If you have not used this set before, introduce the concepts of elements, compound, mixtures with p. 5, 6, & 7. (one class period) Pages here follow lesson plan "Part 1 Understanding Air" found online: http://www.teachersdomain.org/resource/envh10.health.lp58a/
Note: Teachers Domain is moving to PBS LearningMedia on Oct 15, 2013

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

Atoms and Molecules: 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?

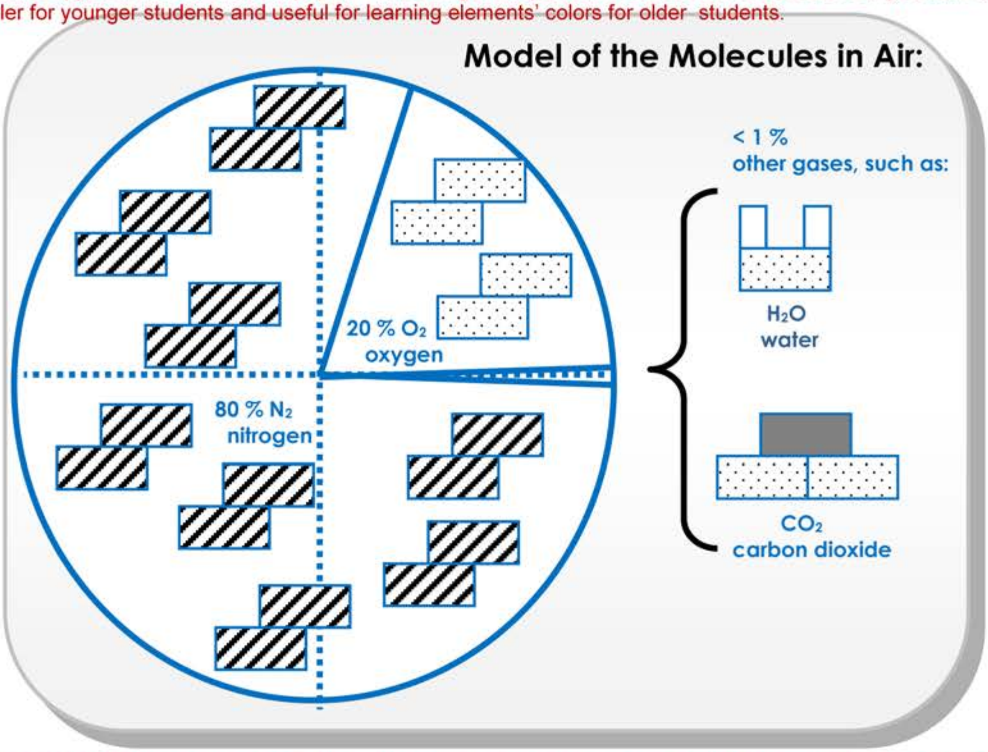
Explain the answer is B. Have students circle the answer on this paper. Tell them to help remember what's in air we are going to build a model of air!

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.



Key for the drawing:

Draw this =	Color =	Element
☐	= white =	hydrogen
■	= black =	carbon
▨	= blue =	nitrogen
⁙	= red =	oxygen

Explain that **CO₂ 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

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

Safe upper limit for CO_2 level = 350 PPM

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.

Mauna Loa Observatory, Hawai'i

Monthly Average Carbon Dioxide Concentration

The Mauna Loa atmospheric CO_2 measurements constitute the longest continuous record of atmospheric CO_2 concentrations available in the world. The Mauna Loa site is considered one of the most favorable locations for measuring undisturbed air because possible local influences of vegetation or human activities on atmospheric CO_2 concentrations are minimal and any influences from volcanic vents may be excluded from the records. The methods and equipment used to obtain these measurements have remained essentially unchanged during the 46-year monitoring program. Because of the favorable site location, continuous monitoring, and careful selection and scrutiny of the data, the Mauna Loa record is considered to be a precise record and a reliable indicator of the regional trend in the concentrations of atmospheric CO_2 in the middle layers of the troposphere.

