If you have not used this set before, introduce the concepts of elements, compound, mixtures with p.**3, 4, & 5** (one class period)

Name: *Instructional Key*
Class/Date: Red = instructional notes
Blue = student answers

MIT Edgerton Center Molecule Set: Understanding Air

Climate Change

To learn student misconceptions and to pique their interest--
Hand out the mat "What is Air Made of? Guess!" Careful--answer is on the back side. Tell them not to turn it over.
Have students vote by secret ballot or by putting heads down, eyes closed, raising a hand. Record the class' results on the board for A, B, C, and D.

Part 1: What is Air?

Explain the answer is B. Have students circle the answer on this paper. Tell them to help remember what's in air we are going to build a model of air!

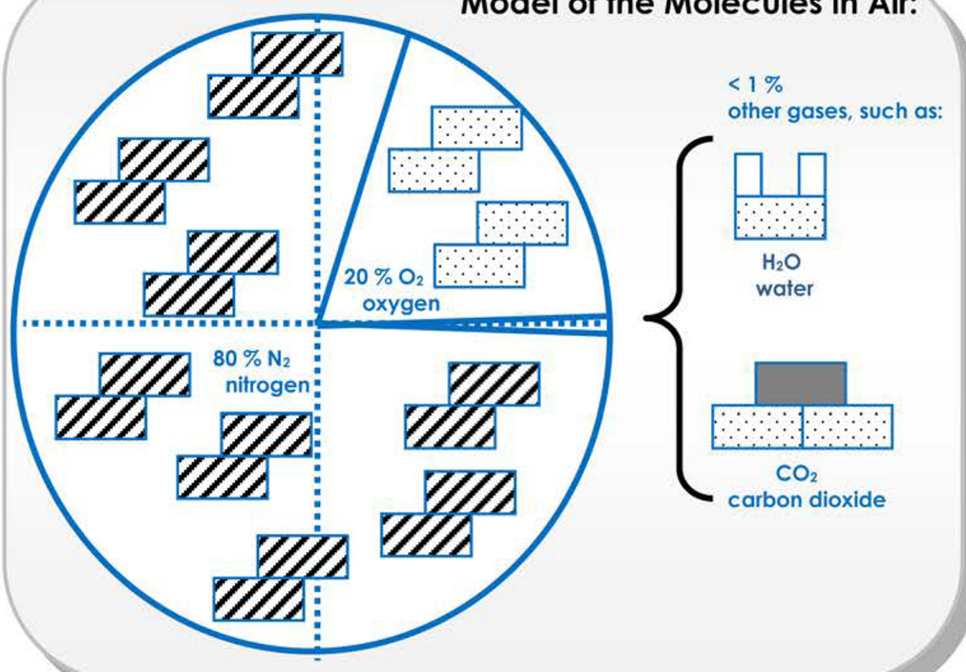
Activity 1 What is air made of? Guess! A (B) C D *(Circle the letter.)*

Turn mat over and build, "Model the Molecules in Air". Tell students to place the bricks on top of their images. Helps students self correct.

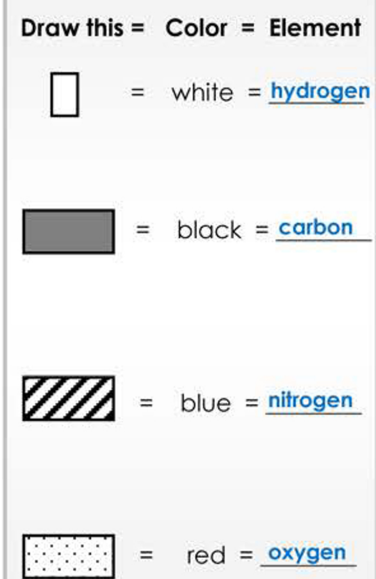
Activity 2 Build with LEGO! Next, draw the model below. (Copy the whole LEGO mat.)
Use the key provided for the brick colors. Label the molecules and add the percents.

Ask students close the lid on the kits, after they finish. This is to prevent off-task building! Use this technique at other times, as necessary. Next, have the students copy their model of air on paper. This is a good repetition. USE the correct COLORS if you have them, instead of the patterns. Colors are simpler for younger students and useful for learning elements' colors for older students.

Model of the Molecules in Air:



Key for the drawing:



Explain that **CO_2 levels are less than 1% .** Therefore we need to measure in PPM to track the changes in CO_2. (The number 390 PPM was the CO_2 concentration when this lesson was created.)

CO_2 level written on the LEGO mat = **390** PPM

Safe upper limit for CO_2 level = **350** PPM

PPM = Parts Per Million (parts per 1,000,000)

You will need to tell them the ideal or "safe" number is "350 PPM" and then explain it. This famous number "350" was determined by an international panel of experts to be the ideal or "safe" level of carbon dioxide. We are above this level. Climate change is happening, when the level is above "350" However people can do something about climate change!

