

19.1

Bonding and Molecules



Question: Why do atoms form chemical bonds?

1 Reviewing atomic structure

There are no questions to answer in part 1.

2 How many electrons are in the outermost level?

Using the atom building game, build each element in the table. For each element, record the number of electrons and the number of unoccupied spaces in the outermost energy level.

element	atomic number	electrons in outermost level	unoccupied spaces in outermost level
hydrogen			
helium			
lithium			
fluorine			
neon			
sodium			
chlorine			
argon			
potassium			

3 What are valence electrons?

a. What do lithium, sodium, and potassium have in common?

b. What do fluorine and chlorine have in common?

c. What do neon and argon have in common?

4**Modeling a chemical bond**

- a. In order to complete its outermost energy level, do you think sodium will tend to lose its only valence electron, or gain seven? Explain your answer.
- _____
- _____
- b. In order to complete its outermost energy level, do you think chlorine will tend to lose all of its valence electrons or gain one electron? Explain your answer.
- _____
- _____
- c. Why might these two atoms bond together to form a molecule? In your answer, describe what you think might happen when sodium and chlorine form a chemical bond.
- _____
- _____
- _____

5**Determining oxidation numbers**

An element's **oxidation number** is equal to the charge an atom has when it **ionizes**, that is, gains or loses electrons.

Use your models of sodium and chlorine to answer the questions below.

- a. Remove the valence electron from sodium. What has happened to the balance of positive and negative charges? What is sodium's oxidation number?
- _____
- _____
- _____
- b. Move the electron you took from sodium into the chlorine. What happens to chlorine's charge when it gains the electron from the sodium atom? What is chlorine's oxidation number?
- _____
- _____
- _____
- c. When sodium and chlorine form a chemical bond, what is the overall charge of the molecule? Why do you think sodium and chlorine combine in a 1:1 ratio?
- _____
- _____
- _____

19.2

Chemical Formulas



Question: Why do atoms combine in certain ratios?

1 Oxidation numbers and ions

- a. How are elements grouped according to the number of valence electrons in their outermost levels?

- b. Why do elements in group 2 have an oxidation number of 2+?

- c. Why do elements in group 17 have an oxidation number of 1-?

- d. Why do the oxidation numbers in the first two groups tend to be positive?

2 Predicting chemical formulas

Record your results in the table below.

element 1	element 2	ion 1	ion 2	number of tiles of element 1	number of tiles of element 2	chemical formula
hydrogen	fluorine					
magnesium	sulfur					
calcium	bromine					
aluminum	oxygen					
potassium	chlorine					
lithium	argon					

Naming ionic compounds

For the table below, fill in the chemical formula for each ionic compound from the table on the previous page in part 2. Then, name the compounds.

element 1	element 2	chemical formula	Name of the ionic compound
hydrogen	fluorine		
magnesium	sulfur		
calcium	bromine		
aluminum	oxygen		
potassium	chlorine		
lithium	argon		

Name: _____

19.3

Comparing Molecules



Question: What is the meaning of a chemical formula?

1 Find the mass of the individual atoms

Find the mass of one **Nu** atom and the mass of one **Bo** atom and record these values below:

Mass of **Nu** atom (g): _____

Mass of **Bo** atom (g): _____

2 How many different compounds can you make?

Record your results in the table below.

chemical formula Nu_xBo_y	mass of one molecule	% Nu $\frac{\text{mass of nuts}}{\text{mass of molecule}} \times 100$	% Bo $\frac{\text{mass of bolts}}{\text{mass of molecule}} \times 100$	ratio of Nu $\frac{\% \text{ of nuts}}{\text{mass of 1 nut}}$	ratio of Bo $\frac{\% \text{ of bolts}}{\text{mass of 1 bolt}}$
1. Nu_4Bo_2					
2. Nu_2Bo					
3. Nu_2Bo_2					
4.					
5.					

3**Determining the empirical formula of your compounds**

Determine the empirical formula for each of your compounds and record below:

ratio of Nu	ratio of Bo	$\frac{\text{largest ratio}}{\text{smallest ratio}}$ Nu or Bo?	$\frac{\text{smallest ratio}}{\text{smallest ratio}}$ Nu or Bo?	Empirical formula Nu _x Bo _y	Molecular formula Nu _x Bo _y

4**Challenge!**

Can you figure out the empirical formula and number of molecules of the mystery compound in the box? For this activity, assume the empirical and molecular formula of your mystery molecule are the same. Show all of your calculations. You may use a balance to find the mass of your box of mystery molecules.

