**Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Determination of Concentration by Redox Titration**

Guiding Question: Is expired hydrogen peroxide safe to use?

Background Information: So far this year, we have learned many ways to express the concentration of a solution, namely molarity (*M*), molality (*m*), parts per million (ppm), and mass percentage (grams solute per 100 grams solution). *Mass-volume percentage* (often abbreviated % m/v) is another way to describe the concentration of a solution. %m/v describes the mass of the solute in g per 100 mL of solution. Mass-volume percentage is often used for solutions made from a solid solute dissolved in a liquid. For example, a 40% m/v sugar solution contains 40 g of sugar per 100 mL of solution. The label on a bottle of commercial antiseptic reads “3% m/v hydrogen peroxide”. But is this accurate? The object of this experiment is to check this value. The *actual* percentage of hydrogen peroxide, H2O2, in the antiseptic can be determined by reacting the peroxide solution with potassium permanganate solution. If we know the molarity of the KMnO4 and the volume used to react with a known volume of H2O2 solution, we can calculate the amount of hydrogen peroxide in the bottle of hydrogen peroxide solution and then its concentration.

**Materials:** Two 1-mL syringes, hydrogen peroxide solution (3% m/v), 6 M sulfuric acid, 2% m/v potassium permanganate solution , sodium carbonate, 1 mini plastic cup

**Pre-lab Questions:**

1. Write the *net ionic* equation for the redox reaction between the potassium permanganate and hydrogen peroxide that will be carried out in this lab under acidic conditions. The peroxide decomposes into oxygen gas and the permanganate becomes manganese (II).
2. Identify which species is oxidized and which species is reduced.
3. Unlike acid-base titrations, we do not need to use an indicator to recognize when this reaction has gone to completion. How will you know when the titration is complete?
4. Calculate the number of moles of H2O2 present in a sample if it takes 0.50 mL of 3.0 M KMnO4 solution to react completely with the sample of H2O2.

**Procedure**

1. Begin by measuring 1.00 mL of H2O2 solution in the blue-tipped syringe. Record the initial volume.
2. Fill the red-tipped syringe with 1.00mL of the standardized potassium permanganate solution. Record the initial volume and concentration of the KMnO4 solution.
3. Add ~5 drops of the hydrogen peroxide solution to the mini plastic cup. Record the final volume of the hydrogen peroxide solution. The remaining H2O2 solution may be discarded in the sink.
4. To the same plastic cup, add **ONE drop of 18M sulfuric acid (careful!)** and carefully swirl the cup to mix.
5. Titrate the potassium permanganate solution drop by drop to the cup, carefully swirling the cup to mix the solution after each drop. Continue adding the potassium permanganate solution and mixing the solution until a faint pink color persists, resisting swirling.
6. Record the final volume of potassium permanganate solution.
7. **Caution!**  The solution in the plastic cup at the end of the titration is highly acidic and must be neutralized before you dispose of it. Add a small amount of sodium hydrogen carbonate to the plastic cup. The solution will foam as the basic sodium carbonate reacts with sulfuric acid. Gentle swirling of the cup speeds the neutralization. Rinse the cup with water and dry with a paper towel.
8. Repeat the titration using the expired H2O2 solution. Use the same blue syringe that you used for the fresh solution. Fill the syringe with the expired solution once and empty that down the drain. Then measure 1.00 mL of the expired solution in the syringe and record the volume.

|  | Trial 1  (Fresh H2O2 solution) | Trial 2  (Expired H2O2 solution) |
| --- | --- | --- |
| Initial volume of **H2O2**solution (mL) |  |  |
| Final volume of **H2O2** solution (mL) |  |  |
| 1. Volume of **H2O2** solution *reacted* (mL) |  |  |
| Initial volume of **KMnO4** solution (mL) |  |  |
| Final volume of **KMnO4** solution (mL) |  |  |
| 1. Volume of **KMnO4** solution *reacted* (mL) |  |  |
| Concentration of **KMnO4** solution | 2.00 % | |
| 2. Molarity of **KMnO4**solution |  | |
| 3. Moles of **KMnO4** consumed in the reaction |  |  |
| 4. Moles of **H2O2** consumed in the reaction |  |  |
| 5. Grams of **H2O2** consumed in the reaction |  |  |
| 6. % m/v of **H2O2** |  |  |
| 7. Molarity of **H2O2** solution |  |  |

**Analysis** (show setups for one Trial only)

1. Calculate the volumes of H2O2 and KMnO4 solutions that were reacted.
2. Calculate the molarity of the KMnO4 solution given the %m/v concentration.
3. Use the molarity to calculate the number of moles of KMnO4 consumed in the reaction.
4. Calculate the number of moles of H2O2 consumed in the reaction.
5. Calculate the number of grams of H2O2 consumed in the reaction.
6. Calculate the concentration of the H2O2 solution in terms of mass-volume percentage (% m/v).
7. Calculate the molarity of the H2O2 solution.
8. Repeat #1-7 for the expired H2O2 solution. No work needed. Record all answers in the data table.

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**Claim:** Compare the concentrations of the fresh and expired hydrogen peroxide solutions to each other. What does it mean if hydrogen peroxide (or anything, including food, for that matter) is “expired”? Is it just “old” or has something else happened to it?

**Evidence**: How do your results compare with the stated concentration on the label of the bottle? Explain with proof.

**Justification:** What scientific concepts are important to explain the evidence?

