The Praying Mantis is a carnivorous insect that has been exploited in order to control "unwanted" insects in the garden. Several gardening companies sell mantids for profit. Let's say that you, an entrepreneur, are looking for an idea for a new business.

The Golden Rule: Hungry female mantids have a nasty habit of eating male mantids (usually head first). Therefore, to insure success in the mating process both female and male mantids should be well fed for many days before the male and female cohabitate the same cage.

For the purpose of this experiment, we will introduce 2 fully fed female mantids and 5 'hungry' female mantids for mating to 1 very randy, and already fed male mantis. To simplify the problem let's make the following assumptions:

#1: A fed male will always mate if a female is available (ignore parallels to human behavior).
#2: If given a choice the male will ALWAYS mate with a female who is fed before he mates with a female that is hungry (wouldn't you do the same thing if you were a male mantis?).
#3: A Female mantis will only eat her mate if she is not fed.
#4: A Female mantis will only eat a male AFTER she has mated with him.

The mating of the mantids is analogous to a chemical reaction since the product of the mating is ~12 to 400 eggs, depending on the mantis species. We will also assume for simplicity that each female mantis that successfully breeds will produce 100 mantis eggs.

The overall reaction is shown in Equation (I):

\[2 \text{ Fed female} + 5 \text{ Hungry female} + 1 \text{ Fed male} \rightarrow 4 \text{ Hungry female} + 3 \text{ Fed female} + 300 \text{ Eggs} \quad \text{Eq. (I)}\]

1. (a) What are the reactants?

2 Fed female + 5 Hungry female + 1 Fed male

(b) Are all of the reactants completely "consumed" in this reaction? No
(c) If not, which reactant(s) species is/are not "consumed"? Hungry female
(d) Write the net reaction.

2 Fed female + 1 Hungry female + 1 Fed male → 3 Fed female + 300 Eggs

2. What is the limiting reactant in Eq. (I)? Fed Male

3. What would be the net reaction and the theoretical yield from Eq. (I) if all of the female mantids were fully fed (not fed by eating the mating male) prior to mating? 700 Eggs
Combustion reactions are defined by our book as “rapid reactions that produce a flame.” An important class of combustion reactions involve the reaction of hydrocarbons, (i.e. methane, propane, octane, etc.) or oxygenated hydrocarbons (i.e. methanol, ethanol, glucose, etc) with oxygen to produce carbon dioxide and water. An example of this type of reaction is the combustion of ethanol (C₂H₅OH). Today we’re going to examine this reaction further.

4. Write a balanced chemical equation for the combustion of ethanol (C₂H₅OH).

\[ \text{C}_2\text{H}_5\text{OH} (\text{g}) + 3\text{O}_2(\text{g}) \rightarrow 2\text{CO}_2(\text{g}) + 3\text{H}_2\text{O}(\text{g}) \]

5. Consider the reaction between 2 ethanol molecules and 7 oxygen molecules shown below (carbon atoms are represented as lightly shaded spheres, oxygen atoms as dark spheres, and hydrogen atoms as the small white spheres). Sketch in the molecules present on the product side.

6. Identify the limiting reactant, excess reactant and theoretical yield of both products (in numbers of molecules).

   Limiting Reactant = Ethanol (C₂H₅OH)
   Excess Reactant = Oxygen (O₂)
   Theoretical Yield = 4 molecules CO and 6 molecules H₂O

7. Now consider the reaction between 9.02 g of C₂H₅OH and 22.4 g of O₂.

   a. How many moles of each reactant are present prior to the reaction?
   
   \[
   \begin{align*}
   9.02 \text{ g C}_2\text{H}_5\text{OH} & \times (1 \text{ mole C}_2\text{H}_5\text{OH} / 46.07 \text{ g C}_2\text{H}_5\text{OH}) = 0.196 \text{ mol C}_2\text{H}_5\text{OH} \\
   22.4 \text{ g O}_2 & \times (1 \text{ mole O}_2 / 32.00 \text{ g C}_2\text{H}_5\text{OH}) = 0.700 \text{ mol O}_2
   \end{align*}
   \]

   b. Identify the limiting reactant, excess reactant and theoretical yield of both products (in grams).
0.196 mol C₂H₅OH × (2 mole CO₂/1 mole C₂H₅OH) × (44.01 g CO₂/1 mole CO₂) = 17.3 g CO₂

0.700 mol O₂ × (2 mole CO₂/3 moles O₂) × (44.01 g CO₂/1 mole CO₂) = 20.5 g CO₂

The yield of CO₂ is smaller when starting from C₂H₅OH. This tells me that C₂H₅OH is the limiting reactant (runs out first), O₂ is the excess reactant and that the theoretical yield of CO₂ is 17.3 g. All that is left is to calculate the theoretical yield of H₂O starting from the amount of the limiting reactant (C₂H₅OH).

0.196 mol C₂H₅OH × (3 mole H₂O/1 mole C₂H₅OH) × (18.02 g H₂O/1 mole H₂O) = 10.6 g H₂O

8. Since a molecule of water contains no ions or mobile electrons, why does tap water conduct electricity?

9. When we stir a spoonful of sugar into a cup of coffee is it melting? In this process do the sugar molecules remain intact or come apart?

A substance, such as sugar, melts when it changes physical state from a solid to a liquid. When it melts it changes from a rigid crystalline structure (a solid) to a much looser, freely flowing, clustered arrangement (a liquid). Dissolving, although it may look very similar, is actually quite different: sugar when dissolved goes from its solid state to its aqueous state. This means that the sugar becomes surrounded by loosely bound water molecules.

10. The following exercise tests if you can distinguish a weak acid from a strong acid. H⁺ is in the form of H₃O⁺ since H⁺ will always hydrogen-bond with at least one nearby water molecule. Classify each of the acids (HA) below as a weak or a strong acid, and list the acids in order of increasing acidity.

Ans: acids increase in this order- HX, HZ, then HY (HY being the strongest acid)
11. Which of the following statement(s) about strong acids is (are) true?
   a) HC₂H₃O₂ is a stronger acid than H₂SO₄ because there are more protons bound to the anion
   b) Strong acids are completely ionized in water
   c) The weak acid HF reacts with glassware, whereas the strong acid HCl does not
   d) A 2M HC₂H₃O₂ solution is more acidic than a 1M HCl solution
   e) Strong acids produce solutions with a high pH.

(b)

12. Beer is a complex aqueous solution but it is dilute. We therefore can approximate its density with that of water (1.00 g = 1.00 mL). Many people have heard of "3.2 beer" which means the beer is 3.2% ethanol by weight. If we have one liter of 3.2 beer (it is Oktoberfest time), what is the molarity of alcohol? Ethyl alcohol has a molar mass of 46.04 g/mol.

Ans:
? moles of ethanol = 1 L beer x (1000 mL beer /L beer) x (1.00 g beer /1.00 mL beer) x (0.032 g ethanol/1.000 g beer) x (1 mol/46.04 g ethanol) = 0.695 mol
? Molarity of ethanol = 0.695 mol ethanol/ 1 L beer = 0.695 M = 0.70 M