

General Chemistry

Introduction

Imagine a world where chemistry didn't exist - actually, that would be quite impossible! Soon you will learn why. This week we are going to discuss the basics of chemistry, which is the study of matter and its reactions. **Matter** is anything that takes up space, and you may have learned that the three main types of matter are solids, liquids, and gases. On a microscopic level, everything around you on this planet is engaging in some type of chemical activity. The water you have poured into a glass? Each water molecule is engaging in hydrogen bonding. The eggs you may have had for breakfast? They require a minimum temperature to cook properly due to its chemical structure. The search and development for a working COVID-19 vaccine? Also would not be possible without chemistry. All in all, life would not exist without the proper understanding of all these different chemical properties and structures!

Everything on this planet, including you, is made up of **atoms**, which are the smallest and most basic unit of life that retain the properties of the various elements. Each atom is made up of three sub particles: **electrons, protons, and neutrons**. Electrons have a negative charge, protons have a positive charge, and neutrons have no charge. We will apply these terms later in this week's newsletter activity. These sub particles end up defining the unique characteristics of the elements you find on the periodic table. These elements can engage in all types of reactions to form **compounds**, which is a substance made up of two or more elements. The salt you have in the pantry? That would be an example of a compound, as it combines sodium and chloride!

Overall, chemistry is a broad subject that can be broken down further into subcategories like **organic, inorganic, medicinal, physical, analytical, and biochemistry**. There is also a branch of chemistry called **chemical engineering**, which focuses on chemical production and the manufacturing of products through chemical processes, including designing equipment and processes for refining raw materials and for compounding chemicals to make valuable products. Research in chemistry is an ongoing process, and new elements are being added to the periodic to this day! Fun fact - the element Californium (Cf) is named after its discovery at the University of California Radiation Lab.

Northeastern Connections

Faculty Connection



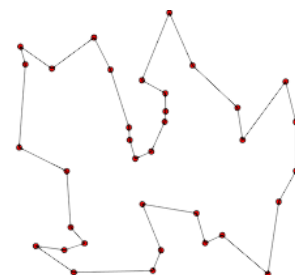
Dr. Michael Pollastri is a professor in the Department of Chemistry and Chemical Biology, with a specific background in organic chemistry. While this newsletter discusses the basics of general chemistry, **organic chemistry** is an important branch of this subject area, dealing with structure and properties of compounds that contain the element carbon. Carbon is an essential element for all life on earth! Organic compounds can exist as carbohydrates (like starches and sugars), lipids, proteins, and other forms.

Professor Pollastri currently serves as a research leader regarding drug discovery for neglected tropical diseases (diseases that thrive in hot, humid conditions), including human African trypanosomiasis, Chagas disease, and leishmaniasis. Tropical diseases affect billions of people every year, but unfortunately there are not many solutions available. His research incorporates another branch of chemistry - **medicinal chemistry**. This branch deals is an intersection between organic chemistry and pharmacology, which is a subset of medicine dealing with the use and effect of drugs. The goal of his research is to discover high quality, biological targets in parasites mirror the appropriate biological targets in humans. Then, he uses historical drug discovery efforts to discover new compounds (known as a lead) to combat parasite activity. Due to the presence of certain enzymes in parasites like *Trypanosoma brucei*, *Trypanosoma cruzi*, *Leishmania sp.*, and *Plasmodium falciparum*, Dr. Pollastri is focused on repurposing inhibitors that target these druggable enzyme families. From there, he hopes to collaborate with organizations specializing in clinical trial development in this area. You can learn more about his research [here](#) through his laboratory website!

Do Now: Chemical Reactions

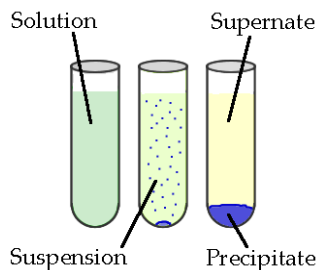
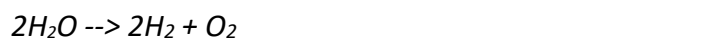
Chemistry is all about reactions, and there are six main types of reactions:

- ❖ **Combination Reaction** (Synthesis) - elements combine to give a new compound
- ❖ **Decomposition Reaction** - a compound is broken down into its elements
- ❖ **Substitution Reaction** (Single Replacement) - an atom or (group of atoms) is replaced by another atom (or group of atoms)



- ❖ **Precipitation Reaction** (Double Replacement) - a solid compound is formed when two soluble solutions are mixed
- ❖ **Acid-Base Reaction** (Neutralization) - an acid and base react to form salt and water
- ❖ **Reduction-Oxidation Reaction** (Redox) - when electron transfer occurs

Now that you have read about the different reactions seen in chemistry, let's apply them! In this brief exercise, match each reaction or image to its corresponding type from above. Note: each reaction will only be used once.



Activity: Periodic Table Puzzle

The periodic table is a chart depicting the chemical elements, and they are grouped by their properties. Each column is called a **group**, and each row is referred to as a **period**. **Cations**

(elements with a positive charge) are found on the left, whereas **anions** (elements with a negative charge) are found on the right side. The number above an element on the periodic table is its **atomic number**, or number of **protons**. There are also various **periodic trends** that are important to discuss.

Here are a few:

- 1) **Atomic radius**, or the size of the atom, increases as you go left and down the periodic table.
- 2) **Electronegativity**, or, an atom's desire for electrons increases as you go up and to the right of the periodic table. Anions are typically electronegative atoms!
- 3) **Metallic character** increases as you go towards the left; non-metallic character increases as you move towards the right.

Now let's get into the activity!

Materials Needed:

- The "periodic table" below and a pen or pencil
- A [periodic table](#) for reference

Steps:

- In this activity, the letters A-R are randomly used as symbols for the first 18 representative elements.

- Based on the clues below, assign each letter to its proper position on the blank periodic chart provided. Keep in mind the previously discussed rules and trends!

A has less electronegativity compared to F

B has a +4 charge and is involved in organic compounds

C would like to gain one more electron and is the most electronegative atom

D has ONE proton

E forms a cation with a +1 charge; also goes well with pepper when reacted with chloride

F is found in group 3A

G is a metalloid (has properties between a metal and non-metal)

H has a full valency (set of electrons)

I forms an anion with a -3 charge

J has a smaller atomic radius than M and is found in the same period

K forms a cation and is found in batteries

L also forms a cation, but has a smaller atomic radius than K

M has fifteen protons

N forms a +2 charge

O has nonmetallic character and is less electronegative than C

P is a very important element that you breathe in!

Q is a noble gas; think LIGHTS!

R is another noble gas with a full set of electrons

Discussion Questions:

- Elements in the same group of a periodic table have what in common?
- What types of elements are typically reactive? Non-reactive?
 - Why would an element want to lose or gain an electron?
- Ionization energy is defined as the energy required to remove an electron. Based on this, what do you think the trend for ionization energy looks like on the periodic table?
- Fun fact, the only letter not found on the periodic table is 'J.' But why?

Share Your Results

We'd love to know how the activity and/or the "do now" turned out! What worked and what didn't work? Please share with us something you learned and/or send us pictures! Email us at stem@northeastern.edu.

Related links/Extensions

- [Chemical Reactions in Action \(10 min video\)](#)
- [Chemical Reactions in the Kitchen \(4 min video\)](#)
- [Chemistry for Kids \(Online Games\)](#)
- [Khan Academy: Chemistry](#)
- [Mr. Nussbaum's Periodic Table Activities](#)
- [American Chemical Society Interactive Content](#)