Name________________________________ Date____________________________

Global Warming Begins at Home— Student Worksheet #1

Part 1: The Chemistry of Combustion

How much carbon dioxide, or CO_2, do we produce by burning a gallon of gasoline? It's an important question, because CO_2 is responsible for more than 60% of all global warming. Although the United States and Canada have only 5% of the world population, they generate 26% of the world's carbon emissions.[1] By calculating how much CO_2 we produce by using a gallon of gasoline, we can learn how much we each contribute to global warming.

Here's how to do it: A gallon of gasoline weighs 6.15 lbs.[2] Combustion, the process of burning gasoline to produce power, involves just three elements: carbon, hydrogen, and oxygen. Each of these has their own weight (in atomic units).

Hydrogen (H): 1
Carbon (C): 12
Oxygen (O): 16

Knowing this, we can figure out what different molecules weigh:

Example: Water or H_2O $= H_2 + O$
$= 2$ Hydrogen $+ 1$ Oxygen
$= 1 + 1 + 16$
$= 18$

So, 1 water molecule weighs 18 atomic units.

The basic formula for combustion looks like this:

Gasoline (or Isooctane) combines with oxygen to form water and carbon dioxide. The energy given off by this reaction is what powers our cars. Scientists write the equation like this:

$$C_8H_{18} + 12.5\,(O_2) \rightarrow 8\,(CO_2) + 9\,(H_2O)$$

or

1(Isooctane) + 12.5(Oxygens) → 8(Carbon Dioxides) + 9(Waters)

1. Calculate the atomic weight of each molecule, the same way the weight of water was calculated above. Then, multiply by the number of molecules in the formula. For example, the formula above produces 9 waters, or 9(18) =162 atomic units.

a. Oxygen: 12.5 (O_2)
O_2 = ____________. 12.5 (O_2)= ____________.

b. Carbon Dioxide: 8 (CO_2)
CO_2 = ____________. 8 (CO_2)= ____________.

c. Isooctane: (C_8H_{18}) = ____________.

2. Check your math: The total weight to the left of the arrow above should equal the total weight to the right of the arrow. What is the total weight on each side of the arrow? _____________ atomic units.

3. You now have enough data to answer the original question: How much carbon dioxide do we produce by burning a gallon of gasoline?

You can use the ratio:

$$\frac{\text{Atomic weight of 8 } CO_2}{\text{Weight of } CO_2 \text{ produced (lbs.)}} = \frac{\text{Atomic weight of isooctane}}{\text{Weight of 1 gallon gas (lbs.)}}$$

Solve for the weight of CO_2 to get your answer: ________________ lbs. This is the amount of carbon dioxide that we add to the air every time we use a gallon of gasoline!

Name______________________________ Date__________________________

Transportation Tally—Student Worksheet

Part 1: Driving to the Limit

1. In 1998, there were about 211 million vehicles on U.S. roads, while the country's population was 270 million.[4] How many people were there for each car in the United States in 1998? (Round to the nearest hundredth.) ________ people.

2. a. How much time would it take someone to get to work if he/she were traveling 20 miles at 30 miles per hour? (Use the formula: Time = Distance/Rate.) ______ hours. How many minutes is this? ______ minutes.

b. As the number of cars on the road increases, the average speed a car can travel decreases. How much time would it take that same person to get to work if he/she could only travel at only 15 miles per hour? ______ minutes.

c. What is the difference in time between the two speeds? ______ minutes.

3. In 1980 there were 155,796,000 vehicles registered in the U.S. and our nation's population was 227,726,000 people.[5] In 1998 there were 211,617,000 vehicles and 270,509,000 people.[6]

a. What was the percent change in number of registered vehicles from 1980 to 1998? ______.
(Percent of change = amount of change/original amount.)

b. What was the percent change in U.S. population during the same time period? _______.

Part 2: Gassing Up

4. In the United States the average car burns 548 gallons of gasoline each year.[7] There are about 211 million autos in the U.S.[8]

a. If a person drives 10 miles each way to work and averages 22 miles per gal., how much gas is used each day?________ gal.

b. If a person drives 10 miles each way to work in a gasoline/electric hybrid that averages 65 miles per gallon, how much gas is consumed each day? _____ gal.

c. If 30 people take a bus 10 miles to work and the bus averages 6.5 miles per gallon, how much gas does the bus consume each day?______ gal. What is each passenger's share of gas consumed?______ gal.

d. Which of the options above is the most energy efficient people-mover? ________________.

5. How many gallons of gasoline do all of the cars in the United States, combined, burn each year? ______________ gallons.