Percent Nu:

Percent Bo:

Mass of 1 molecule of Nu_xBo_y:

Mass of box:

Use the space below to show your calculations.

Write down your findings and the methods you used as a paragraph. Use this paragraph to help present your findings from the Investigation to the class.

Name:

20.1

Chemical Changes



Question: What is the evidence that a chemical change has occurred?



Safety Tip: Wear goggles and an apron during the entire Investigation.

1

Reaction #1 observations:

2

Reaction #2 observations:

3

Reaction #3 observations

4

Reaction #4 observations:

5**Reaction #5 observations:**

6**Reaction #6 observations:**

7**Interpreting your observations**

Make a table like the one below on a separate sheet of paper. An example has been provided.

observation category	evidence of chemical change
bubbles/gas formation	The formation of a gas indicates that a new substance that exists as a gas at room temperature was probably produced.

8**Developing your set of rules**

Use the table to develop your set of rules for determining when a chemical change has occurred. Write your rules and share them with the class.

Name:

20.2

Chemical Equations



Question: How do you balance chemical equations?

1 Writing chemical equations

There are no questions to answer in part 1.

2 Trying out the reaction with periodic table tiles

Rearrange the reactants to make the products. Is there any problem? What are you missing?

3 Balancing the reaction

Which atoms did you need more of for the reaction you tried?

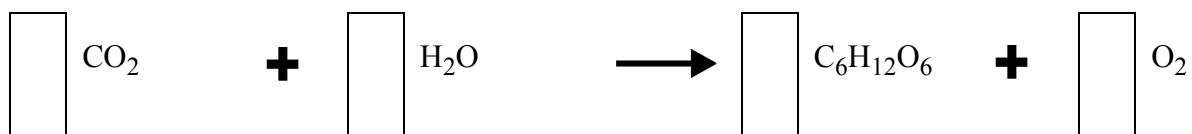
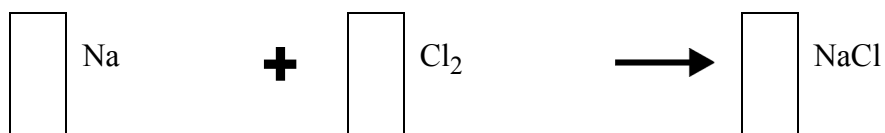
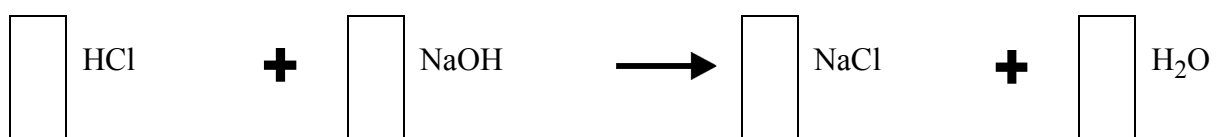
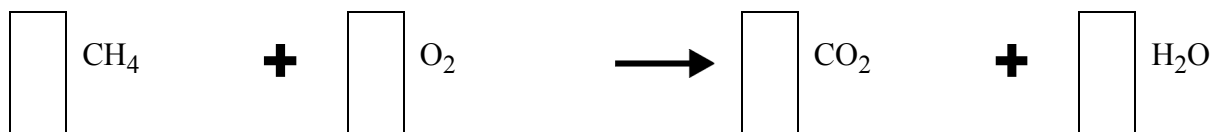
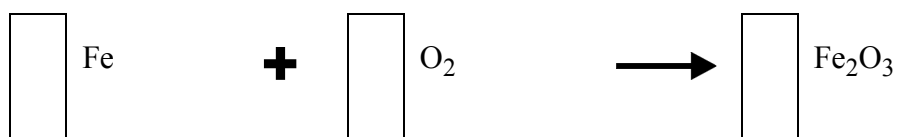
Try adding another water molecule to the reactants and rearrange them to form the products again. Did the reaction work this time?

4 Writing balanced chemical equations

There are no questions to answer in part 4.

5**Try balancing these chemical equations**

Balance the equations below.



20.3

Conservation of Mass



Question: How can you prove that mass is conserved in a reaction?

1 Testing the reaction

Safety Tip: Wear goggles and an apron during the Investigation.

Follow the procedures below and record your data as you go.

