
- $10^{-15}$ m
- $\leq 10^{-18}$ m

• [http://www.pitt.edu/~jdnorton/Goodies/size_atoms/](http://www.pitt.edu/~jdnorton/Goodies/size_atoms/)
• [https://www.youtube.com/watch?v=yQP4UJhNn0I](https://www.youtube.com/watch?v=yQP4UJhNn0I)
How can I see an atom?

• [https://www.quora.com/What-magnification-is-needed-to-see-atoms](https://www.quora.com/What-magnification-is-needed-to-see-atoms)

• [http://motherboard.vice.com/read/this-microscope-can-see-down-to-individual-atoms](http://motherboard.vice.com/read/this-microscope-can-see-down-to-individual-atoms)
What is a proton made of?


![Diagram of quarks and gluons]

- **Quarks**: up (u), down (d), bottom (b), charm (c), top (t)
- **Gluons** are the force carriers for the strong nuclear force.
A quirky proton? NO Quark – 3 of them!

- A **proton** is composed of two **up quarks**, one **down quark**, and the **gluons** that mediate the forces "binding" them together. The **color assignment** of individual quarks is arbitrary, but all three colors must be present.
Atomic Number = the number of protons in the nucleus
Mass Number = the whole number sum of the number of protons and neutrons in the nucleus
Atomic Mass = the mass of the atom weighted across its isotopes
### Periodic Table of Elements

<table>
<thead>
<tr>
<th>1</th>
<th>H</th>
<th>2</th>
<th>He</th>
<th>3</th>
<th>Li</th>
<th>4</th>
<th>Be</th>
<th>5</th>
<th>B</th>
<th>6</th>
<th>C</th>
<th>7</th>
<th>N</th>
<th>8</th>
<th>O</th>
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<td>K</td>
<td>Ca</td>
<td>Sc</td>
<td>Ti</td>
<td>V</td>
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<td>Mercury</td>
<td>Lithium</td>
<td>Beryllium</td>
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<td>Sodium</td>
<td>Aluminium</td>
<td>Silicon</td>
<td>Phosphorus</td>
<td>O</td>
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<td>Potassium</td>
<td>Calcium</td>
<td>Scandium</td>
<td>Titanium</td>
<td>Vanadium</td>
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<td>0</td>
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</tbody>
</table>

For elements with no stable isotopes, the mass number of the isotope with the longest half-life is in parentheses.

Isotopes

Three Isotopes of Hydrogen

1\(^1\)H
Protium

2\(^2\)H
Deuterium

3\(^3\)H
Tritium
Isotopes of carbon

- Carbon
  - 6 Protons
  - 6 Neutrons

- Carbon-13
  - 6 Protons
  - 7 Neutrons

- Carbon-14
  - 6 Protons
  - 8 Neutrons

Number of Neutrons = Atomic Mass – Atomic Number

<table>
<thead>
<tr>
<th>Number of Neutrons</th>
<th>Number of Neutrons</th>
<th>Number of Neutrons</th>
</tr>
</thead>
<tbody>
<tr>
<td>$12 - 6 = 6$</td>
<td>$13 - 6 = 7$</td>
<td>$14 - 6 = 8$</td>
</tr>
<tr>
<td>12</td>
<td>13</td>
<td>14</td>
</tr>
<tr>
<td>$\begin{array}{c} \text{Carbon-12} \ \text{98.9%} \end{array}$</td>
<td>$\begin{array}{c} \text{Carbon-13} \ \text{1.1%} \end{array}$</td>
<td>$\begin{array}{c} \text{Carbon-14} \ \text{&lt;0.0001%} \end{array}$</td>
</tr>
</tbody>
</table>
Isotopes of Carbon

- Carbon-12: stable
- Carbon-13: stable
- Carbon-14: unstable (radioactive)

Key:
- Proton
- Neutron
- Electron
Radioisotopes cont.
Alpha Particles are relatively large and slow. They can't penetrate skin, but if inhaled or ingested, their size and energy can cause more damage than other forms of radiation.

Click on alpha (α), beta (β) or gamma (γ) to learn more.
Ions

This Atom is Neutral
Same number of protons and electrons
- 6 Protons
- 6 Neutrons
- 6 Electrons

This Atom is Negatively Charged
More electrons than protons
- 5 Protons
- 6 Neutrons
- 6 Electrons

This Atom is Positively Charged
More protons than electrons
- 6 Protons
- 6 Neutrons
- 5 Electrons
Cations and anions

Ca^{++} = divalent cation
Na^{+} = monovalent cation

Cl^{-} = monovalent anion
S^{2-} = monovalent cation
Ions...ionic bonds...

A sodium atom: $\text{Na}$

A chloride atom: $\text{Cl}$

A sodium cation: $\text{Na}^+$

A chloride anion: $\text{Cl}^-$

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Practice calculating the number of protons, neutrons, and electrons....

• [http://www.wikihow.com/Find-the-Number-of-Protons,-Neutrons,-and-Electrons](http://www.wikihow.com/Find-the-Number-of-Protons,-Neutrons,-and-Electrons)
### Periodic Table of Elements

<table>
<thead>
<tr>
<th>Periods</th>
<th>Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Atomic number increases

For elements with no stable isotopes, the mass number of the isotope with the longest half-life is in parentheses.
Meet the elements....


SPONCH – 99.9% (BY WEIGHT) MOST LIVING THINGS....
GROUPS...chemical families – share chemical and physical properties.

• Group is referred to by 1\textsuperscript{st} atom in that group.
  – Ex. Group 14 is carbon group

• Metals vs. nonmetals

• 4 special groups we will focus on
  – 1: Alkali metals
  – 2: Alkaline Earth metals
  – 17 (or 7): Halogens
  – 18 (or 8): Nobel gases
4 main groups...

