Names: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Incomplete Combustion

(completely problematic!)

Burning carbon-based fuels (both fossil fuels and biofuels) gives us lots of energy, but can also produce some pretty nasty air pollutants. In this activity you will compare different carbon-based fuels to explore which ones burn most cleanly.

**Complete Combustion:**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Propane |   + | Oxygen gas |  → | Carbon Dioxide |  + | Water vapor |
|  |  |  |  |
|  = Carbon  = Hydrogen |   = Oxygen |   = Carbon = Oxygen |   = Hydrogen  = Oxygen |

1. In the reaction above, the fuel propane is burned completely. Propane is a fuel that is often used in grills, camping stoves, and sometimes engines. Which of the molecules above are reactants? What are their chemical formulas?
2. The two products in the reaction above are the two gases that are always produced in the complete combustion of carbon fuels. What are their chemical formulas?
3. How many molecules of carbon dioxide are produced when 1 molecule of propane is completely combusted?
4. How many molecules of O2 are required to completely combust 1 molecule of propane?
5. Are any atoms gained or lost in this chemical reaction?
6. Write a complete balanced equation for the combustion of propane shown in the model above.
7. Ok, nobody is going to burn just one molecule of propane, you’re going to need a lot more than that to produce energy. How many moles of oxygen gas are needed to completely burn one mole of propane?

**Incomplete combustion**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Octane (gasoline) |   + | Oxygen gas |  → |  |
|  |  |  |
| * = Carbon
* = Hydrogen
 |  = Oxygen | * = Carbon  = Hydrogen

 = Oxygen |

8. In the reaction above octane (which is a key molecule in gasoline) is combusted. But WAIT! We have the same number of oxygen molecules that we had for propane and IT’S NOT ENOUGH OXYGEN to completely combust the octane! When there is not enough oxygen **incomplete combustion** occurs. What are the two new products (besides carbon dioxide and water) that are produced in the reaction above? What are their chemical formulas?

9. Which of these products do you think represents the molecule of fuel that was not completely burned?

10. These two new pollutants are carbon monoxide and an unburned molecule of fuel. The unburned fuel can take the form of soot-- solid particles suspended in air which are also called Particulate Matter (PM for short), or the unburned fuel can be a smelly gas known as a Volatile Organic Compound (VOC). PM, VOCs and Carbon monoxide are all very harmful to humans. Carbon monoxide is a specific compound but PM and VOCs can be many different compounds. Draw at least two other carbon molecules that you think could result from incomplete combustion. (Hint: look at the octane molecule above and imagine that either more or fewer carbons are pulled off than in the model.)

11. In the incomplete combustion above, oxygen is the **limiting reactant**. Write your own definition for the term limiting reactant.

12. How much oxygen would you need to completely combust the octane? Hint: complete combustion would produce only CO2 and H2O. You can draw pictures if you need to.

Two other fuels:

|  |  |  |
| --- | --- | --- |
| Pentadecane (Diesel) |    | Methane (Natural Gas)  |
|  |    |
| * = Carbon
* = Hydrogen
 | * = Carbon
* = Hydrogen
 |

13. What are the chemical formulas for each of the fuels above?

14. Write a balanced chemical equation for the complete combustion of methane (i.e. reacting with oxygen gas and producing only carbon dioxide and water).

15. How many moles of O2 are required to completely combust 1 mole of methane?

16. Write a balanced chemical equation for the complete combustion of diesel.

17. How many moles of O2 are required to completely combust 1 mole of diesel?

18. Of the 4 fuels presented in this activity (propane, gasoline, diesel and natural gas. Which one do you think is most likely to burn incompletely and produce pullutants such as carbon monoxide and particulate matter? Explain why.

19. (Answer this question on back) Wood is made primarily of cellulose which is a carbon molecule with hundreds of individual carbon atoms bonded together. Based on the trends you’ve identified in this activity, why is it important to restrict wood burning when air pollution is bad?