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual	Annual-Fit
1958	-99.99	-99.99	315.71	317.45	317.50	-99.99	315.86	314.93	313.19	-99.99	313.34	314.67	-99.99	-99.99
1959	315.58	316.47	316.65	317.71	318.29	318.16	316.55	314.80	313.84	313.34	314.81	315.59	315.98	316.00
1960	316.43	316.97	317.58	319.03	320.03	319.59	318.18	315.91	314.16	313.83	315.00	316.19	316.91	316.91
1961	316.89	317.70	318.54	319.48	320.58	319.78	318.58	316.79	314.99	315.31	316.10	317.01	317.65	317.63
1962	317.94	318.56	319.69	320.58	321.01	320.61	319.61	317.40	316.26	315.42	316.69	317.69	318.45	318.46
1963	318.74	319.08	319.86	321.39	322.24	321.47	319.74	317.77	316.21	315.99	317.07	318.36	318.99	319.02
1964	319.57	-99.99	-99.99	-99.99	322.23	321.89	320.44	318.70	316.70	316.87	317.68	318.71	-99.99	319.52
1965	319.44	320.44	320.89	322.13	322.16	321.87	321.21	318.87	317.81	317.30	318.87	319.42	320.03	320.09
1966	320.62	321.59	322.39	323.70	324.07	323.75	322.40	320.37	318.64	318.10	319.79	321.03	321.37	321.34
1967	322.33	322.50	323.04	324.42	325.00	324.09	322.55	320.92	319.26	319.39	320.72	321.96	322.18	322.13
1968	322.57	323.15	323.89	325.02	325.57	325.36	324.14	322.11	320.33	320.25	321.32	322.90	323.05	323.11
1969	324.00	324.42	325.64	326.66	327.38	326.70	325.89	323.67	322.38	321.78	322.85	324.12	324.62	324.60
1970	325.06	325.98	326.93	328.13	328.07	327.66	326.35	324.69	323.10	323.07	324.01	325.13	325.68	325.65
1971	326.17	326.68	327.18	327.78	328.92	328.57	327.37	325.43	323.36	323.56	324.80	326.01	326.32	326.32
1972	326.77	327.63	327.75	329.72	330.07	329.09	328.05	326.32	324.84	325.20	326.50	327.55	327.46	327.52
1973	328.54	329.56	330.30	331.50	332.48	332.07	330.87	329.31	327.51	327.18	328.16	328.64	329.68	329.61
1974	329.35	330.71	331.48	332.65	333.09	332.25	331.18	329.40	327.44	327.37	328.46	329.58	330.25	330.29
1975	330.40	331.41	332.04	333.31	333.96	333.59	331.91	330.06	328.56	328.34	329.49	330.76	331.15	331.16
1976	331.74	332.56	333.50	334.58	334.87	334.34	333.05	330.94	329.30	328.94	330.31	331.68	332.15	332.18
1977	332.92	333.42	334.70	336.07	336.74	336.27	334.93	332.75	331.58	331.16	332.40	333.85	333.90	333.88
1978	334.97	335.39	336.64	337.76	338.01	337.89	336.54	334.68	332.76	332.54	333.92	334.95	335.50	335.52
1979	336.23	336.76	337.96	338.89	339.47	339.29	337.73	336.09	333.91	333.86	335.29	336.73	336.85	336.89
1980	338.01	338.36	340.08	340.77	341.46	341.17	339.56	337.60	335.88	336.01	337.10	338.21	338.69	338.67
1981	339.23	340.47	341.38	342.51	342.91	342.25	340.49	338.43	336.69	336.85	338.36	339.61	339.93	339.95
1982	340.75	341.61	342.70	343.56	344.13	343.35	342.06	339.82	337.97	337.86	339.26	340.49	341.13	341.09
1983	341.37	342.52	343.10	344.94	345.75	345.32	343.99	342.39	339.86	339.99	341.16	342.99	342.78	342.75
1984	343.70	344.51	345.28	347.08	347.43	346.79	345.40	343.28	341.07	341.35	342.98	344.22	344.42	344.44
1985	344.97	346.00	347.43	348.35	348.93	348.25	346.56	344.69	343.09	342.80	344.24	345.56	345.90	345.86
1986	346.29	346.96	347.86	349.55	350.21	349.54	347.94	345.91	344.86	344.17	345.66	346.90	347.15	347.14
1987	348.02	348.47	349.42	350.99	351.84	351.25	349.52	348.10	346.44	346.36	347.81	348.96	348.93	348.99
1988	350.43	351.72	352.22	353.59	354.22	353.79	352.39	350.44	348.72	348.88	350.07	351.34	351.48	351.44
1989	352.76	353.07	353.68	355.42	355.67	355.13	353.90	351.67	349.80	349.99	351.30	352.53	352.91	352.94
1990	353.66	354.70	355.39	356.20	357.16	356.22	354.82	352.91	350.96	351.18	352.83	354.21	354.19	354.19
1991	354.72	355.75	357.16	358.60	359.34	358.24	356.17	354.03	352.16	352.21	353.75	354.99	355.59	355.62
1992	355.98	356.72	357.81	359.15	359.66	359.25	357.03	355.00	353.01	353.31	354.16	355.40	356.37	356.36
1993	356.70	357.16	358.38	359.46	360.28	359.60	357.57	355.52	353.70	353.98	355.33	356.80	357.04	357.10
1994	358.36	358.91	359.97	361.26	361.68	360.95	359.55	357.49	355.84	355.99	357.58	359.04	358.88	358.86
1995	359.96	361.00	361.64	363.45	363.79	363.26	361.90	359.46	358.06	357.75	359.56	360.70	360.88	360.90
1996	362.05	363.25	364.03	364.72	365.41	364.97	363.65	361.49	359.46	359.60	360.76	362.33	362.64	362.58
1997	363.18	364.00	364.57	366.35	366.79	365.62	364.47	362.51	360.19	360.77	362.43	364.28	363.76	363.84
1998	365.32	366.15	367.31	368.61	369.29	368.87	367.64	365.77	363.90	364.23	365.46	366.97	366.63	366.58
1999	368.15	368.87	369.59	371.14	371.00	370.35	369.27	366.94	364.63	365.12	366.67	368.01	368.31	368.30
2000	369.14	369.46	370.52	371.66	371.82	371.70	370.12	368.12	366.62	366.73	368.29	369.53	369.48	369.47
2001	370.28	371.50	372.12	372.87	374.02	373.30	371.62	369.55	367.96	368.09	369.68	371.24	371.02	371.03
2002	372.43	373.09	373.52	374.86	375.55	375.41	374.02	371.49	370.71	370.25	372.08	373.78	373.10	373.07
2003	374.68	375.63	376.11	377.65	378.35	378.13	376.62	374.50	372.99	373.00	374.35	375.70	375.64	375.61

