Exploring Elements Using Legos

---------Example of a Science Lesson Based on the NGSS Framework----------

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Current Arkansas Framework:
http://arkansased.org/educators/curriculum/frameworks.html#science

PS.5.7.1- Explain how a small number of naturally-occurring elements can result in the large variety of substances found in the world
PS 5.7.3-Identify compounds as substances consisting of two or more elements chemically combined
PS 5.7.4- Compare and contrast properties of compounds to those of the elements that compose them.
-salt: sodium, chlorine
-water: hydrogen, oxygen
-carbon dioxide: carbon, oxygen

Next Generation Science Standard: (Insert after NGSS are released.)

Strand: (Insert after NGSS are released.)

Essential Questions: (Correct/Complete after NGSS are released.)

Science/Engineering Practices 1-8:

Disciplinary Core Ideas (Insert after NGSS are released):
1. Asking Questions & Defining Problems (54, 69)
2. Developing and Using Models (56, 71)
3. Planning and Carrying Out Investigations (59, 74)
4. Analyzing and Interpreting Data (61, 76)
6. Constructing Explanations and Designing Solutions (67, 82)
7. Engaging in Argument from Evidence (71, 86)
8. Obtaining, Evaluating, and Communicating Information (74, 89)

Crosscutting Concepts (1-7):
A. Patterns (85, 100)
B. Cause and effect (87, 102)
D. Systems and system models (91, 106)
E. Energy and matter (94, 109)
F. Structure and function (96, 111)
G. Stability and change (98, 113)

Core Idea with Essential Question: (from Framework for K-12 Science. Insert more specific NGSS after released.)

Physical Sciences: PS1.A: Structure and Properties of Matter

Grade Level End-point (from Framework for K-12 Science):
All substances are made from some 100 different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. Pure substances are made from a single type of atom or molecule; each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.
Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. In a liquid, the molecules are constantly in contact with other; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations. Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g. crystals). The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter (Boundary: Predictions here are qualitative, not quantitative.)

Summary:

- All substances are made from 100 different types of atoms
- Atoms form molecules
- We can identify different substances by their unique physical and chemical properties
- Gases and liquid atoms are in constant motion and collide with each other with gases wider spaced and liquid colliding more often.
- Solids atoms vibrate but do not change relative location.
- Changes in temperature and pressure cause changes of states of matter, which can be predicate using models.

Class Time: 120 Minutes

Key Vocabulary Terms: elements, molecule, compounds, chemical properties, physical properties

Materials: (HINT: Each Lego represents one atom. Each color represents one element type.)

color	# of pegs	quantity
white	1	10
black	8	8
red	6	6
blue	4	6
green	2	5
yellow	4	5

- **NOTE:** The pegs on the Legos DO NOT represent the actual number of element bonds. Bonds are not taught at this grade level, and the instruction/activity is showing that elemental atoms combine to form compounds. The activity also shows that there are numerous ways to combine atoms, representing a different new compound based on the elements combined and the combination order.

Teacher Preparation:

- Gather Legos
- Print handouts

BACKGROUND INFORMATION

Atoms are the smallest bits of ordinary matter and are made from particles called protons (which carry a positive electrical charge), neutrons (which carry no electrical charge) and electrons (which carry a negative electrical charge). The protons and neutrons cluster together in the central part of the atom, called the nucleus, and the electrons 'orbit' the nucleus. A particular atom will have the same number of protons and electrons and most atoms have at least as many neutrons as protons.

An element is a substance that is made entirely from one type of atom. For example, the element hydrogen is made from atoms containing just one proton and one electron. If you had very, very good eyes and could look at the atoms in a sample of hydrogen, you would notice that most of the atoms have no neutrons, some of them have one neutron and a few of them have two neutrons. These different versions of hydrogen are called isotopes. All isotopes of a particular element have the same number of protons, but can have different numbers of neutrons. If you change the number of protons an atom has, you change the type of element it is. If you change the number of neutrons an atom has, you make an isotope of that element. All known elements are arranged on a chart called the Periodic Table of Elements.

