Chem 107B - In-lab Problem Set #1 - Stoichiometry

1. How many pounds of carbon dioxide are released from the complete combustion of 10 gallons of gasoline?

Gasoline is a complex mixture of many chemicals. For the purpose of this calculation, we will assume that gasoline is comprised entirely of a compound called isooctane. You may know that gasoline pumps report the octane number for gasoline. The octane number is a comparison of how well the gasoline burns relative to pure isooctane. The chemical formula for isooctane is C_8H_{18}.

1 gallon = 3.8 liters
Density of isooctane = 0.703 g/ml
One pound = 454 grams

2. How much carbon dioxide and water are produced if 50 g of glucose and 70 g of oxygen gas react?

Glucose is a sugar that is the principal source of energy for humans. The energy is produced by a complex series of reactions which consume oxygen gas in the process. The final reaction we could write to summarize the entire series of reactions is identical in appearance to a combustion reaction. The chemical formula for glucose is $C_6H_{12}O_6$.

Chem 107B – In-lab problem set #2 - Concentration

1. Heavily impacted acid rain has a pH of 4.5 (we will cover acid-base chemistry and the concept of pH later this term). If the acidity were made up entirely of nitric acid, the concentration of nitric acid would be 3.16×10^{-5} M. If you wished to study the effects of acid rain in the lab, you would probably make up a solution of artificial acid rain for some of your testing.

a) What weight of pure nitric acid would be needed to make 3 liters of artificial acid rain?

   Is this a reasonable amount of nitric acid to weigh out?

b) Suppose you found a bottle of 15.9 M nitric acid. This is too concentrated for your purposes, but the concentration could be lowered by adding water to the solution. What volume in milliliters of this 15.9 M solution would be needed to prepare 3 liters of artificial acid rain?

   Is this a reasonable volume of the nitric acid to measure out?

2. One approach that has been used to neutralize the acidity in ponds and lakes heavily impacted by acid rain is to add a suspension of lime in water. The lime in such a mixture is calcium hydroxide, which has the chemical formula $Ca(OH)_2$. The concentration of lime in a typical suspension is 3.8 M.

What volume of this suspension would be needed to neutralize nitric acid in Lake Andrew if the concentration of nitric acid was 3.16×10^{-5} M. Assuming a diameter of 300 feet and average depth of 6 feet, the volume of Lake Andrews is 1.2×10^{7} liters.

Perform a similar calculation for Lake Auburn, the drinking water supply for Lewiston-Auburn. Lake Auburn has a volume of approximately 1.24×10^{11} liters.

Chem 108 - First Out-of-lab Assignment

1. The combustion of fossil fuels that are high in sulfur (and high-sulfur coal is a particular culprit) contributes considerably to acid precipitation through the formation of sulfuric acid H_2SO_4. The sulfuric acid is formed by a series of three reactions.

In the first, sulfur (S) reacts with oxygen gas to form sulfur dioxide (SO_2). Sulfur dioxide then reacts with oxygen gas to form sulfur trioxide (SO_3). Finally, sulfur trioxide reacts with water in the atmosphere to form sulfuric acid.

A) How many kilograms of sulfuric acid would form if one ton (2,000 pounds) of coal that was 0.5% in sulfur was burned in a power plant?

B) One way of removing sulfur dioxide from the smokestacks of power plants is to spray a slurry of lime - $Ca(OH)_2$ - in water into the exhaust gases. The lime will react with the sulfur dioxide to form calcium sulfite ($CaSO_3$) and water. What weight in kilograms would be needed to remove the sulfur dioxide produced by burning one ton of coal that was 0.5% in sulfur?

2. Another important component of acid rain is nitric acid (HNO_3). One environmental precursor to nitric acid is nitrogen dioxide (NO_2). The nitrogen dioxide reacts with water to produce nitric acid and nitric oxide (NO). An airplane such as the Concorde (or super-sonic transport) produced approximately 66 tons of nitrogen dioxide per hour of flight (this is a real number). How many tons of nitric acid are produced per hour of flight assuming all the nitrogen dioxide released is converted by the atmosphere into nitric acid?

3. Ethanol (CH_3CH_2OH or C_2H_6O) is the alcohol in wine and other alcoholic beverages. If ethanol is allowed to sit in contact with oxygen gas, a slow conversion to acetic acid (the active component in vinegar – $C_2H_4O_2$) occurs. Water is the other product of the reaction. How many grams of acetic acid would be produced if 90 g of ethanol reacted fully with 50 g of oxygen gas.

4. How many grams of carbon dioxide and water would be produced if 500 g of propane (C_3H_8) reacted fully with 1,000 g of oxygen gas?

Chem 107B - Second Out-of-lab Assignment

1. Referring back to problem 4 on the first out-of-class assignment, how many grams of propane remain unreacted?

2. Now lets add another wrinkle to problem 4 on the first out-of-class assignment. What we might say is that we are burning the propane under oxygen-lean (or oxygen-deficient) conditions. In this case, what might actually happen, is that the propane all burns so that there is none left over. Under such conditions, the end product is not all carbon dioxide, but a mixture of carbon monoxide (CO) and carbon dioxide. The other product of such a reaction is water. No oxygen gas will be left at the end of such a reaction.

If 500 grams of propane were reacted with 1,500 grams of oxygen gas under these conditions, how many grams of carbon monoxide and carbon dioxide would be produced?

HINT: You can think of this as a two-step process in which the propane is first combusted to carbon monoxide and water. If oxygen gas is then remaining, it can react with carbon monoxide to produce carbon dioxide.

3. A solution is prepared by dissolving 10.8 grams of ammonium sulfate [$(NH_4)_2SO_4$] in enough water to make 100.0 ml of stock solution. A 10.00 ml sample of this stock solution is added to 50.00 ml of water (note, the final volume is 60.00 ml). Calculate the concentration of ammonium sulfate in the final solution.

4. All of the lime [$Ca(OH)_2$] in a 50.00 ml aqueous sample can be reacted by adding 34.66 ml of a 0.0980 M solution of nitric acid. What is the molar concentration of lime in the original solution?

5. Problems in the textbook:

Page F69/70 - Problems G12 and G16
Page F107 - Problem L5
Page F114 - Problems M3 and M5