Thermodynamics of Hydrogen Peroxide's Decomposition

At the beginning of the term we discussed and observed the exothermic decomposition of hydrogen peroxide in the presence of Fe^{3+}. Although present as a reactant, the reaction's stoichiometry does not include Fe^{3+}

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

The purpose of this two-week, open-ended project is to design and carry out suitable experiments that will help you answer the following three questions:

- Does the absolute amount of heat produced during the decomposition of hydrogen peroxide depend on the quantity of H_2O_2 and/or the quantity of Fe^{3+} used?
- Can you demonstrate experimentally that Fe^{3+} serves as a catalyst for the decomposition of hydrogen peroxide?
- What is the value of ΔH for the decomposition of hydrogen peroxide?

Preparing for Lab

Planning for this lab is critical to your success. Be sure to complete the relevant sections of your notebook before each week's lab session. As you develop strategies to explore and answer the questions posed above, keep the following in mind:

- The easiest way to demonstrate a relationship between two variables is to ensure that all other variables remain fixed.
- A calorimeter is not a perfect insulator; thus, you need to determine if the amount of heat your calorimeter absorbs is significant and, if so, determine how to correct for this when you report ΔH. Hint: Search for information about calorimeter constants, but be forewarned that many on-line sources do not follow the standard convention for reporting a change in temperature.
- Be sure to investigate the properties of a catalyst and to consider how you can verify that Fe^{3+} behaves as a catalyst for this reaction.
- To determine a value for ΔH you must make some assumptions. Identify these assumptions and, where possible, consider how you can minimize them. When an assumption is necessary, consider how it might affect your results. Not all assumptions are reasonable and unreasonable assumptions can lead to poor results.
- Compare your experimental result for ΔH with its theoretical values and identify possible source(s) of error that are consistent with their difference.

Procedure

Stock solutions of H_2O_2 and $Fe(NO_3)_3$ are available in lab (the exact concentrations are provided on the bottles). You may dilute these solutions as needed. Calorimeters also are provided.

Cautions

The decomposition of hydrogen peroxide is reasonably exothermic and, depending on your experimental conditions, can produce solutions with temperatures near or above 60°C. Additionally, the rapid formation of O_2 can produce enough pressure to shoot the hot contents out through the small holes in the calorimeter's lid. It is a good idea to first test any reaction without placing a lid on your calorimeter, observing the approximate change in temperature and noting how vigorous the reaction is. Be careful and wear your safety glasses at all times.

Waste Disposal

You may dispose of all solutions by rinsing them down the drain with copious amounts of water.

Lab Report

For the first three project-based labs, each group member will take on one of the following three roles, each of which defines responsibilities and the form of the final report. Each group member will serve once in each role; the assigning of roles is left to you. *Note: For a group with two members, you will need to share the responsibilities assigned to the chemist and the technician during all three experiments and share the responsibilities of lab manager for one experiment.*

Role	Final Product	Responsibilities
Manager	formal report	organizes all aspects of the group's work both in and out of lab; makes all final decisions on experimental design; determines when sufficient work is complete
Chemist	short report	prepares solutions; weighs out samples; carries out the experiment
Technician	oral report	sets up, calibrates, and optimizes the group's equipment; maintains the group's electronic laboratory notebook

All group members must contribute to planning the experiment and to the analysis of data, and are responsible for understanding how to convert the experiment's data into results. Here are some details on the different types of reports:

- For the **formal** report you will present the results of your experimental work in the form of a journal article. For more details on the format of formal reports, review the document "Some Guidelines for Preparing a Formal Report," "Sample Report," and "Rubric for Evaluating Formal Reports" available at the course website. Although I will not formally review a draft of your report, I do encourage you to bring a draft of your report to my office with specific questions you wish to discuss. This report is due Thursday, April 6th.
- For the **short** report you will receive a set of data that is similar to that collected in lab along with some specific questions to answer using this data. This report is due Friday, March 24th.
- For the **oral** report we will meet to discuss your group's work on this experiment. To prepare for this meeting, review your group's experimental plan, your group's data, and your group's analysis of that data. When you are ready, schedule a 30 minute meeting with me. This meeting should take place after your group has finished analyzing the data, but no later than Friday, March 24th.