What is Chemistry?

Unit: Chemistry

NGSS Standards/MA Curriculum Frameworks (2016): N/A

Mastery Objective(s): (Students will be able to…)

- Explain what chemistry is and what is studied in different branches of chemistry.

Success Criteria:

- Explanation describes what is studied in each of the branches of study described in this section.

Tier 2 Vocabulary: matter

Language Objectives:

- Understand and correctly use terms relating to each branch of chemistry.

Summary of Concepts:

chemistry: the study of the "stuff" that everything is made of (matter), including:

- Properties of matter
- How matter can be changed through "chemical reactions", changing one substance into another.
- The energy needed or the energy released when chemical reactions happen.

Chemistry can be challenging to learn (and to teach) for a variety of reasons.

Notes:

matter: the "stuff" that everything is made of. Matter is anything that has mass and takes up space (has volume).

chemistry: the study of matter, its properties, how it behaves, how it's put together, and how it can be changed or rearranged .

chemical: a specific substance (regardless of size or shape) that has a specific arrangement of the atoms that it's made of, and has specific properties because of that arrangement.

chemical reaction: what happens if we put chemicals (substances) together and their atoms switch around to make new chemicals (substances).

Use this space for summary and/or additional notes:

The major units we will study this year include:

- **macroscopic properties of matter**
  - solids & liquids
  - gases
  - when a change is or is not caused by a chemical reaction
- **atoms**
  - what they're made of (protons, neutrons & electrons)
  - history of our understanding of atoms
  - what properties they have (periodic table and periodic properties)
- **chemicals**
  - how atoms combine
  - how the names tell us what's they're made of
  - the shapes of the molecules or crystals (bonding and molecular geometry)
  - how the shapes affect the properties they have
  - dissolving in water (solutions) and forces between molecules
- **chemical reactions**
  - different ways atoms can rearrange (chemical reactions & equations)
  - calculating how much of the reactants you use and products you make (stoichiometry)
  - heat (energy) produced (or consumed) by chemical reactions
  - how fast chemicals react (kinetics)
  - the extent of how much chemicals react (equilibrium)
  - acids & bases

Branches of Chemistry

The study of chemistry is divided into different branches, including:

organic chemistry: the study of chemicals and reactions involving molecules that contain carbon and hydrogen.

inorganic chemistry: the study of chemicals and reactions involving molecules that do not contain both carbon and hydrogen.

biochemistry: the study of chemicals that play important roles in biological processes, such as amino acids, lipids, and sugars.

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physical chemistry: the study of energy changes in chemistry. Some sub-fields include thermodynamics (the study of heat energy), statistical mechanics (the study of molecular collisions and momentum), and quantum mechanics (the study of discrete energy changes at the sub-atomic level).

analytical chemistry: quantitative aspects of chemistry, such as determining what a chemical is made of, how much of it reacts under certain conditions, *etc.*

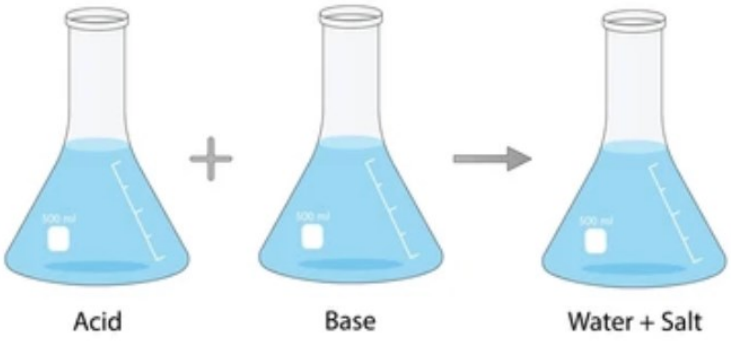
green chemistry: the study of making decisions about how chemicals are made or used in order to reduce the impact on the environment.

What Makes Chemistry Hard to Learn?

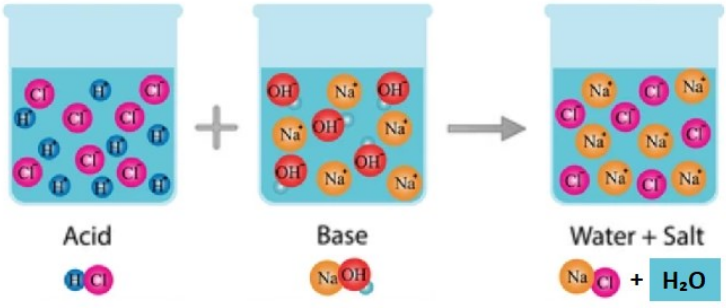
The biggest problem with learning chemistry is that the things that make chemical reactions happen—the atoms getting rearranged—is too small to see. Atoms are 1000 times smaller than waves of visible light, so it's actually impossible to see the atoms.