Step	Data and observations
a. <i>Mass of effervescent tablet.</i> Use a balance to find the tablet's mass. Record it here.	
b. <i>Mass of beaker and water.</i> Find the mass of the beaker and water. Record it here.	
c. <i>Mass before the reaction.</i> Add the two masses and record the result.	
d. <i>Observations.</i> Drop the tablet into the beaker of water. Record your observations.	
e. <i>Mass after the reaction.</i> Let the reaction finish, then tap the beaker gently to release as many bubbles as you can. Find and record the mass of the beaker again.	
f. <i>Mass difference.</i> Subtract e. from c. Record the result.	

2 Was there a difference in mass?

Does this experiment agree with the law of conservation of mass? Explain why or why not based on your results. Write your response in the space below.

20.4

Using Equations



Question: How can you predict the amount of product in a reaction?

1 Writing the balanced equation for the reaction

In this experiment, you will react sodium hydrogen carbonate (baking soda) with acetic acid (vinegar) to produce carbon dioxide gas, water and sodium carbonate. The equation for this reaction is written below. Balance the equation by writing coefficients in front of the reactants and products:



2 What does the balanced equation tell you?

Use your balanced equation to complete the table below:

reactants				products				
NaHCO_3	+	$\text{HC}_2\text{H}_3\text{O}_2$	yields	CO_2	+	H_2O	+	$\text{NaC}_2\text{H}_3\text{O}_2$
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
coefficient	+	coefficient	yields	coefficient	+	coefficient	+	coefficient
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
formula mass	+	formula mass	yields	formula mass	+	formula mass	+	formula mass

Doing the experiment and recording the data



Safety Tip: Wear goggles and an apron during the Investigation.

Follow the procedures below and record in the table your data for all four trials.

data and procedures	trial 1	trial 2	trial 3	trial 4
1. <u>Mass of beaker A</u> . Find and record the mass of your empty beaker (beaker A).				
2. <u>Mass of beaker A + NaHCO₃</u> . Add about 2.0 grams of NaHCO ₃ to beaker A. Find and record the mass of beaker A + NaHCO ₃ .				
3. <u>Mass of NaHCO₃ used</u> . Subtract number 1 from number 2. This is the mass of NaHCO ₃ .				
4. <u>Mass of beaker B with HC₂H₃O₂ before the reaction</u> . Find and record the mass of the 250 mL beaker full of HC ₂ H ₃ O ₂ (beaker B).				
5. <u>Mass of beaker B after HC₂H₃O₂ is used in the reaction</u> . Slowly add HC ₂ H ₃ O ₂ , a little at a time, to beaker A. As you add, gently swirl beaker A to dissipate the bubbles of CO ₂ . Add HC ₂ H ₃ O ₂ until the bubbling stops. Find and record the mass of beaker B again.				
6. <u>Mass of HC₂H₃O₂ used</u> . Subtract number 5 from number 4. Record the result.				
7. <u>Mass of beaker A before the reaction</u> . Add numbers 2 and 6. This will give you the mass of beaker A before the reaction occurred. Record your answer.				
8. <u>Mass of beaker A after the reaction</u> . Let beaker A sit for a few minutes. Tap it gently to release as much of the CO ₂ as you can. Find and record the mass of beaker A.				
9. <u>Mass of CO₂ produced</u> . Subtract number 8 from number 7. This will give you the mass of CO ₂ produced. Record your answer.				

4

Identifying relationships between reactants and products in a reaction

Fill in the table and identify a relationship between the variables by trying out different calculations (multiplying, dividing, adding, and subtracting). You may need to round decimals to the nearest tenth in order to identify relationships in your answers.

Trial 1	reactant NaHCO ₃	product CO ₂	Trial 2	reactant NaHCO ₃	product CO ₂
coefficient			coefficient		
formula mass			formula mass		
actual mass			actual mass		
Trial 3	reactant NaHCO ₃	product CO ₂	Trial 4	reactant NaHCO ₃	product CO ₂
coefficient			coefficient		
formula mass			formula mass		
actual mass			actual mass		

5

Writing your rule for predicting the amount of product in a reaction

Write a mathematical formula that will allow you to predict the amount of product given the amount of the limiting reactant in a reaction. Your formula should have the limiting reactant variables on one side and the product variables on the other side. Use the following variables in your rule:

Limiting reactant	Product
C_r = coefficient in front of the limiting reactant	C_p = coefficient in front of the product
F_r = formula mass of limiting reactant	F_p = formula mass of product
A_r = actual mass of limiting reactant	A_p = actual mass of product

Your rule:

combination of reactant variables	=	combination of product variables

6**Testing your rule**

Does your rule work? Test it by carrying out the same reaction again, using a different amount of NaHCO_3 . Record your results below.