1: Alkali metals
- hydrogen – exception
- Malleable and ductile
- Low mps, very reactive with air and \( \text{H}_2\text{O} \)

2: Alkaline Earth metals
- Metal but not as reactive
- 2 valence e\(^-\) (can be lost, form cation)

17: Halogens
- Nonmetal
- Noticeable color (intensity inc. as go down)
- Reactive (disinfectant)
- Gain e\(^-\), form anion
- Mp go up as go down

18: Nobel gases
- Exist on their own
- Stable
- Valence shell is full
- Does not bond with anything
- Naturally exist, colorless gas
- Glow with bright colors if electric current passed thru them
Chemical bonds

(a) Nonpolar covalent bond
Bonding electrons shared equally between two atoms. No charges on atoms.

(b) Polar covalent bond
Bonding electrons shared unequally between two atoms. Partial charges on atoms.

(c) Ionic bond
Complete transfer of one or more valence electrons. Full charges on resulting ions.

https://www.youtube.com/watch?v=QIfTT-__xLo
The chemical bond song!!
https://www.youtube.com/watch?v=7DjsD7Hcd9U
Chemical bonds – may the force be with you!
Types of Chemical Bonds

- From Strongest to Weakest:
  - Covalent
  - Ionic
  - Hydrogen
  - van der Walls = hydrophobic
Cosmogenic origin of each element

<table>
<thead>
<tr>
<th>Element</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>Cosmic rays</td>
</tr>
<tr>
<td>N</td>
<td>Large stars</td>
</tr>
<tr>
<td>Be</td>
<td>Big Bang</td>
</tr>
<tr>
<td>O</td>
<td>Supernovae</td>
</tr>
<tr>
<td>Na</td>
<td>Small stars</td>
</tr>
<tr>
<td>Mg</td>
<td>Man-made</td>
</tr>
</tbody>
</table>

The periodic table shows the cosmogenic origin of each element.
<table>
<thead>
<tr>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
<th>VII</th>
<th>0</th>
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<tbody>
<tr>
<td>H</td>
<td></td>
<td>B</td>
<td>C</td>
<td>N</td>
<td>O</td>
<td>F</td>
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<td>Li</td>
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<td>Mg</td>
<td>Ga</td>
<td>Ge</td>
<td>As</td>
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<tr>
<td>K</td>
<td>Ca</td>
<td>In</td>
<td>Sn</td>
<td>Sb</td>
<td>Te</td>
<td>I</td>
<td>Xe</td>
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<td>Bi</td>
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<td>Rn</td>
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<tr>
<td>Cs</td>
<td>Ba</td>
<td></td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

- **Metal**: Blue
- **Metalloid**: Light Green
- **Nonmetal**: Yellow
<table>
<thead>
<tr>
<th>Family</th>
<th># Covalent Bonds*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Halogens</strong></td>
<td></td>
</tr>
<tr>
<td>F, Br, Cl, I</td>
<td>1 bond often</td>
</tr>
<tr>
<td><strong>Calcogens</strong></td>
<td></td>
</tr>
<tr>
<td>O, S</td>
<td>2 bond often</td>
</tr>
<tr>
<td><strong>Nitrogen</strong></td>
<td></td>
</tr>
<tr>
<td>N, P</td>
<td>3 bond often</td>
</tr>
<tr>
<td><strong>Carbon</strong></td>
<td></td>
</tr>
<tr>
<td>C, Si</td>
<td>4 bond always</td>
</tr>
</tbody>
</table>
Ion typically formed

1+ 2+

1 2

Na Mg Li Be

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 Hf Ta W Re Os Ir Pt Au Hg Ti Pb Bi Po At Rn

3+ 4– 3– 2– 1– 0

He

B C N O F Ne Ar

Al Si P S Cl Ar

Ga Ge As Se Br Kr

In Sn Sb Te I Xe

Ti Pb Bi Po At Rn

Fr Ra Ac Rf Db Sg Bh Hs Mt Uun Uuu Uub

= Weak nuclear attraction for valence electrons; tendency to form positive ions

= Strong nuclear attraction for valence electrons; tendency to form negative ions

= Strong nuclear attraction for valence electrons but valence shell is already filled; no tendency to form ions of either type

From Conceptual Chemistry, Second Edition by John Suchocki. Copyright © 2004 Benjamin Cummings, a division of Pearson Education.
Milk Experiment:

Part 1.

Step 1: pour whole milk into bowl or plate, about ¼” thick. Let milk settle.

Step 2: Add one drop of each color food coloring to the milk.

Step 3: touch the tip of the cotton swab to the center of the milk. Don’t swirl or mix, just touch the milk.

What do you think will happen?
**Milk Experiment:**

**Part 2.** (can skip steps 1-3 and go to step 4 and reuse milk from above)

**Step 1:** pour milk into bowl or plate, about ¼” thick. Let milk settle.

**Step 2:** Add one drop of each color food coloring to the milk.

**Step 3:** touch the tip of the cotton swab to the center of the milk. Don’t swirl or mix, just touch the milk. Hold it there for 10-15 seconds.

**Step 4:** Place a drop of liquid dish soap on the end of the cotton swab and then touch the tip of the cotton swab to the center of the milk. Don’t swirl or mix, just touch the milk.

What do you think will happen?

Was it the same or different? Why...what is happening??
Milk Experiment:

Repeat step 4. (q-tip with soap inserted into milk)

What happens this time?

Was it the same or different? Why...what is happening??

Repeat part 2 with skim milk.

What do you think will happen?

Was it the same or different? Why...what is happening??