Part 3: Human Masses, Greenhouse Gases

The "greenhouse effect" is caused by a layer of gases in the atmosphere. These gases trap the sun's warmth just like a greenhouse. If we add too many "greenhouse gases" to the air, the planet may get warmer and warmer. Carbon dioxide (CO_2), one of these gases, is released into the air when gasoline is burned. Nationwide, transportation accounts for 30% of all CO_2 emissions.[9]

6. To describe how much of something is in the air, scientists use the expression "parts per million," or "ppm." (For example, if you had a million dots, one of which was orange, while the rest were purple, the concentration of orange dots would be one part per million.) In the year 1900, the concentration of CO_2 in the air was around 270 ppm. In 1998 it was 366 ppm.[10] What percent increase is this?_________.

7. Scientists estimate we need to reduce CO_2 emissions to 7.34 billion tons per year by 2050, in order to stabilize global temperatures.[11]

a. By 2050, the population of the world is expected to grow to 9 billion.[12] How many tons of CO_2 would each person be allowed to add to the atmosphere if permits were allotted equally to all people? ______________ tons.

b. How many pounds per day could each of us produce? (1 ton = 2,000 lbs.) ________ lbs.

c. Driving 1 mile releases approximately 1 pound of CO_2 into the air, on the average.[13] How far could you get on your allotted CO_2 emissions by car? _______________ miles.

d. What are some things you could do now and in the future to limit your share of CO_2 production?

8. a. If Americans drive a total of 1.5 trillion (1,500,000,000,000) miles each year, how many tons of CO_2 do cars release each year? [14] ____________________________ tons.

b. If the average fuel efficiency increases from about 22 mpg to about 44 mpg, but the number of miles driven by all the cars on the roads doubles from 1.5 trillion to 3.0 trillion, how much will we have changed our total CO_2 production? ____________.

Sources: [1,2,4,5,6,7,8,14] Statistical Abstract of the United States: 2000; *U.S. Census Bureau.* [3,9] Vital Signs 2001; *Worldwatch Institute, WW Norton and Company, New York, 2001.* [11] Vital Signs 1998, *Worldwatch Institute, WW Norton and Company, New York, 1998.* [12] World Population Data Sheet 2001; *Population Reference Bureau, www.prb.org.* [13] *American Forests Association, www.americanforests.org.*

Name______________________________ Date________________________

How Much Space Do We Need?— Student Worksheet #1

In order to survive, we all depend on some basic resources that the Earth provides.

1) Oxygen to breathe (produced from the Earth's vegetation)
2) Food
3) Energy (from renewable and nonrenewable resources)
4) Water

In the following math problems, you will be calculating how much land area you require to meet your needs for these essential things.

Problem 1: How much space in square meters (m^2) do you need for generating oxygen to breathe?

Data: One acre of trees generates enough oxygen each day for the needs of 18 people.[1] One acre is equal to 4,046.9 m^2.

How to do it:

Divide 4,046.9 m^2 by 18 people to determine the number of m^2 needed for oxygen production =________________.

Problem 2: How much space in square meters (m^2) do you need for growing food?

Data: It takes roughly 1 m^2 to grow 1,000 calories' worth of food over a year.[2] Animals use an average of about 16 calories of grain, soybeans, etc., for every calorie they produce as meat or other animal products.[3]

Refer to the chart below to find your recommended caloric intake per day.[4]

How to do it:

Males	Recommended Daily Calories
Age 11-14	2,500 cal./day
Age 15-~~18~~ 25	3,000 cal./day
Females	
Age 11-~~18~~ 15	2,200 cal./day

Step 1: Tally your individual needs:

Calories: How many calories do you consume each day? ___________.
Food source: Approximate the percentage of the calories in your diet that are made up of meat and animal products? _________.
Convert this percentage to a ratio. (Express in decimal terms.) ___________.

Step 2: Figure out how many calories you need to grow daily to maintain your diet:
Multiply your proportion of vegetable calories by the number of calories you consume daily. Add to this the proportion of meat and animal calories, multiplied by 16, multiplied by the number of calories you consume daily.

Example: For a person who consumed 2,500 cal/day, 10% of which was meat and animal, the equation would look like this:
(.9 veg)(2,500 cal/day) + (.1 meat)(16)(2,500 cal/day)
or
(2,250 veg cal/day) + (4,000 meat cal/day)
or
(6,250 (total cal/day)

= ________________________.

Name________________________________ Date____________________________

How Much Space Do We Need?—
Student Worksheet #2

Step 3: Figure out how much land you need to grow the calories you want:
Multiply your total calories/day by 365 days to get total cal./year. Divide this figure by 1,000 cal/m^2 to get the number of square meters that you would need.

