Lesson Title	What *is* Chemistry, anyway?
Length of Lesson	1 hour 15 min
Created By	Chris Ruhs
Subject	Chemistry
Grade Level	10-12th Grade
State Standards	Chemistry 1: 1c,d,; Underpins 7;
DOK Level	DOK 2
DOK Application	Use concepts to infer, classify, and explain differences in physical and chemical properties/changes.
National Standards	9-12: B (Physical Science)
Graduate Research Element	Discussion of tools I use in my research that help measure different chemical and physical properties of matter.

Student Learning Goal:
MS 9-12th Grade:
1 (c) Define chemistry and matter. *Lecture will rely on the definitions of chemistry and matter to point out chemical and physical properties as well as chemical and physical changes.* (d) Apply the language of chemistry appropriately including terms such as element, atom, compound, and molecule. *The language of chemistry will be important for distinguishing chemical properties and changes from physical ones* .
7 Interpret chemical change in terms of chemical reactions. *All concepts in Standard 7 are underpinned by an understanding of chemical properties and changes.*

National Science Education Standards of Content 9-12:
B: Physical Science: Structure of atoms. Structure and properties of matter. Chemical reactions. Motion and forces. Interactions of energy and matter. *Students will understand the distinction we make between physical and chemical properties/changes and therefore need to understand what makes up an atom, how atoms deal with energy, and how this produces physical and chemical changes and reflects physical and chemical properties..*

Materials Needed (supplies, hand-outs, resources):
Scenario Cards, 2 Label Cards, 2 Goosh Balls (or any item that can be easily grabbed).

Lesson Performance Task/Assessment:
Formative: we will have an opening discussion on physical and chemical properties/changes, we will discuss different measurement and observational instruments used to detect these properties/changes, and we will have a closing teacher-guided, student-lead summary discussion.

Summative: we will have a team game with a point system, students will list physical and chemical properties cars and kitchens, there will be questions on a test at a later date.

Lesson Relevance to Performance Task and Students:
Students will be taught the difference between chemical and physical properties/changes in lecture.

Students will be able to discover chemical and physical changes in everyday life by listing physical and chemical changes associated with vehicles and kitchens (two places where many changes take place, and which appeal to both genders).

Students will be able to transfer the knowledge covered in the lecture portion of this lesson plan to scenarios and questions regarding physical and chemical properties that have not been discussed. To do so, they will be divided into two teams, where one member of each team will approach a central desk. The students challenging each other at this desk will be given a scenario or a property simultaneously (read aloud), and the students must then grab the appropriate ball (or other easily grabbable item), which will be labeled "chemical" or "physical". Their choice will indicate their decision of whether they think the scenario or property given is of a chemical nature or of a physical nature. If a student grabs the wrong ball, they are disqualified. If they go after the same ball, and it is correct, then the student who gets it first will get the opportunity to explain why their choice is correct. If their explanation is also correct, then they win a point. If their explanation is incorrect, then the opportunity to explain goes to the challenger, who is then able to gain a point by providing the correct explanation. In this way, the entire class will work through many examples of chemical and physical properties in a fun and challenging way, they will build teamwork skills, and they build speaking and explanatory impromptu skills (a valuable ability in the scientific and business arenas).

Anticipatory Set/Capture Interest:
This lesson plan will include a discussion on the idea of a "chemical property" is in fact arbitrary, since all properties are ultimately a product of physical realities, though the distinction is useful for understanding the focus of the class. The game will also serve to capture interest.

Guided Practice:
Students will be taught the difference between chemical and physical properties according to the textbook definition.

We will discuss different instruments used to detect physical and chemical changes (eyes, thermometers, voltmeters, probes, GC-MS, pH, etc.)

Independent Practice:
Students will list all the physical and chemical changes they can think of involving the use of an automobile or a kitchen (chosen to appeal to guys and girls, though students can pick which one they want: guys don't have to do cars and girls don't have to do kitchens).

Students will apply the understandings in a "Jeopardy" style team game.

Remediation and/or Enrichment:
Remediation:
Individual IEP

Enrichment: Students will be given a published research paper involving biogeochemistry and asked to identify all the physical and chemical changes studied and/or measured in the experiments.

Check(s) for Understanding:
Do chemical properties actually exist?
Is every change a physical change?
Is every change a chemical change?
Why do we use the distinction?

Closure:
A student-lead, teacher-guided summary discussion will bring closure to the lesson plan.

Possible Alternate Subject Integrations:
Physics could use this lesson plan as an introduction to material and how it relates to chemistry.
Biology could use this lesson plan to integrate biological changes with chemical changes and physical changes, even though every biological change is ultimately a physical change, and if humans had the time, could be explained by the plethora of physical realities involved (this is usually avoided because it is not often useful to think of biology in terms of physics, though on occasion we find out that biology is using a physical phenomenon for some benefit, eg., both geese and plants use quantum physics, geese to "see" the magnetic field lines of the earth for navigation, plants for achieving high efficiency in photosynthesis).

Teacher Notes:
A "chemical change" is usually explained as an observable change in the nature of some material, but is more precisely explained as a change in the electronic environment of the atoms of some material. Interestingly, this change in the electronic environment always takes place because of the material's natural, physical penchant to move from a relatively unstable state to a relatively stable state where possible, according to the energy available

and the forces at play. This entropic change in state can *always* be explained using physical laws and phenomena, and therefore does not need an arbitrary “chemical change” category placed on it. As such, all changes in material are always physical, though not all physical changes are considered “chemical changes”; further, chemical changes are discussed in “chemical terms” at this level, without discussing the underpinning physical realities that produce those “chemical phenomena”. For instance, we say that because acetone reacts with oxygen to make carbon dioxide and water, the nature of these materials is observably changed, electrons have moved, bonds have been broken, and new bonds have been made. This all makes sense “chemically”, but ignores the physical realities that underpin the ideas of matter, bonds, reaction energy, potential energy, and electron excitement. These physical realities are glossed over and assumed by chemistry teachers in favor of simpler chemical terminology, even though the physical changes taking place are the only actual changes taking place. The label “chemical change” does not have any real value in the physical world. *However*, it is of value for students, in order to get them thinking along the lines of what we intend to study in chemistry class, to help them make this distinction for the purposes of learning, even though the distinction does not actually exist in reality, nor is it used by professionals anywhere accept for in communicating ideas that are easier communicated using chemical terminology over physical terminology. It is always easier to say that two chemicals have “reacted chemically”, than to explain the physics involved, the role played by each subatomic particle, the forces at work, and the energy stored/released. The danger lies in the fact that simplified chemical terminology does not always capture the complexity of reality, and many times the phenomenon being explained lies in the “grey” area of our chemical understandings. For instance, chromatography separates mixtures into chemically similar groupings. This separation is physical, but exacts a chemical separation. Or take solutions for an example: the ionic bonds of a salt crystal, negative to positive, are broken and rearranged so that the polar ends of each water molecule “mediates” the attractive forces. This is considered by many to be merely a physical change, because the change is easily reversible by evaporating the water. However, if the specific sodium and chloride ions were radioactively tagged, one would observe that a radioactive sodium ion would break from its radioactive chloride ion pair upon solvation and reform with a completely different chloride ion upon crystallization. An ionic bond is broken and a new ionic bond was formed—yet it is still arbitrarily considered a physical change.