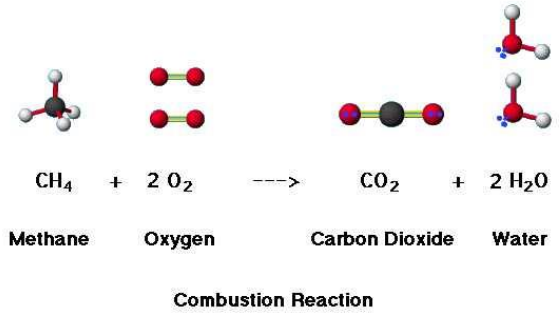
eCLEAR Combustion of Fossil Fuels Lab

Name **Date**

Can we calculate the amount of CO2 produced during the combustion of a butane lighter?

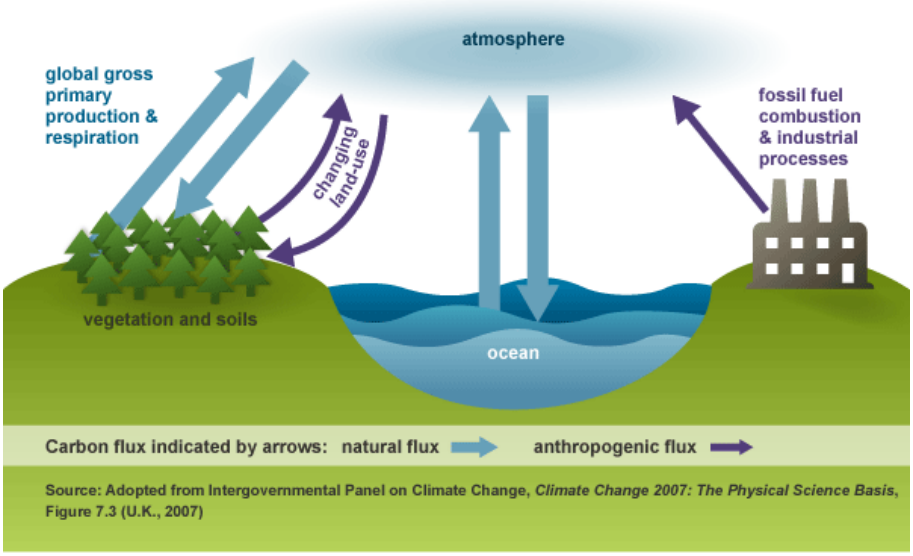
Combustion is an important category of chemical reactions. Combustion reactions are exothermic and produce heat and light. Combustion of **fossil fuels** (categorized as mostly "hydrocarbons" - what are the 2 main elements they contain? ___ & ___) require oxygen as a reactant and produce carbon dioxide and water as products.

Here is an example of a chemical equation showing the combustion reaction of methane (aka *natural gas*).



(Elmhurst College diagram)

The problem in that in the last 200 years of human history the combustion of fossil fuels has upset the carbon cycle balance in the Earth's system. Because of CO_2 and other "greenhouse gases" (like methane) increasing in the atmosphere, more heat is being trapped on the Earth's surface and is increasing both land and oceans temperatures. (see diagram below)



Is it possible to calculate the amount of CO_2 produced during combustion in a lab? Yes, and that is what we will try to do in this experiment using the fossil fuel butane C_4H_{10} from a lighter.

The balanced equation of the combustion of butane is:

$2C_4H_{10} + 13\ O_2 \rightarrow 8CO_2 + 10H_2O$

We are going to use a chemical that absorbs CO_2 in the lab. If we weigh this chemical before and after the combustion reaction, we should be able to calculate the MASS of CO_2 produced during combustion of our butane lighter.

In the CO_2 diagram above, what do you think is the difference between “natural flux” and “anthropogenic flux”? Explain:

Procedure and Set Up

Wear safety goggles at all times! Use appropriate flammable precautions (such as pulling back hair and no dangling jewelry or clothing items) Make sure lab glass is Pyrex quality - ask your teacher if unsure.

1.Mass the butane lighter and the empty U tube and record in the data table.