NaHCO_3 used in reaction

Predicted yield of CO_2

Actual yield of CO_2

7**Calculating percent yield**

The predicted yield of a reaction is rarely exactly equal to the actual yield. Why do you think there might be differences?

Calculate the percent yield for the reaction you just completed.

8**Analyzing the Investigation**

- a. Why was it necessary to measure the amount of carbon dioxide produced in the reaction instead of one of the other products?

b. Why do you think it was necessary to round off your calculations to the nearest tenth in order to identify a relationship between the variables?

c. How could your mathematical relationship be useful to a company that uses chemical reactions to manufacture products?

Challenge!

You use products made with aluminum metal everyday, but do you ever wonder where this metal comes from? To obtain pure aluminum, aluminum ore is treated with large amounts of heat to produce pure aluminum metal. Oxygen gas is another product in this reaction. The balanced equation for this reaction is:



If you heat 50.0 grams of aluminum ore, and the reaction is completed, how many grams of pure aluminum will you get? Show your work in the available space on this page.

_____ grams of aluminum

21.1

Classifying Reactions



Question: How can you predict the products in a reaction?



Safety Tip: Wear goggles and a lab apron during the Investigation.

1

Writing the chemical formulas of the reactants

Write the chemical formulas for the compounds you will react (Table 19.2 of the Student Edition).

compound	positive ion	column # of periodic table (if monoatomic)	negative ion	chemical formula
ammonium hydroxide				
calcium chloride				
magnesium sulfate				
sodium chloride				
sodium hydroxide				
sodium phosphate				

2**Deducing your rules for solubility - part I**

Write your rules for solubility in the space below. You may include the rule on the previous page.

3**Determining products and writing the equations**

Complete the table as you complete each reaction:

reactants	possible products	precipitate? yes or no
$\text{CaCl}_2 + \text{NaOH}$		
$\text{CaCl}_2 + \text{Na}_3\text{PO}_4$		
$\text{NaOH} + \text{Na}_3\text{PO}_4$		
$\text{NaCl} + \text{NH}_4\text{OH}$		
$\text{NaOH} + \text{MgSO}_4$		
$\text{Na}_3\text{PO}_4 + \text{MgSO}_4$		
$\text{MgSO}_4 + \text{CaCl}_2$		
$\text{CaCl}_2 + \text{NH}_4\text{OH}$		
$\text{NaCl} + \text{MgSO}_4$		
$\text{NH}_4\text{OH} + \text{MgSO}_4$		

21.2

Energy in Reactions



Question: How can you classify reactions based on energy?



Safety Tip: Wear goggles and a lab apron for this Investigation.

1 Measuring energy changes in reactions

- a. What does a change in temperature tell you about the energy in a reaction?
- _____
- _____
- b. If a reaction occurs and no temperature change can be measured, what might that indicate about the reaction?
- _____
- _____

2 Reaction #1 Dissolution of ammonium nitrate

Beginning temperature (°C)

End temperature (°C)

Additional observations:

3 Reaction #2 Decomposition of hydrogen peroxide

Beginning temperature (°C)

End temperature (°C)

Additional observations:

4**Reaction #3 Dissolution of calcium chloride**

Beginning temperature (°C)

End temperature (°C)

Additional observations:

5**Classifying the reactions and showing energy changes**

For each reaction you just observed, indicate whether it is exothermic or endothermic, based on your observations. Next, write the balanced equation for each reaction. Indicate energy changes in each reaction by following the example below.



Is this an example of an exothermic or endothermic reaction?

rxn	type of reaction (exothermic or endothermic)	Write the complete, balanced equation. Show energy changes in your equation.
#1		
#2		
#3		

22.1

Nuclear Reactions



Question: How do you simulate nuclear decay?

1 Discussing radioactivity

Your teacher has given you a can of pennies to represent the atoms of a sample of a newly discovered, radioactive element. Discuss the following with your group. Record your answers in the spaces provided.

- a. With your group, decide on a name for your element. _____
- b. Why is your element radioactive? What does this tell you about its nucleus?

- c. Since your element is radioactive, what is happening to its nucleus?

- d. If this were a real radioactive element, what precautions would you have to take? Why?

2 Making a prediction

What do you think your graph will look like? Sketch your prediction in the space below.

