Experiment 14 - Preparation of Glutamic Acid

Monosodium glutamate, commonly known as MSG, is a well-known food additive. When MSG is mixed with a strong acid, such as sulfuric acid or hydrochloric acid, it reacts to form glutamic acid. Glutamic acid is one of the 20 amino acids that are the components of all proteins. MSG is very soluble in water, but glutamic acid is only slightly soluble. When sulfuric acid is added to a solution of MSG in water, glutamic acid will precipitate out of solution as it forms. The reaction that takes place is:

$$\underset{\text{MSG}}{2\ NaC_5H_8NO_{4\ (aq)}} + \underset{\text{sulfuric acid}}{H_2SO_{4\ (aq)}} \rightarrow \underset{\text{glutamic acid}}{2\ C_5H_9NO_{4\ (s)}} + \underset{\text{sodium sulfate}}{Na_2SO_{4\ (aq)}}$$

Notice that in the balanced equation *two* moles of MSG react with *one* mole of H_2SO_4. In this experiment, glutamic acid will be prepared from MSG. The glutamic acid will be collected and weighed. From the weight of glutamic acid that is collected, the <u>percentage yield</u> of the reaction will be calculated.

<u>Safety Precautions:</u>

- Wear your safety goggles.
- Use care when handling sulfuric acid. If any acid splashes on you, rinse it off immediately with lots of water.

<u>Waste disposal:</u>

- Liquid waste from this experiment can go down the sink with plenty of water. (Run the faucet as you dump the waste in the sink.)
- Solid waste can go in the regular garbage can.

<u>Procedure</u>

1. Weigh a clean, dry 125-mL or 250-mL Erlenmeyer flask. (Use a digital balance for all weighings.) Add between 3 and 5 grams of MSG to the flask. The MSG can be weighed directly into the flask by measuring the increase in the weight of the flask when MSG is added to it. Record the weight of the flask both before and after the MSG is added to it as accurately as possible.
2. Dissolve the MSG in water by adding 30 mL of water to the flask and swirling until you no longer see any solid. (The amount of water added does not need to be measured accurately.) You are now ready to start the reaction by adding sulfuric acid to the solution. Add between 4 mL and 6 mL of 2.5 M H_2SO_4 from a graduated cylinder or from a buret to the MSG solution. The volume of H_2SO_4 can be anywhere between 4 mL and 6 mL, but you should record the exact volume used to the nearest 0.1 mL (e.g., 4.5 mL, 6.0 mL, 5.7 mL, etc.). Swirl the entire solution to mix the contents. Then put a cork or stopper on the flask and let it stand. Crystals of glutamic acid will appear. If the flask is allowed to stand completely undisturbed, the crystals will form slowly, but they will be large, well-formed crystals. If the flask is shaken or stirred with a stirring rod, glutamic acid will come out of solution more rapidly, but it will not form large crystals. Slowly crystallized material is generally considered to be more pure than a quickly precipitated product. Allow the flask to stand until crystallization is complete, preferably until the next lab period.

3. To collect the glutamic acid, prepare a funnel with a piece of filter paper. (Ask your lab instructor for the correct method of folding the filter paper.) Place the funnel in the neck of a flask or suspend it from a ring over a flask or beaker. Then pour the reaction mixture onto the filter paper in the funnel. Try to pour it so that as much of the glutamic acid as possible gets onto the filter paper (and does not remain in the flask). If some of the glutamic acid remains on the walls of the flask, remove it by adding some of the filtrate (the filtrate is the liquid that went through the filter paper) back to the flask with the glutamic acid in it, swirling the liquid to suspend the glutamic acid in it, and pouring the mixture onto the filter paper. Finally, wash the glutamic acid by pouring 10 mL of distilled water over it and through the filter paper. It is important not to add a lot of wash water to the crystallized glutamic acid. Glutamic acid is not very soluble in water, but it is *somewhat* soluble. If you add a lot of wash water, you increase the danger of losing glutamic acid because of it dissolving in the wash water. This is also the reason for using the filtrate instead of water to collect the last bits of glutamic acid from the flask. The filtrate is already saturated with glutamic acid, so additional glutamic acid will not dissolve in it.
4. The glutamic acid must now be dried. This can be done by leaving the funnel with the glutamic acid and the filter paper in it in your locker until the next lab period, or the glutamic acid can be dried more rapidly by placing it in an oven at 110°C.
5. When the glutamic acid is dry, it should be collected and weighed. First weigh an empty container in which the glutamic acid will be collected. Then remove the filter paper from the funnel, scrape the glutamic acid loose from the filter paper with a spatula or scoop and pour it into the container. Weigh the container with the glutamic acid in it.
6. Determine the mass of glutamic acid by subtraction, and calculate the percentage yield of glutamic acid collected from your reaction.

$$\text{percent yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100$$

Calculations

1. To calculate the percentage yield of glutamic acid, the number of moles of MSG and H_2SO_4 that reacted must be known. For the MSG, the number of moles is calculated from the number of grams weighed out and the molar mass of MSG (see the introduction section for the formula of MSG). For the sulfuric acid, the number of moles is calculated from the number of milliliters used and the molarity of the solution.
2. Next, the limiting reactant must be found. This will not be the same for all students, since the amounts of chemicals used varied. In determining the limiting reactant, remember that the balanced equation shows that two moles of MSG react with one mole of H_2SO_4.
3. When the limiting reactant is known, the theoretical yield of glutamic acid from the reaction you performed can be calculated. By comparing the number of grams of glutamic acid that you obtained to the theoretical yield, the percentage yield of your reaction can be calculated.

Questions

1. List and explain any steps in the procedure in which it is possible to lose glutamic acid or otherwise decrease the actual yield of the reaction.
2. What would you conclude if you determined that your percent yield was over 100%?
3. If you used 7.50 g of MSG and 7.00 mL of 3.0 M H_2SO_4, what mass of glutamic acid should be formed in theory? Show your work.