	Mass in grams on a analytical balance
Mass of empty U tube	
Mass of butane lighter BEFORE combustion	
Mass of U tube with carbon dioxide absorber chemical BEFORE combustion (lightly packed in the bottom of the U tube - see picture of setup below)	
Mass of butane lighter AFTER combustion	

Mass of U tube with carbon dioxide absorber chemical AFTER combustion	

2. Set up your combustion apparatus as shown in the diagram below or as directed by your teacher. *Don't ignite the butane lighter until your teacher has approved of your set up.* Note the CO_2 absorber material is lightly packed in the U tube and there is a clear flow of the combustion products from the funnel, through the tubing, and into and out of the U tube. *NOTE! Do not allow the flame to come in contact with the tubing - the flame should entirely be contained by the Pyrex funnel.*

3. Your teacher will tell you how long to burn the butane lighter. We burned ours for about 5 min. *Notice we have a clamp to hold the lighter in place but the student will need to pull down on the butane trigger to initiate and sustain combustion.*

4. Let the setup cool and then weigh the U tube with the carbon absorber after the combustion and record in the data table.
5. Weigh the butane lighter after the combustion experiment and record in the data table.

6. What is the mass of the CO_2 that was produced and absorbed in this experiment? (hint: subtract the weight of the U tube with the CO_2 absorber BEFORE combustion from the weight of the U tube with the CO_2 absorber AFTER the combustion and record here: _____g

7. What was the mass of the butane burned in this experiment? _____g

8. Clean up and put away equipment as directed by your teacher.

9. Let's try to calculate how many grams of CO_2 you should have expected to produce when burning **butane**. Look at the equation below.

$2C_4H_{10} + 13\ O_2 \rightarrow 8CO_2 + 10H_2O$

How many CO_2's are produced for every ONE butane? ____

10. Calculate the molar mass (or "formula mass") of butane _____ g/mol and the molar mass ("formula mass") of CO_2, _____g/mol. Show all work for credit!

11. What is the ratio of the mass of 4 carbon dioxide's to 1 butane? Show all work for credit!

12. If you calculated above that you should get a 3:1 ratio of carbon dioxide to butane and you know the mass of butane you combusted, what is the mass of carbon dioxide you should have collected?

13. Now let's look at the combustion of gasoline (which we will assume is all octane C_8H_{18}). Here is the balanced combustion equation of **octane**:

$2C_8H_{18} + 25\ O_2 \rightarrow 16\ CO_2 + 18\ H_2O$

Calculate the molar mass of octane _____ g/mol

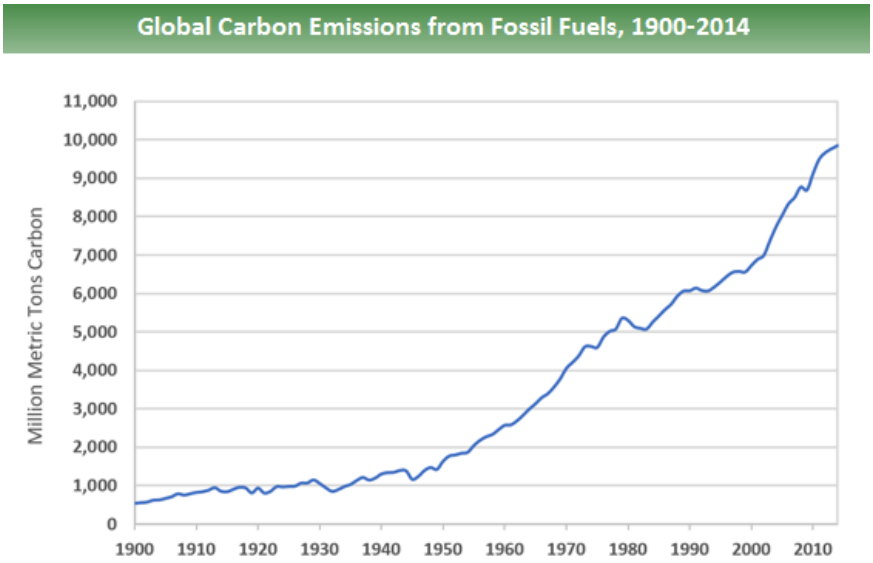
Record again the molar mass of CO_2 _____g/mol

You calculated that the ratio of carbon dioxide was 3:1 when burning butane. Is it the same ratio of CO_2 to octane in this combustion? Show all work for credit!

14. Ok! Now let's calculate how many kg of CO_2 you are producing in the atmosphere when you drive to and from school. Let's assume you live about 10 miles from school and so you are using up 1 gallon of gasoline in your commute. If the density of octane is 0.703 g/mL, and you use the ratio of 3:1 CO_2 to octane, what is the mass of CO_2 in kg that you produce in this commute? Use factor labeling ("dimensional analysis") and show all work for credit!