Example: For the above example, the person would need:
(6,250 cal/day)(365 days/year)÷(1,000 cal/m^2)
or
(2,281,250 cal/year)÷(1,000 cal/m^2)
or
(2,281.25 m^2/year)

= ______________________.

Problem 3: How much space in square meters (m^2) do you need for collecting energy?

Energy can come from a variety of sources on Earth, both renewable and nonrenewable. Renewable sources include solar, wind, water (hydropower), nuclear and geothermal. Nonrenewable sources include fossil fuels which are in finite supply, such as coal, oil and gas. For this calculation, you will be considering how much space you need to collect energy from the sun (solar power) using solar panels. Solar panels are made up of photovoltaic cells which absorb the sun's heat.

Data: 1 m^2 of photovoltaic cells can produce an average of about 1,460 kilowatt-hours (KWH) of power annually.[5]

Average energy use per person in various countries:[6]

Ethiopia: 270 KWH/year United States: 12,000 KWH/year Sweden: 6,840 KWH/year

How to do it:

Step 1: Tally your individual use:
(Look at a copy of your home power bill to see how many KWH were used during the billing cycle. Divide the KWH by the number of days to determine KWH/day. Multiply the daily figure by 365 days/year to calculate KWH/year for your house. Divide that number by the number of people in your house to calculate your share.)

Example: Consider a three-person house that has an electrical bill for 3,250 KWH for a 30 day billing cycle.
(3,250 KWH)÷(30 days) = (108.33 KWH/day)
or
(108.33 KWH/day)(365 days/year) = (39,541.66 KWH/year)
or
(39,541.66 KWH/year)÷(3 people/house) = (13,180.55 KWH/person/year)

= ______________________.

Step 2: How many solar panels will you need?
Divide the number of KWH you use a year by 1,460 KWH/m^2/year

Example: (13,180.55 KWH/person/year) ÷ (1,460 KWH/m^2/year)
or
(9.03 m^2/person)

= ______________________.

Name______________________________ Date________________________

How Much Space Do We Need?— Student Worksheet #3

Problem 4: How much space in square meters (m²) do you need for collecting water?

Data: Average annual rainfall for some major U.S. cities:[7]

Chicago: 90.98 cm Houston: 117.02 cm
Los Angeles: 37.52 cm Miami: 142 cm
New York City: 106.98 cm

Average water use per person in various countries:[8]

Ethiopia: 6,000 liters/year Sweden: 123,000 liters/year United States: 244,000 liters/year

1 gallon = 3.785 liters 1 liter = 1,000 cubic centimeters (cm^3) 1 meter = 100 centimeters (cm)

How to do it:

Step 1: Availability: Approximate how much rain falls in your area from the above figures, or determine a more exact figure from an almanac or other appropriate reference text. Calculate rainfall per square meter by multiplying annual rainfall by 10,000 cm^2/m^2 to find rainfall in cm^3/m^2. Divide by 1,000 to convert cm^3 to liters.

Example: For Chicago:
(90.98 cm/year)(10,000 cm^2/m^2) = (909,800 cm^3/m^2)(year)
or
(909,800 cm^3/m^2/year)÷(1,000 cm^3/liter) = 909.8 liters/m^2(year)
= ________________________.

Step 2: Tally your individual use: Look at a copy of your home water bill to see how many gallons were used during the billing cycle. Divide the gallons by the number of days to determine gallons/day. Multiply the daily figure by 365 days/year to calculate gallons/year for your house. Divide that number by the number of people in your house to calculate your share.

Example: Consider a three-person house that has a water bill for 32,000 gallons for a 90-day billing cycle.
(32,000 gal./house)÷(90 days) = (355.55 gal./house/day)
or
(355.55 gal./house/day)(365 days/year) = (129,777.77 gals./house/year)
or
(129,777.77 gals./house/year)÷(3 people) = 43,259 gal./year/person
= ________________________.

Step 3. Convert use to liters

Example: (43,259 gals./year)(3.785 liters/gallon) = 163,735 liters/year
= ________________________.

Step 4. Calculate number of m^2 needed to provide a year's worth of water by dividing annual usage by available number of liters per m^2.

Example: from above we have:
(163,735 liters/year)/(909.8 liters/m^2/year) = 180 m^2
= ________________________.

Total it up:

Oxygen space: ___________ m^2.
Energy space: ___________ m^2.
Food space: ____________ m^2.
Water space: ___________ m^2.
Total space: ____________ m^2.
Express in acres (4,046.9 m^2 = 1 acre): _______________ acres.
Express in square feet (1 acre = approximately 43,560 ft^2): ________ ft^2.