

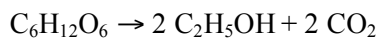
CHEM 101: PROBLEM SET #7

Due: Wednesday, October 31, 2007 by 11 AM.

Turn in to the Chem 101 box at the beginning of lecture or if you want to turn it in early, the box will be in Kathy Kennedy's office, the Chemistry Department secretary (Chem 303).

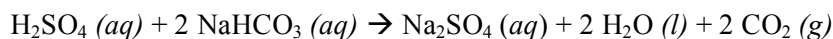
- Rain water is naturally slightly acidic because CO_2 in the atmosphere can dissolve in water droplets in clouds to form H_2CO_3 , carbonic acid. This is not usually acidic enough to cause problems. Usually the "acid rain" that we are concerned about results when sulfur oxides and nitrogen oxides dissolve in rainwater. A common source of SO_2 comes from burning coal that contains the mineral pyrite, FeS_2 .
 - Write a balanced equation for the reaction of FeS_2 with O_2 to produce Fe_2O_3 and SO_2 .
 - If 2.55 kg FeS_2 is burned, how many kg of SO_2 are produced?
 - If 125.0 g FeS_2 reacts with 125.0 g O_2 , how many grams of Fe_2O_3 can be produced? Which of the reactants is the limiting reagent?
 - SO_2 can be oxidized further by molecular oxygen to form SO_3 , which then reacts with water to form H_2SO_4 . Describe both of these processes with balanced chemical equations.
 - Assuming the availability of plenty of oxygen and water, how many kg of H_2SO_4 are produced from the burning of 2.55 kg FeS_2 in part (b)?
- Ammonia, NH_3 , is a popular fertilizer for cornfields in the Midwestern United States. An acre of corn requires 150. lbs of ammonia, which is applied in one allotment at the beginning of the growing season. Much of the nitrogen from the ammonia is incorporated into the structure of the plant. However, recent analysis by Crutzen and colleagues suggests that approximately 3.0% of the nitrogen from the NH_3 is eventually released by the plants in the form of nitrous oxide.
 - How many grams of N_2O are released into the atmosphere for every acre of corn grown?
 - According to an EPA website, there are 72.7 million acres of corn grown in the US. How many grams of N_2O are released by this total production on an annual basis?
 - The government is currently giving incentives for growers to produce corn in order to make ethanol for fuel. With the current incentive programs, the EPA estimates that an additional 16 million acres of corn could be added to the current yearly acreage. What would be the percent increase in the yearly production of N_2O if this increase in acreage occurs?
 - In addition to the nitrogen released to the atmosphere as N_2O , some of the nitrogen fertilizer is washed into nearby rivers such as the Mississippi. When nitrogen and phosphorus fertilizers enter the Gulf of Mexico, they cause algal blooms. When the algae die and decompose, this absorbs oxygen from the water, which results in there being insufficient dissolved oxygen for fish to survive. This is the "dead zone" in the gulf, which has been growing every year. In July 2007, the dead zone was judged to be approximately 7900 square miles. What would be the size of the dead zone you predict if the additional 16 million acres of corn are grown using the same fertilizers as they currently use?

3. As we try to find a new fuel source to supplement or replace waning petroleum reserves, ethanol and hydrogen gas are two of the top contenders. Ethanol (C_2H_5OH) is the product of carbohydrate (in this case glucose, $C_6H_{12}O_6$) fermentation, and right now fermentation of glucose in corn is the current favorite method:



- a) Write balanced reactions for the combustion of glucose, the combustion of ethanol, and the combustion of hydrogen gas (H_2).
- b) Hydrogen gas is most commonly produced by reacting natural gas with high temperature water vapor in the presence of a catalyst. Write a balanced equation showing the reaction of propane (C_3H_8) with H_2O to form H_2 and CO_2 .
- c) The heat content of glucose is 15.6 kJ/g (that means that 15.6 kJ of energy are released by burning 1 g of glucose). For ethanol, the heat content is 29.7 kJ/g. The heat content of hydrogen gas is 142 kJ/g. Calculate the mass of CO_2 produced per kJ of energy for each fuel. *Hint:* Consider burning 1.00 kg of each fuel. For H_2 , consider the CO_2 that was produced to make the H_2 in the first place.
4. Hydrogen cyanide, HCN, can be prepared from ammonia, NH_3 , oxygen gas, and methane gas, CH_4 . The reaction also produces H_2O .
- a) Write a balanced equation showing the reaction that forms HCN.
- b) If the reaction vessel contains 11.5 g NH_3 , 24.0 g O_2 , and 10.5 g CH_4 , what is the theoretical yield (in grams) of HCN?
- c) If 9.35 g of HCN is actually produced, what is the percent yield?
5. A flask containing 225 mL of 0.855 M H_2SO_4 was knocked on the floor.

- a) How many grams of $NaHCO_3$ do you need to put on the spill to neutralize the acid according to the following equation?



- b) How many grams of CO_2 are produced in this reaction?