3 Simulating the process of radioactive decay

There are no questions to answer in part 3.

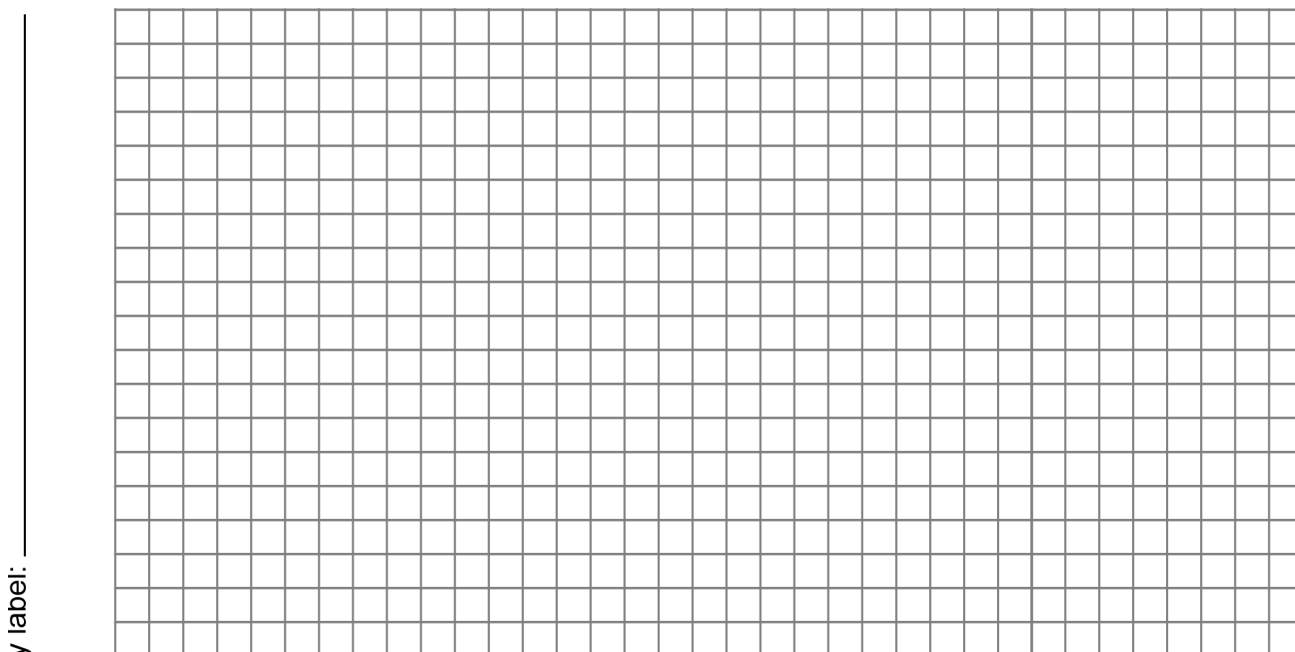
4**Recording the data**

sample number	number of decayed atoms	sample number	number of decayed atoms
1		8	
2		9	
3		10	
4		11	
5		12	
6		13	
7		14	

5**Graphing your data**

Graph your data for number of decayed atoms per sample vs. sample number. Label the axes clearly. Be sure to provide a title for the graph. Be sure to use the entire graph in plotting your data.

Title: _____



6**Interpreting your graph**

a. Write a paragraph that describes what your graph looks like.

b. What part of this simulation represents the half-life of this new element? Explain your answer.

c. If the half-life of your element was 430 years and you had 2000 atoms of this element, how long would it take for the element to undergo complete radioactive decay to a stable isotope? What year would it be when the element finished decaying? Note: As you work through this problem, round the number of atoms left to a whole number. For example, round 62.5 to 63.

7 Wrapping up

- a. Were you correct in your prediction for what your graph would look like?

- b. Make a list of pros and a list of cons regarding the uses of radioactive elements. Each list should have at least three points. As you make your lists, think about how radioactive elements are used today. You may need to do research on the Internet or in your library to make your lists.

Pros regarding the uses of radioactive elements	Cons regarding the use of radioactive elements

22.2

Carbon Reactions



Question: How do your choices impact the environment?

1**Choosing a car or truck**

1. Prior to the Investigation, choose the car or truck you would buy to drive to work or school each day. Find three facts that justify your choice. Write these facts in the space below. Use these facts to make a brochure that describes your car. Include in your brochure the facts and any photographs, magazine clippings, or articles you find.

