Oxidation of Acetone by Bleach

Calorimetry

Concepts

- Calorimetry
- Specific heat capacity

Background

The energy released during a chemical reaction may be determined by the use of a *calorimeter*. A calorimeter is a closed, insulated container in which the reaction may take place without exchanging heat with the surroundings. In real systems, of course, we must allow for the heat that will be absorbed by the calorimeter itself, but this amount of heat known as the *heat capacity* of the calorimeter, is easily measured. Knowledge of the magnitude of the temperature change that takes place, the specific heat capacity of the calorimeter and the amount of one of the reactants that is consumed in the reaction allows the energy released or absorbed to be calculated in terms of Joules per mole of reactant. See Equation 1.

$$q = m_{water} \times \Delta T \times 1 \text{ cal/g } ^\circ\text{C} \qquad \textit{Equation 1}$$

For the case where all the heat released is used to heat water, the amount of heat involved was traditionally found by the relation where the last term, 1 cal/g °C, is called the *specific heat capacity of water*; it is in fact the definition of a calorie. The value of q may be changed to Joules by the conversion factor, 1 calorie = 1.184 Joules, exactly; thus, the equation which is used is listed below.

$$q = m_{water} \times \Delta T \times 4.184 \text{ J/g } ^\circ\text{C}$$

This reaction will mix acetone and sodium hypochlorite. See Equation 2 below.

$$CH_3{-}\overset{\overset{O}{\|}}{C}{-}CH_3 + 3OCl^- \rightarrow 2OH^- + CH_3{-}\overset{\overset{O}{\|}}{C}{-}O^- + CHCl_3 \qquad \textit{Equation 2}$$

Materials

Acetone, CH_3COCH_3, 5.0 %, 4 mL	Graduated cylinder, 50-mL
Sodium hypochlorite solution, NaOCl, 5%. 20 mL	Paper towel
Beaker, 50-mL	Styrofoam® cup
Beaker, 100-mL	Thermometer
Graduated cylinder, 10-mL	Water bath

Safety Precautions

This demonstration must be done in a fume hood. One of the products of this reaction is chloroform which is a possible carcinogen. Prolonged inhalation may be fatal; toxic and narcotic by inhalation, ingestion may be fatal. Sodium hypochlorite solution is a corrosive liquid; causes skin burns; reacts with acid to evolve chlorine gas; evolves chlorine when heated; moderately toxic by ingestion and inhalation; avoid contact with organic material. Acetone is a dangerous fire risk; flammable; slightly toxic by ingestion and inhalation. Wear chemical splash goggles, chemical-resistant gloves and a chemical-resistant apron. Wash hands thoroughly with soap and water before leaving the laboratory. Follow all laboratory safety guidelines. Please review current Material Safety Data Sheets for additional safety, handling and disposal information.

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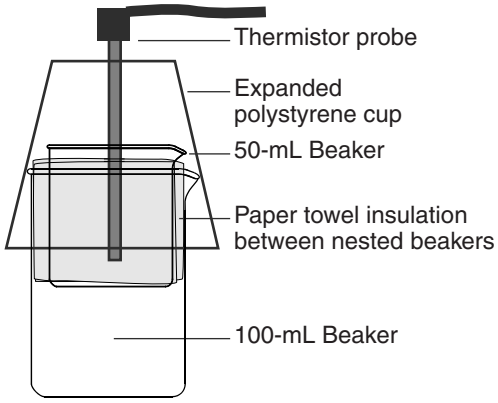
Preparation



1. The acetone sold at Flinn Scientific is 13.6 M. 5.0% acetone is approximately .68 M. To make 50 mL of .68 M acetone used in this lab mix 2.5 mL of reagent grade acetone (13.6 M) with 47.5 mL of distilled or deionized water.
2. Nest a 50-mL beaker, wrapped with paper towel, inside a 100 mL beaker.
3. Cut a hole large enough to snuggly fit a thermometer in either a piece of cardboard or a Styrofoam® cup which serves as a lid of the calorimeter. *Note:* The thermometer should extend to just above the bottom of the 50-mL beaker so that the liquid will cover the bulb as much as possible.

Procedure

Part A. Determining Change in Temperature

1. Use a 25-mL graduated cylinder to measure 20 mL of 5.0 % sodium hypochlorite and add it to the 50-mL beaker.
2. Place the lid (containing the thermometer) on the calorimeter and record the temperature of the sodium hypochlorite.
3. Use a 10-mL graduated cylinder to measure 4 mL of 5.0% acetone.
4. Remove the lid of the calorimeter and quickly add the 4 mL of acetone to the 50-mL beaker.
5. Quickly replace the lid and thermometer. Record the highest temperature reached by the mixture. Gently swirl the beaker to ensure thorough mixing. *Note:* The system usually takes 3–4 minutes to reach maximum temperature.
6. Rinse and dry the 50-mL beaker and repeat the experiment twice and average the results for change of temperature for the reaction.

Part B. Determination of Heat Capacity of the Calorimeter

7. Clean and dry the 50-mL beaker and thermometer.
8. Repeat the experiment with the following changes. Replace the bleach with 12 mL of water at room temperature. Replace the acetone with 12 mL of water heated to a temperature of 40–50 °C. Record the exact temperature.
9. It is important to note that the total volume of liquid after mixing equals the total volume of acetone and sodium hypochlorite in part A. The cool water is placed directly into the 50-mL beaker.
10. Place an equal volume of water in a 25-mL graduated cylinder. Place the cylinder in a hot water bath for about five minutes or until the temperature of the water in the cylinder equals that of the water bath.
11. Place a thermometer directly into the graduated cylinder and record the temperature of the warm water just before pouring it into the 50-mL beaker with the room temperature water.
12. It is critical that the hot water is added immediately to the 50-mL beaker as it rapidly loses heat in air.
13. Take temperature data in the same manner as in Part A.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. One of the products of this lab is chloroform. This solution should be evaporated in a hood according to Flinn Suggested Disposal Method #27j.

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12
Evidence, models, and explanation
Constancy, change, and measurement
Content Standards: Grades 5–8
Content Standard B: Physical Science, properties and changes of properties in matter, transfer of energy.
Content Standards: Grades 9–12
Content Standard B: Physical Science, structure and properties of matter, conservation of energy and increase in disorder, interactions of energy and matter.

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Oxidation of Acetone by Bleach* activity, presented by John Little, is available in *Calorimetry*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Oxidation of Acetone by Bleach* are available from Flinn Scientific, Inc.

Catalog No.	Description
S0079	Sodium Hypochlorite Solution, 5%, 500 mL
A0009	Acetone, 500 mL

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.