Name: Instructional Key
Class/Date: red=instructional notes
blue=student answers

LEGO® Atoms and Molecules: Chemical Reactions

What defines a chemical reaction?

Part 1: Wet Lab.

Discuss and record preconceptions about chemical reactions. Then share safety rules.

A) Safety. Listen to the safety rules for today's experiment. Write one of them here:
Answers will vary: no tasting, wear gloves and goggles, waft to smell, work over the tray

B) Observations. Write your observations of the three substances:

Baking soda – *powdery, white, fluffy, solid, no odor, small pieces*

Calcium chloride – *hard, white, solid, no odor, crunchy*

Phenol red solution – *liquid, red, like cough syrup, like water.*

C) Procedure. *Class should do each step together.*

Step 1. Put 1 teaspoon of baking soda into a sealable bag.

Step 2. Put 2 teaspoons of calcium chloride into the same bag.
Ask students if anything is happening yet.

Step 3. Place a test tube with 10 mL of phenol red solution into the bag and hold it upright. *Teacher demonstrates first. One partner holds the tube. The other will remove the top in the next step.*

Step 4. Remove the top of the tube. While holding the tube upright, squeeze all the air out of the bag and seal the bag. (The test tube will stay in the bag.) Have your partner make sure the bag is well sealed.

Step 5. Tip the tube of phenol red solution onto the solids. Mix gently from the outside of the bag with your fingertips. (You can let the test tube fall to the bottom.)

D) Results. Write your observations of the reaction:

NOTE! Inform students that if their bags are filling with gas, they should open them a little!!

It got hot! foamy,
yellow, like eggs,
made a gas (CO_2),
smells like plastic, bubbly…

Share observations, then demonstrate flame test.

Do this as a demo. Choose a bag that is still quite full of carbon dioxide. Have a student hold the top edges, ready to open it on your signal. Light a match and shield it with your hand. Instruct the student to open the bag. Quickly place the match in the center of the bag. It will go out immediately. You may also consider pouring the gas into a beaker holding a lit candle.

E) Flame test. Placing a flame into different gasses can help to identify the gasses.

Hydrogen gas = makes a popping sound

Oxygen gas = the flame will grow bigger

Carbon dioxide gas = the flame will go out

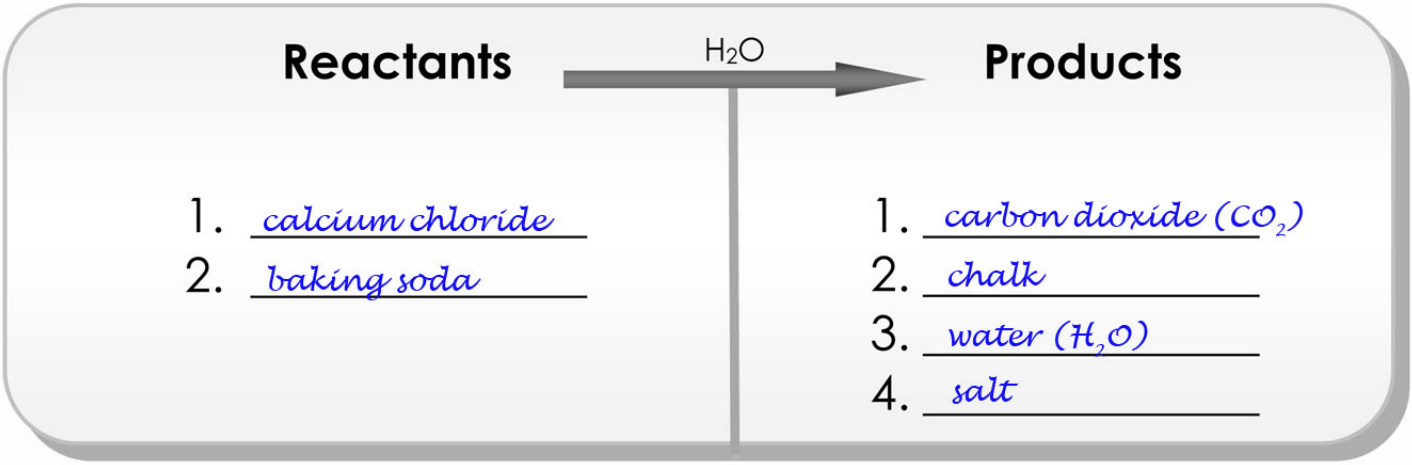
Watch the flame test. What new gas was formed? carbon dioxide (CO_2)

F) The BIG Idea: Not all chemical reactions produce heat, a color change, or a gas. **All chemical reactions will produce NEW substances (new molecules)!**

Write the definition for yourself here: *Be sure to emphasize this key point!*

In a chemical reaction, new substances are produced

G) Reactants and Products. What did we start with, and what are the new substances made in today's chemical reaction?