For example, if we mixed equal amounts and concentrations of a strong acid and a strong base together:

What We Would See



How We Would Represent It



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In the lab, it would look like we mixed two clear liquids together and nothing happened. This is because we can't see that:

- The first flask has a strong acid dissolved in it.
- The second flask has a strong base dissolved in it.
- When we mix the two chemicals together, the acid reacts with the base to form a salt (which stays dissolved in the water).

However:

- If someone drank the liquid in the first flask, the acid might dissolve their gut lining and they would probably die.
- If someone drank the liquid in the second flask, the base would poison them and they would probably die.
- If someone drank the liquid in the third flask, the mixture would taste salty, but they would be fine.

In the second picture, which shows circles that represent the atoms and molecules of acid and base, we can see that the way that the atoms/molecules are arranged has changed.

Everything you learn this year will be about relating what happens with the individual atoms *vs.* what we need to do to observe it.

How Much Math Does Chemistry Require?

One concern that many high school students have is being able to do the math that is needed for chemistry. Any question that asks "how much" will require math, but the extent of the math depends on the level at which you are studying what happens.

"On-level" (CP1) Chemistry: ideally requires algebra 1, but most of it can be done using middle school math (ratios & proportions).

AP® and Honors Chemistry: requires algebra 1, algebra 2 and a little bit of precalculus.

College Chemistry: requires algebra 1, algebra 2, precalculus, and calculus.

While I will do my best to review the math required, you need to *be proactive* and *ask for help whenever you need it*.[*] As the teacher, I promise to give you whatever help you need, as long as you are able to make the time to get it (usually by coming after school for extra help).

[*] Even if you are still learning English and it is hard to ask, *it is important that you do so anyway*. I promise that I will always be patient with you and do whatever I can to get the chemistry to make sense.

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What Makes Chemistry Hard to Teach?

First of all, teaching any math-based subject at the high school level is challenging, because students' ability to understand and use math is so widely varied.

Second, it requires explaining what the atoms are doing and how it relates to what we can observe, so everything need to be explained in at least two different ways. Because we can't observe atoms, we model what they look like. Different ways of representing concepts make different amounts of sense to different students.

Third, most of the time when chemicals are put in contact with each other, nothing happens. (This is a good thing. Imagine if every time you sat in a chair, it could get burning hot, dissolve your pants, or explode.) If something does happen, the result could be toxic or dangerous.

Even if a chemical reaction happens that can be safely observed in the classroom, the amounts of each chemical, the temperature, and how the chemicals are mixed affects whether or not something happens and whether or not we will be able to observe or measure it. This means that when we perform experiments, it will be important to follow directions and work carefully, because if you don't do these things the result could be boring, unsafe, or both!

The Problem With Using Calculators, PhotoMath, Desmos, AI, *etc.*

In your previous math and science classes where you were graded based on whether or not your answers were correct, you probably used "black box" technology—software and hardware tools that generate the answers to problems for you. However, the purpose of studying these topics in school is for you to understand them yourself.

If you give a three-year-old a hammer, the child will almost certainly break things with it, and will probably hurt himself or others in the process; it is unlikely that the child will learn how to use a hammer effectively in the way that it is intended to be used. The same is true with math-related software tools:

- If you only ever did multiplication and division problems on a calculator, it made algebra much harder, because you couldn't immediately see where each step of a problem was going.
- If you only ever solved algebra problems using PhotoMath, it prevented you from learning which procedures apply to which problems, making it quite difficult to look at a problem and know how to solve it.
- If you only ever plotted graphs using Desmos, it prevented you from seeing a graph as anything other than a picture that somehow represents an equation.

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- If you only ever solved word problems using artificial intelligence (AI), it prevented you from learning the process of identifying what a problem is asking and how to systematically work out the answer.

Tools are great, but only to the extent that they make it more convenient to use the intelligence that you have already acquired. ***If you continually use tools in ways that prevent you from acquiring intelligence, you will never acquire the intelligence.***

Note also that in chemistry problems, finding the "correct" answer to a specific problem is never the ultimate goal. Learning the *process* that you need to use to solve problems is the goal; the answers to problems are simply a convenient way to check how well you have learned the process. ***If you have a homework paper (or even a test) full of correct answers that you don't understand, you have failed the course, regardless of the grade that you receive.***

This means that, as mentioned above, you need to *be proactive* and *ask for help whenever you need it*. As the teacher, I promise to give you whatever help you need, as long as you are able to make the time to get it (usually by coming after school for extra help).

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