Analysis of Hydrogen Peroxide
Prelab & Introductory Activity Key

Prelab Questions

1) A sample of oxalic acid, $H_2C_2O_4$, is titrated with a standardized solution of $KMnO_4$. A 25.00-mL sample of oxalic acid required 12.70 mL of 0.0206 M $KMnO_4$ to achieve a pink solution. The balanced equation for this reaction is shown below.

$$\mathbf{6\ H^+\ (aq) + 2\ MnO_4^-\ (aq) + 5\ H_2C_2O_4\ (aq) \rightarrow 10\ CO_2\ (g) + 8\ H_2O\ (\mathit{l}) + 2\ Mn^{2+}\ (aq)}$$

a. The pink is the excess MnO_4^- after reaching the equivalence point

b. $5\ H_2C_2O_4 : 2\ MnO_4^-$

c. $$?\ \text{mol}\ MnO_4^- = 12.70\ \text{mL} \times \frac{0.0206\ \text{mol}\ MnO_4^-}{1000\ \text{L}} = 2.62 \times 10^{-4}\ \text{mol}\ MnO_4^-$$

d. $$?\ \text{mol}\ H_2C_2O_4 = 2.62 \times 10^{-4}\ \text{mol}\ MnO_4^- \times \frac{5\ \text{mol}\ H_2C_2O_4}{2\ \text{mol}\ MnO_4^-} = 6.54 \times 10^{-4}\ \text{mol}\ H_2C_2O_4$$

e. $$?\ \text{M} = \frac{6.54 \times 10^{-4}\ \text{mol}\ H_2C_2O_4}{25.00\ \text{mL}} \times \frac{1\ \text{mL}}{1 \times 10^{-3}\ \text{L}} = 0.0262\ \text{M}\ H_2C_2O_4$$

f. $$\text{Mass}\ H_2C_2O_4 = 6.54 \times 10^{-4}\ \text{mol}\ H_2C_2O_4 \times \frac{90.03\ \text{g}\ H_2C_2O_4}{1\ \text{mol}\ H_2C_2O_4} = 0.0589\ \text{g}\ H_2C_2O_4$$

$$\text{Mass solution} = 25.00\ \text{mL} \times \frac{1\ \text{g}}{1\ \text{mL}} = 1.00\ \text{g}$$

$$\text{Mass \%}\ H_2C_2O_4 = \frac{0.589\ \text{g}\ H_2C_2O_4}{25.00\ \text{g solution}} \times 100 = 0.236\%\ H_2C_2O_4$$

Part A: Introductory Activity: Standardizing a Potassium Permanganate Solution
(Titration of a $KMnO_4$ with Fe^{2+} standard)

2) The purpose of this part of the lab is to standardize a potassium permanganate solution.
   a) What does "to standardize a solution" mean?
   Standardizing means determination of the concentration of the titrant, the solution used in the titration as the known concentration to determine the unknown concentration of the solution being analyzed.

   b) The standardization of $KMnO_4$ will be accomplished by doing a titration. What specific compound (give full chemical formula) will act as the standard? Why can it act as a standard?
   Ferrous ammonium sulfate [note: ferrous is the traditional name for iron(II)]. It can act as a standard since it is easy to measure out a known mass, and since it is not a hydrate it has a known molar mass.

3) In step #8 of the procedure given, it states to add about 10 mL of water to the flask. Would the results of the experiment be affected if 20 mL of water were used instead? Explain.
   No, adding extra water would not affect the results since it is the absolute *moles* of the standard, not its concentration, that we are determining.

PART B: Guided-Inquiry: Determination of the percent hydrogen peroxide in a given H_2O_2 sample (Titration of H_2O_2 sample with standardized $KMnO_4$ solution.)

The purpose of this part of the lab is to determine the percent hydrogen peroxide in a given H_2O_2 sample by titrating it with the standardized $KMnO_4$ solution. The balanced chemical equation for the reaction that occurs during the titration is the following:

6)
$$m_{H_2O_2} = 1.00 \text{ mL sol'n} \times \frac{1.00 \text{ g}}{1 \text{ mL}} \times \frac{3\% \text{ } H_2O_2}{100\% \text{ sol'n}} = 0.0300 \text{ g } H_2O_2$$

$$\text{mol}_{H_2O_2} = 0.0300 \text{ g } H_2O_2 \times \frac{1 \text{ mol } H_2O_2}{34.02 \text{ g } H_2O_2} = 8.82 \times 10^{-4} \text{ mol } H_2O_2$$

7)
$$V_{MnO_4^-} = 8.82 \times 10^{-4} \text{ mol } H_2O_2 \times \frac{2 \text{ mol } MnO_4^-}{5 \text{ mol } H_2O_2} \times \frac{1000 \text{ mL } MnO_4^-}{0.02 \text{ mol } MnO_4^-} = 18 \text{ mL } MnO_4^-$$

8) In neutral or basic solution, MnO_4^- is reduced to MnO_2, a dark brown solid, which will form an opaque slurry that interferes with determination of the endpoint color change:

Reduction ½ reaction: $2\ H_2O + MnO_4^- + 3\ e^- \rightarrow MnO_2 + 4\ OH^-$

Full Reaction: $2\ MnO_4^-\ (aq) + 3\ H_2O_2\ (aq) \rightarrow 2\ MnO_2\ (s) + 2\ OH^-\ (aq) + 3\ O_2\ (g) + 2\ H_2O\ (l)$