			↓Density of octane	↓ratio of CO_2:octane	
1 gal octane	3.79 Liters	?? mL			?? kg
	1 gal	?? L			?? g

Analysis



Source: Boden, T.A., Marland, G., and Andres, R.J. (2017). Global, Regional, and National Fossil-Fuel CO2 Emissions. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tenn., U.S.A. doi 10.3334/CDIAC/00001_V2017.

9. Write the mass of CO_2 produced in 2014 in metric tons. Notice the Y axis is MILLIONS of metric tons!

Make sure you include all of your zero's! _____

HINT: So for example, in the year 1910, there were 1,000,000,000,000 metric tons of CO_2 produced (1,000 from the graph x 1,000,000,000)

10. A small watermelon weighs about 1 kg. Convert your metric tons of CO_2 into kg of CO_2

1000 kg = 1 metric ton

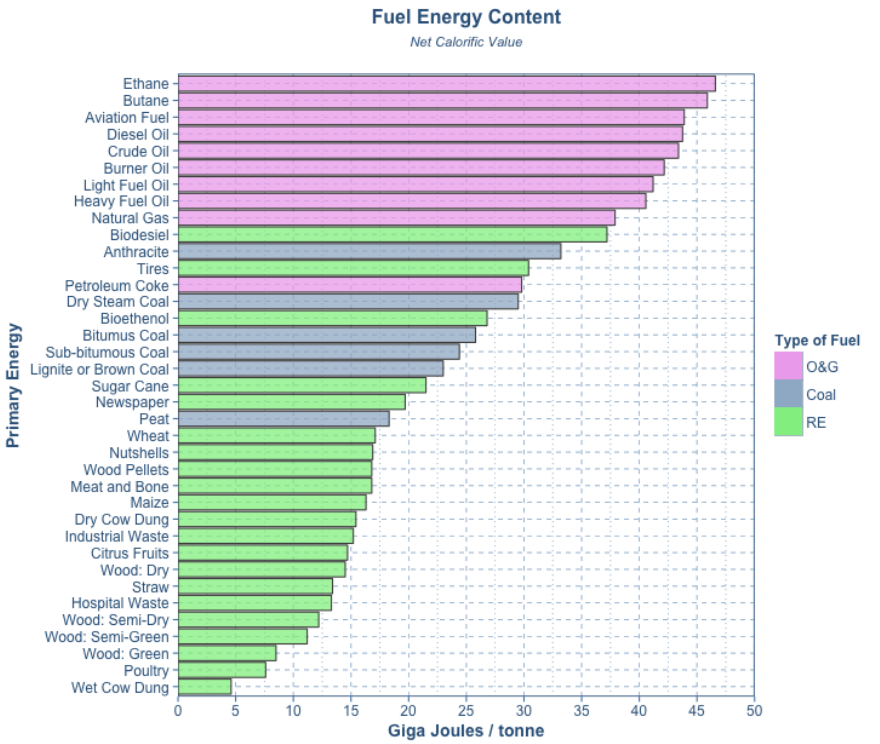
11. Here is a table of the CO_2 emissions from the top 10 biggests CO_2 producer countries summarized from the Union of Concerned Scientists in 2015. Which country is the biggest CO_2 producer? _____ What does "per capita" mean? _____ Which country has the biggest per capita production of CO_2? _____

2015 total emissions country rank	Country	2015 total carbon dioxide emissions from fuel combustion (million metric tons)	2015 per capita carbon dioxide emissions from fuel combustion (metric tons)
1	China	9040.74	6.59
2	United States	4997.50	15.53
3	India	2066.01	1.58
4	Russia	1468.99	10.19
5	Japan	1141.58	8.99
6	Germany	729.77	8.93
7	South Korea	585.99	11.58
8	Iran	552.40	6.98
9	Canada	549.23	15.32
10	Saudi Arabia	531.46	16.85

What kind of summary statement can you make from this table? Explain.

12. In 2016, the countries of the United Nations agreed to an historic pact to limit CO_2 emissions and thus control the effects of climate change. It is called the Paris Agreement. To date (2018), the only country who has NOT signed the Paris Agreement is the United States. Click HERE for a short video What questions do you have about the Paris Agreement and controlling CO_2 emissions?

13. Below is a diagram of some of the fuels burned in combustion around the world. O&G stands for oil and gas. Coal is the darker color, and RE is renewable fuels that are combusted. Write 3 summary statements that you can make about the information in this table.



http://bxhorn.com/energy-content-of-fuels/

14. Draw a model of what is happening to the carbon in the combustion of butane. Include in your model how the carbon ends up affecting the chemistry of the atmosphere.