Monthly values are expressed in parts per million (ppm) and reported in the 2003A SIO manometric mole fraction scale. The monthly values have been adjusted to the 15th of each month. Missing values are denoted by -99.99. The "annual" average is the arithmetic mean of the twelve monthly values. In years with one or two missing monthly values, annual values were calculated by substituting a fit value (4-harmonics with gain factor and spline) for that month and then averaging the twelve monthly values.

Source: Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy

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)

$$C_3H_8 + 5\,O_2 \xrightarrow{\text{Spark!}} 4\,H_2O + 3\,CO_2$$

Propane, oxygen → 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" Videos

Activity 1 Listen to the video "Global Warming and the Greenhouse Effect"

- Name 2 weather-caused disasters: *forest fires, hurricanes, floods, record high temperatures, and drought.*
- Name 3 contributors/offenders: *1) carbon dioxide, 2) CFCs, 3) methane*
- Explain how a greenhouse gas works: *Light from the sun heats the earth, which radiates heat back into the atmosphere. Some gases like carbon dioxide can hold the heat, much like a car window or greenhouse can.*

Activity 2 Examine the Data Table: "Monthly Average Carbon Dioxide Concentration" on page 2. Record the measurements for 1990 and 2000 here. Round off to whole numbers

Year	Annual CO_2 PPM
1990	**354**
2000	**369**

Work space
In 2000 = 369 PPM
+15
In 2010 = 384 PPM
+15
In 2020 = 399 PPM

What was the increase in CO_2 PPM between 1990 and 2000?

1) The CO_2 increased _**15**_ PPM in 10 years.

Assume that the increase will be the same every 10 years:

2) Predict the CO_2 PPM in 2010: _**384**_ PPM
3) Predict the CO_2 PPM in 2020: _**399**_ PPM

Find out* the CO_2 PPM now:

4) Measured CO_2 PPM in _______ (year): ______ PPM *Answers will vary*

Think about it! CO_2 levels are rising... [✓ faster] or slower than predicted. (circle one)

Activity 3 Listen to the video "Global Warming: the Physics of the Greenhouse Effect" 2 min

- Why is the greenhouse effect usually a good thing?

You may want to teach the greenhouse gases (methane, carbon dioxide, nitrous oxide, ozone and water vapor.) These are mentioned here.

The greenhouse effect keeps the earth warm. Without the green house gases the average temperature on earth would be much colder, 0 degrees Fahrenheit, and the oceans would freeze. The greenhouse gases absorb the sun's infrared heat and re-emit the heat back into the atmosphere so that the average earth surface temperature is 79 degrees Fahrenheit.

- Where is the carbon dioxide coming from?

The carbon dioxide is coming from fossil fuels (coal, oil and natural gas.) which release CO2 when burned.

Ask: Does using electricity put carbon dioxide into the air? Yes, when we use electricity produced from burning coal we are adding more carbon dioxide to the air. Ask: Can we produce electricity in a way that doesn't add carbon dioxide to the air? Hydroelectric production and solar cells

* website: http://co2now.org/

Part IV: Human Health

Activity 1 Use the Interactive "Climate Change and Human Health." Select a topic:

☑ Airway Diseases ☐ Developmental Disorders ☐ Mental Health Disorders

Group work time if you have computers for students.