Activity 3 Practice figuring out PPM:
Calculate the PPM of 80% nitrogen in air
Calculate the PPM of 20% oxygen in air

N_2= **800,000** PPM
O_2= **200,000** PPM

Show your work ***(hint: use fractions)***
This is equivalent fractions work, for example:
75% = 75/100 = 3/4

80% nitrogen

$$\frac{80}{100} = \frac{?}{1{,}000{,}000} = \frac{800{,}000}{1{,}000{,}000}$$

20% oxygen

$$\frac{20}{100} = \frac{?}{1{,}000{,}000} = \frac{200{,}000}{1{,}000{,}000}$$

Explain that CO_2 concentrations are very low compared with other gases like nitrogen and oxygen. However CO_2 can have a big effect!

Let's look at the records of CO_2 concentration over time.

https://edgerton.mit.edu/molecule-sets

Part II: Burning Fuel: Complete Combustion

Have students build reactants on LEGO mat. (Close kit lid.) Wait. Then clap to signal the spark! Turn over mat. Convert reactants into the products.

Activity 1 Complete combustion is a chemical reaction in which all the fuel is burned. Record the complete combustion reaction from the LEGO mat. Use chemical symbols.

Reactants (What we burn)		**Products** (What we find in the exhaust)
C_3H_8 + 5 O_2 (Propane, oxygen)	Spark! →	4 H_2O + 3 CO_2 (Water, carbon dioxide)

Ask students to name different kinds of fossil fuels/ hydrocarbons: *(Coal, oil, gasoline, diesel fuel, natural gas)* natural gas= methane
Octane in gasoline has 8 carbons and its formula is C8H18. You can build this like propane. For methane put 4H bricks on all 4 edges of the carbon brick.
Briefly discuss how CO_2 in the atmosphere traps the heat from the earth that is radiated back into the atmosphere using the figure on the mat.

Part III: Global Warming and the Greenhouse Effect

Activity 1 Use your computer or smartphone to go to the National Oceanic and Atmospheric Administration (NOAA) website:
https://gml.noaa.gov/ccgg/trends/graph.html

Teachers may choose to give the students the PPM data from the graph.

Examine the graph "Mauna Loa Monthly Averages." This is a graph of CO_2 averages over time in Hawaii. The carbon dioxide data on Mauna Loa constitute the longest record of direct measurements of CO_2 in the atmosphere. You will need to mouse over the chart to find specific CO_2 measurements. Use the blue dot to read off values in January of 2000, 2010, and 2020. Round to whole numbers.

Year	January CO_2 PPM
2000	369
2010	389
2020	414

What was the increase in CO_2 PPM between Jan 2000 and Jan 2010?

1) The CO_2 increased __20__ PPM.

What was the increase in CO_2 PPM between Jan 2010 and Jan 2020?

2) The CO_2 increased __25__ PPM. Have the students show their work in the box on the left.

Work space

389 − 369 = 20

414 − 389 = 25

414 + 30 = 444

Based on these measurements, predict what the CO_2 PPM will be in 2030: answers will vary (from 434-444)

3) I predict the CO_2 measurement in 2030 will be _______ PPM.

Explain how you made this prediction: answers will vary

Students should increase the number based on the 20 PPM difference between 2000 and 2010, the 25 PPM difference between 2010 and 2020, or predict that the increase will be even higher in the next decade - about 30 PPM.

(This is your best educated guess.)

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

The Molecule Reference Sheet

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.

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

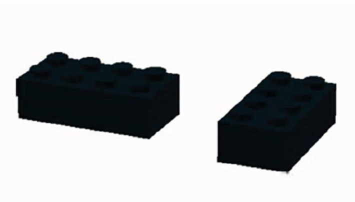
1) Element - a pure substance that has only one kind of **atom** in it.

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.

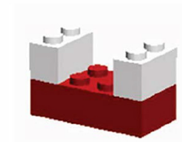
3) Mixture - a combination of two or more pure substances (elements or compounds) that can be separated by physical methods. The substances keep their original properties.

Examples of mixtures:

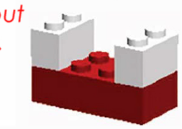
salt water, brass(copper and zinc),

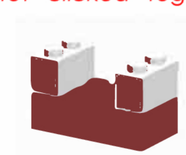
iron filings and sand,

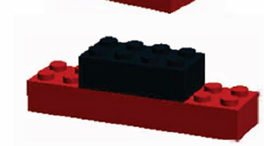
dry calcium chloride and baking soda



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".

https://edgerton.mit.edu/molecule-sets

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 changing state by moving a few LEGO molecules around:
- Ice: very slowly and close together,
- Water: faster and further apart
- Boiling water and water vapor: even faster and further apart. Students love it if you allow the molecules to fly into the air as vapor.

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.

B) **Practice Writing Chemical Formulas.**

Review these rules for writing chemical formulas with the students.

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

Use the "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 Atom Key.

Directions.

1) Build the compound on the "Chemical Formula Practice Mat." (This would not be a real compound!)
2) Watch your teacher demonstrate how to write a formula.
3) Write out the formula for the compound here (write the symbols in the order of the Atom Key, from top to bottom):

$H_2Na_2Ca_4C_3N_5O_2Cl_2$

4) Now you and your teammate will each build your own made-up compound and write the formula for it below.
5) Trade compounds with your teammate and write out the formula for your TEAMMATE'S compound below.
6) Check that you and your teammate have the same answers!

Answers will vary

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!