A compound is a substance made from two or more different elements that have been chemically joined. Some examples of compounds are water (H_2O), table salt (NaCl), table sugar ($C_{12}H_{22}O_{11}$) and chalk ($CaCO_3$).

A mixture is a substance made by combining two or more different materials in such a way that no chemical reaction occurs. A mixture can usually be separated back into its

original components. Some examples of mixtures are a tossed salad, salt water and a mixed bag of M&M's candy.

A molecule is formed when two or more atoms join together chemically. A compound is a molecule that contains at least two different elements. All compounds are molecules but not all molecules are compounds.

Molecular hydrogen (H_2), molecular oxygen (O_2) and molecular nitrogen (N_2) are not compounds because each is composed of a single element. Water (H_2O), carbon dioxide (CO_2) and methane (CH_4) are compounds because each is made from more than one element. The smallest bit of each of these substances would be referred to as a molecule. For example, a single molecule of molecular hydrogen is made from two atoms of hydrogen while a single molecule of water is made from two atoms of hydrogen and one atom of oxygen.

LESSON PROCEDURE

Pre-Assessment Plan:

Engage (Part 1) Lego Structure Activity: ***(3)(7)(8) (A)(D)(G)***

- Place a bag of Legos with students in groups of 2-3. Ask students to take the Legos and create anything they want.
- Set time limit of 5-7 minutes.

Once time is up-

- Have students display their creations.
- Have students describe what they observed when they put the Legos together- *(Should see students who cannot attach anymore Legos on to the white Lego, only so many will fit on the different colors, are they flat or tall? etc.)*

Engage (Part 2) Lego Structure with Limitations: ***(2)(3)(6)(8) (B)(D)(G)***

- Have students use the same bag of Legos, but this time establish conditions in which the Legos can and cannot be attached.
- Here are some rules:
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black Legos	***must*** have 4 Lego connections on its base/platform
yellow Legos	***cannot*** connect with blue Legos
green Legos	***cannot*** connect with red Legos
red Legos	can ***attach to any*** color Lego

- After time is up, ask students to display their creation.
  Do any of the students have identical creations?

- Ask students to share their observations and processes for building their creation:

- *Was it easier or harder to create this display with rules? Why?*
- *Did you notice if your design was more likely to remain flat or build up with your new rules?*
- *Did you have "leftover" Legos after time expired?*

Explore: ***(2)(3)(6)(8) (B)(D)(G)***

- Now ask students to classify Legos with these titles:

element	color	# of pegs	quantity
hydrogen	white	1	1
carbon	black	4	8
oxygen	red	6	6
nitrogen	blue	3	4
chlorine	green	2	2
sodium	yellow	4	4

- Construct Lego creations within these rules:

Carbon can attach to all colors
Only two hydrogen can be attached to one hydrogen
Only chlorine and sodium can combine
Nitrogen can combine with all colors except green, yellow

- Instruct student groups to construct the following:
  - 4 hydrogen can combine with 1 carbon. (Note: CH_4 –methane)
  - 1 nitrogen can combine with 3 hydrogen (NO_3 – nitrate)
  - 1 carbon can combine with 2 oxygen (CO_2 – carbon dioxide)
  - 2 hydrogen can combine with 1 oxygen. (H_2O – water)
  - 1 sodium can combine with 1 chlorine. (NaCl – sodium chloride)

- What did they create? Have students share out their observations.
- Students will now see that specific things are created through the combining or "compounding" of various elements.
- Some elements may remain due to the "rules" that are in place. Compounds have specific properties that determine how they can be arranged.

Explain: ***(4)(8) (A)(D)(F)***

Currently, the Framework in K-12 Science requires students to understand atoms and its relationship to matter by the end of 5th grade. An understanding of elements and compounds are not required until the end of 8th grade.