☐ Vectorborne Diseases ☐ Waterborne Diseases

- Describe the issue and one or two examples of what could go wrong.

Have teams of students each pick a topic and complete this paper. Pick teams to report back to the class as you show the slides to the class.

OR Just pick 1 or 2 topics to complete as a class group. Note: Airways; Vectorborne, and Waterborne Diseases are best topics for middle school students.

Airway Diseases could increase

Asthma is an example of an airway disease. Increasing temperatures could cause:

1) plants to make more pollen
2) droughts to occur and make more dust,
3) wildfires to occur and make more smoke and particulates.

- Describe one or two things we can do.

Things to do for managing Airway Diseases include

1) Plant more trees in urban spaces to reduce ozone and other pollutants. Plants also create shade
2) Walk, bike ride and use public transportation
3) Reduce energy use overall

Part V: Proposed Solutions

Activity 1 Discussion of what we can do.

Describe some general approaches

1) What citizens can do: switch to different and, preferably, renewable fuels, and reduce driving

2) What scientists and engineers can do: develop technologies that can capture the CO_2 and store it in places underground like mines, or in plants or under oceans.

See interactive "Capturing Carbon" below.

3) What governments can do: increase fuel efficiency standards, limit the amount of carbon that polluters are allowed to make, invest in cleaner fuels, promote more efficient energy technologies and industries

(Optional) Activity 2 View interactive: "Capturing Carbon Where do we put it?"

Click on the options to get explanations and to learn the advantages and disadvantages of each

Carbon dioxide storage is becoming an important science and engineering research topic.

Alkaline minerals (above and underground) , silviculture (forests), aquaculture, unmineable coal seams, deep saline aquifers, oil and gas fields, oceans (surface), and oceans (deep sea and seabed.)

(Optional) Activity 3 View the slide: "The Carbon Cycle"

Notice where the carbon is moving. One industry produces a lot of carbon dioxide.

Point out the main idea here:
Carbon atoms move around on our planet.
We call this the carbon cycle. Carbon atoms can be found in water, air and soil.

Surprise! Carbon dioxide production from world-wide cement production is significant: 5 to 10 percent of the world's CO_2 emission.

Final Check for Understanding:

What other activities besides driving cars do millions of people do that emit tons of carbon dioxide into the atmosphere?

Answers might include breathing, heating our homes by burning wood or coal, cutting down trees, flying on jets, and manufacturing cement.

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

The Molecule Reference Sheet

A) Chemical Vocabulary.

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.

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

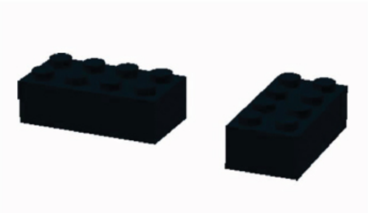
1) Element - a pure substance that has only one kind of **atom** in it.

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.

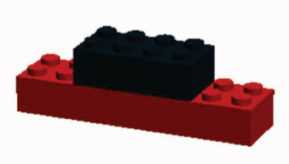
2) Compound - a pure substance made up of 2 or more different kinds of atoms bonded together. New properties appear.

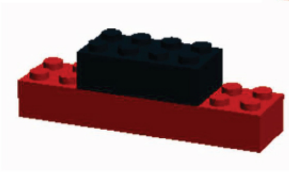
Examples of compounds:

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.

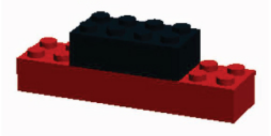
Molecule – a combination of atoms bonded together. It comes from a Latin word meaning "little lump."

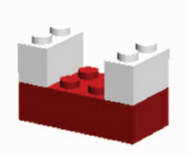
Correct student molecules so that they all look alike.

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.

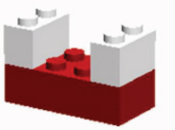
Examples of mixtures:

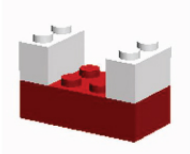
salt water, brass(copper and zinc), iron filings and sand, dry calcium chloride and ~~baking soda~~

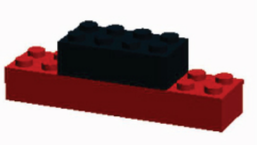




Different LEGO compounds (and/or free bricks) are near each other, but not "clicked" together.







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".

Page 5. Atoms and Molecules: Understanding Air, Climate Student Worksheet Version: Feb 2014

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.

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) 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!