H) Frequently asked questions:

Phenol red turns yellow below a pH of 6.6 (indicating an acid) and turns pink above pH of 8.0 (indicating a base) It is in aqueous solution, so in addition to the phenolsulfonphthalein water was added to the reaction.

Why isn't phenol red listed as a reactant?
It is an "indicator" and it changed color, showing that other new substances were present.

Why is water listed above the arrow?
The phenol red was a powder mixed with water. So water was present in the reaction. It allowed the baking soda and calcium chloride molecules to come close enough together to trade some of their atoms, and therefore form new molecules. Without the water the reaction wouldn't occur. We write it above the arrow to show that the reaction happened in the presence of water.

Each team of 2 needs 1 LEGO Kit, and 1 Layout Mat /Atom Key.

First introduce LEGO kits, showing how to line bricks up on the Layout Mat for easy counting and cleanup. Then close kits, only opening as needed for vocabulary.

Part 2: LEGO® Lab

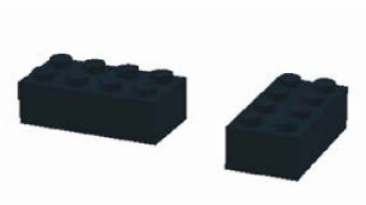
A) Chemical Vocabulary.

Matter is anything that has mass and takes up space. *Answers will vary....*
There are 3 major types of matter: elements, compounds, and mixtures.
Examples of matter are: a hat, *pencil*, *trees*, *me*. *Is air matter?* (Y) / N

1) Element - a pure substance that has only one kind of **atom** in it.

Examples of elements:

oxygen O
iron Fe
chlorine Cl



Different colored LEGO bricks represent different elements

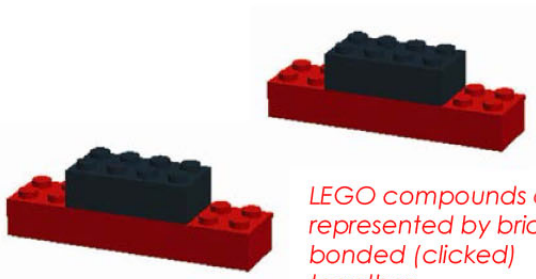
These bricks are black. What element do they represent? *carbon*

Atom - the smallest unit of an element. Atoms can exist either alone or in combination with other atoms.

2) Compound - a pure substance made up of 2 or more different kinds of atoms bonded together. New properties appear.

Examples of compounds:

water H_2O
salt NaCl
carbon dioxide CO_2



LEGO compounds are represented by bricks bonded (clicked) together.

Make the compound carbon dioxide. The chemical formula is CO_2

Now make a water molecule. What might it look like? *Students may connect 2 water molecules together and incorrectly call it ice. Explain that this makes a new compound, H_4O_2*

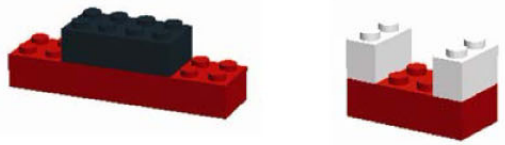
Molecule – a combination of atoms bonded together. It comes from a Latin word meaning "little lump."

Correct student molecules so that they all look alike.

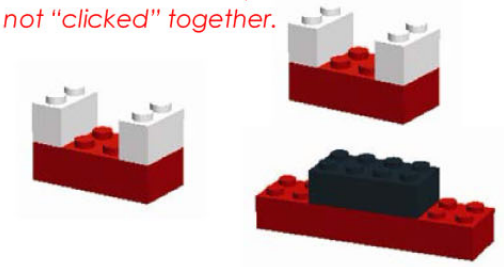
3) Mixture - a combination of two or more pure substances (elements or compounds) that can be separated by physical methods. The substances keep their original properties.

Examples of mixtures:

salt water, brass(copper and zinc), iron filings and sand, dry calcium chloride and ~~baking soda~~



Different LEGO compounds (and/or free bricks) are near each other, but not "clicked" together.



Make some carbonated water (soda). It is a mixture of CO_2 and H_2O. Could you still separate the molecules? How?

Yes. Open bottle and let the CO_2 escape! The soda will "go flat".

Matter can change in appearance. Is it a physical change or a chemical change? Here's how to decide: *Answers may vary:*

4) Physical change - *molecules are the same before and after the change, although the matter may look different.*

LEGO compounds and atoms are near each other, but do not bond (click) together.