The instructor will now ask:

- *What is an element in relationship to the Legos?*
- *What is a compound in relationship to the Legos?*

- Have the students continue with the explanation by elaborating on elements and compounds by addressing the following:
  - *How can a small number of naturally occurring elements result in the large variety of substances found in the world?* (Help students think of this in relationship to the building of the Legos at the beginning of the lesson.)

- Be sure and note that there are about 100 different type of elements. Everything in the entire universe is created from the combining of the 100 basic "blocks" in various combinations.
- Some elements can only attach (combine) to a certain amount of other elements.
- Elements have rules for what it can/cannot attach to.
- Some elements never exist by itself. It is so "attractive" [reactive] that it must connect with something else.
- Some elements can only combine with other specific elements.
- Some elements will combine with almost any other element.

Elaborate: ***(6)(8) (A)(B)(F)***

- Design analogies for the following terms:

  A molecule is formed when two or more atoms join together chemically. A compound is a molecule that contains at least two different elements. All compounds are molecules but molecules are not all compounds.

❖ NOTE: Be sure to model analogies before releasing students to do this activity independently.

Evaluate:

- Construct a foldable that describes, illustrates, and provides examples for the following terms: atom, molecule, element, and compound (See Handout #7).

- Have students complete an exit slip that compares the structure of elements, molecules and compounds.

Extensions:

<u>Extension Activity1: Molecule/Compound Worksheet</u> ***(4)(8) (A)***

- Demonstrate how the number of atoms for each element is placed as a subscript after each element symbol (H_2O).
- Provide students with *H.O. # 7: Lego Lesson Handout.*
- Have students look at their last Lego creation.
- Instruct the student to write the element symbol down for each element Lego that was used, along with the number of Legos for that element.

Extension Activity 2: Element Display ***(2)(4)(7)(8) (A)***

- Ask students to create a display of each of the elements listed below, describing their physical properties, if they are natural or human creations, and what is their natural state (is it typically a solid, liquid or gas at room temperature):

  hydrogen: H_2
  oxygen: O_2
  sodium: Na
  chlorine: Cl_2
  iron: Fe
  carbon: C

  - *NOTE:You might want to introduce the concept of diatomic molecules at this time. These will never appear as individual atoms in nature: H, N, O Fl, Cl, Br, I*

- Take two white and one red Legos, representing hydrogen and oxygen, and have the students put them together and describe what is the new state (a solid, liquid or gas at room temperature) when the two elements are combined. Ask: *Does this compound have a common name?*

- Have the students continue this process with the following Lego combinations:

  - 1 yellow Lego and 1 green Lego (chlorine and sodium)
    - sodium chloride [table salt]: NaCl

  - 2 grey Legos and 3 red Legos (iron and oxygen)
    - iron oxide [rust]: Fe_2O_3

  - 1 black Lego and 2 red Legos (carbon and oxygen)
    - carbon dioxide: CO_2

Extension Activity 3: Molecular Models

- Bring in a molecular kit containing the elements of hydrogen, carbon, oxygen, nitrogen, chlorine, sodium, and iron, if available.

- Have students compare the Lego kits to the molecular kits. Have students identify elements using the molecular kits and create the following compounds using the molecular kits:
  - water (H_2O)
  - rust (Fe_2O_3)
  - carbon dioxide (CO_2)
  - table salt (NaCl)

• Have the students update their journal or notebook on a daily basis with new or current information.

CROSS-CURRICULAR CONNECTION STANDARDS	
Same Grade level Discipline:	
Lower/Upper Grade Level Discipline:	
ELA:	
Math:	

ADDITIONAL RESOURCES	
Technology:	
Social Studies:	
Resources:	**Lesson built from:** **http://www.aquariumofpacific.org/teachers/resources/lesson_plans/lego_molecules**
Math:	
Bibliography:	
Notes:	