2. Use the ACEEE's Green Book -- The Environmental Guide to Cars and Trucks or the Internet (<http://www.fueleconomy.gov> or <http://greencars.org>) to find the fuel economy for your car or truck for highway and city driving. Write this information in the space below. The unit for fuel economy is miles per gallon of gasoline (MPG).

3. Figure out how many gallons of gasoline you will need to drive 500 miles in the city and 500 miles on the highway. Perform the calculation based on your response in step 2. Show your work below.

4. Use the price per gallon of gas provided by your teacher to calculate the cost of enough gasoline for your car or truck to travel 500 miles in the city and 500 miles on the highway. Show your work.

Price of a gallon of gas: \$_____

2 The environmental effects

- a. You will use the combustion reaction for iso-octane to find out how much carbon dioxide (CO₂) your car produces. The equation for the combustion of iso-octane is:



From this equation, you can tell that you would need 2 moles of iso-octane and 25 moles of oxygen to get a complete combustion reaction that produces 10,900 kilojoules of energy.

- b. Calculate the formula masses of iso-octane and CO₂. Use the periodic table to help you. Your values will be in atomic mass units. Before going to the next step, convert from atomic mass units to grams.

Formula mass of iso-octane: _____

Formula mass of CO₂: _____

- c. Calculate the mass of one gallon of iso-octane. The density of iso-octane is 0.69 g/ml. One gallon is equivalent to 3,840 ml.

- d. Calculate the mass of CO₂ that will be produced to drive 500 miles in the city and 500 miles on the highway. Use the following formula:

$$\frac{\text{mass of iso-octane needed to travel 500 miles}}{(\text{formula mass of iso-octane} \times 2)} = \frac{\text{mass of carbon dioxide produced after 500 miles}}{(\text{formula mass of carbon dioxide} \times 16)}$$

3 Using the sun's energy

All plants use photosynthesis to convert the sun's energy into chemical energy. Unlike combustion which is exothermic, photosynthesis is endothermic and requires energy. The chemical equation for photosynthesis is:



Through photosynthesis, plants assimilate the carbon in CO₂ into their tissues. In this way, photosynthesis does contribute to reducing CO₂ in the atmosphere. For this Investigation, assume that one tree converts 32 pounds of CO₂ to glucose (C₆H₁₂O₆) each year. This figure is equivalent to 14.545 kilograms or 14,545 grams of CO₂.

Figure out how many trees you would need to plant to offset the amount of CO₂ your car or truck produces each year for driving 500 miles in the city and 500 miles on the highway.

4**Evaluating choices**

Use the data from the whole class to make a list of the top five cars and trucks in each category.

- a. The best fuel economy for driving in the city.

1. 2. 3. 4. 5.

- b. The best fuel economy for driving on the highway.

1. 2. 3. 4. 5.

- c. The worst fuel economy for driving in the city.

1. 2. 3. 4. 5.

- d. The worst fuel economy for driving on the highway.

1. 2. 3. 4. 5.

- e. The least carbon dioxide produced each year.

1. 2. 3. 4. 5.

- f. The most carbon dioxide produced each year.

1. 2. 3. 4. 5.

5**Reaching conclusions**

Respond to the following the in the spaces provided.

- a. Was your car in any of the top five lists? If so, which one?

- b. On a scale of 1 - 5, rate the fuel economy of your car or truck. A “1” means your car is not fuel efficient and a “5” means that your car or truck is very fuel efficient. Explain your rating choice.

c. On a scale of 1 - 5, rate your car or truck according to how much carbon dioxide it produces. A “5” means that your car or truck produces a great deal of carbon dioxide. Explain your answer.

d. Go back to the three reasons that you chose your car or truck. Have your three reasons changed because of this Investigation? Give at least one new reason for selecting or not selecting your car or truck. Explain your answer.

e. What are the consequences of having too much carbon dioxide in the atmosphere?

f. Is it reasonable to say that we can plant trees to compensate for all the carbon dioxide we produce? Why or why not?

g. Carbon dioxide (CO_2) is an end-product of a combustion reaction that occurs in car engines. Scientists believe the presence of too much CO_2 in Earth’s atmosphere is contributing to global warming. What is the economic impact of global warming on the world? What kind of extra costs would people and society have if Earth’s average temperature increased? In other words, what is the cost of producing too much CO_2 ? Discuss these questions with your group. Make a list of things that would cost more, or have to be paid for, if Earth were to get warmer.