Examples:

dissolving,

cutting paper, breaking pencil

freezing, mixing

Hints:

1) Physical changes include making mixtures, dissolving one thing in another, and cutting or breaking something.
2) All **changes of state** are physical changes. A water molecule is the same water molecule when it is ice, when it is liquid water, and when it is water vapor in the air.

5) Chemical change - *new and different molecules are formed.*

LEGO compounds break apart, and the atoms recombine, or "re-click".

Examples:

today's reaction

rusting

digesting food

Hints:

1) All **chemical reactions** are chemical changes.
2) New properties appear.
3) The bonds between the atoms are broken and the atoms recombine in new ways.

Demonstrate water in different states of matter by moving the LEGO models. Emphasize that the molecules are the same molecules.

1) Ice: move the models slowly and keep them close together, maintaining them in about the same position. *
2) Water: move the models faster and with greater range of motion.
3) Water vapor: move the models even faster and further apart— and perhaps toss them into the air for a finale!

* Ice is an exception in states of matter. In most substances, molecules are more closely packed in solids than in liquids. The molecules in ice are in a crystal form which actually locks them further apart than they were as a liquid. This fact can be demonstrated by filing an ice cube tray to a marked line and freezing it. The ice will take up more space than the water did, rising above the line. For younger students teachers may choose to omit this information.

The carbon dioxide gas was produced through the chemical reaction in the bag. Be sure students don't misinterpret it as a change of state.

Each team of 2 students needs: 1 LEGO Kit, 1 Chemical Reactants/Chemical Products laminated sheet, 1 Layout Mat/Atom Key.

B) Modeling a chemical reaction.

Directions:

1) Write the formulas for the molecules on the lines below. Check for subscripts, capitalization, and spacing.

2) Build and place each LEGO molecule on its formula using the "Chemical Reactants" and "Chemical Products" cards.

It is important for students to put all other bricks away before transforming their chemical reactants into products. They should notice that no extra atoms were needed, and none were left over. Emphasize the point that chemical reactions don't destroy or create matter. Atoms are simply rearranged to make new products. Reinforce this idea by crossing off each atom first on the reactant side, and then the product side of the page below.

H_2O

Reactants
(What we put in the bag)

CHEMICAL REACTION!

Products
(What ended up in the bag)

$NaHCO_3$
baking soda molecule

$NaHCO_3$
baking soda molecule

$CaCl_2$
calcium chloride molecule

The above formula balances the equation. However, some students may be concerned that there are 2 **molecules** of baking soda and only one of calcium chloride, the opposite of the number of **TEASPOONS** of each reactant. You can explain that the spoonfulls are not perfect measurements. Also, ask students to consider the sizes of the particles. The baking soda material is more dense than the calcium chloride and therefore more molecules can pack together.

$NaCl$
salt molecule

$NaCl$
salt molecule

$CaCO_3$
chalk molecule

CO_2
carbon dioxide molecule

H_2O
water molecule

C) Practice Writing Chemical Formulas.

A chemical formula is an easy way to tell what atoms are present in a compound.

Use the "LEGO® Atom Key" to find the **chemical symbol** for each element.

It is important to write your formula using the correct uppercase or lowercase letters. The subscript number refers to the atom before it. Remember that "H_2O" means there are 2 hydrogen atoms and 1 oxygen atom. We write the subscript 2 for the hydrogen but it is unnecessary to write the 1 after the oxygen.

Chemists have a complicated set of rules about the order of atoms in their formulas. For this activity, we'll keep it simple, and list the atoms in order starting from the top of the LEGO Atom Key.

Directions.

1) Watch your teacher demonstrate how to write a formula. Make something simple in a funny shape

2) Build a compound with less than 10 LEGO bricks. (Don't worry about whether it would be a real compound. Build any shape/color you like!)

3) Write out the formula for YOUR compound here (write the symbols in the order of the Atom Key, from top to bottom):

Answers will vary but will look something like: $H_3Na_2C_2NO_2$

4) Trade your compound with your teammate and write out the formula for your TEAMMATE's compound here:

Another sample: Na_5Ca_2C

Compare answers with your teammate. Do you agree? (Y)/N

5) Build a second molecule and name it.

My formula _____ My Teammate's formula _____

Look! These formulas follow more complicated rules but are still neat to see!				
CH_3COOH is the formula for vinegar!	$C_{19}H_{14}O_5S$ is the formula for phenolsulfonphthalein or phenol red!	CH_4 is the formula for methane gas!	$C_6H_{12}O_6$ is the formula for glucose!	$NaOCl$ is the formula for bleach!