Appendix 1: Graphical Determination of the Rate of a Chemical Reaction

The numerical value for the rate of reaction can be determined by studying the change in quantity of a substance at different times. The substance being studied can be either product or reactant. The average rate of reaction can be determined by:

$$\text{average rate} = \frac{\Delta\text{amount of substance}}{\Delta\text{time}}$$

or

$$\text{average rate} = \frac{\text{final quantity} - \text{initial quantity}}{\text{final time} - \text{initial time}}$$

The instantaneous rate of a reaction at any time, t, can be found by drawing the tangent to the curve at time = t and then determining the slope of the tangent line.

The reaction you will be studying is

$$2\ HCl(aq) + CaCO_3(s) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

You will be observing the loss in mass of the system as the carbon dioxide produced escapes into the atmosphere from an open container.

Procedure:

1. Place 100 mL of a 3 mol / L HCl solution into a 600 mL beaker. Find the mass of the beaker with the acid and 10 large $CaCO_3$ crystals. Do not add the $CaCO_3$ to the acid at this point.

2. Leave the beaker on the balance and add the $CaCO_3$ to the acid solution. Record the mass of the beaker with acid and $CaCO_3$ at 30 second intervals for 20 minutes.

Questions:

1. Determine the mass of CO_2 produced at each interval. Note: the mass of CO_2 is equal to the mass loss for that interval.

   Mass CO_2 (t = 30 s) = Initial mass – mass (t = 30 s)
   Mass CO_2 (t = 5 min) = Initial mass – mass (t = 5 min)

2. Determine the average rate for the following intervals.

   a. Entire 20 minutes
   b. First 5 minutes
   c. 5 minutes to 15 minutes
   d. Last 5 minutes

3. Construct a graph of mass of CO_2 produced versus reaction time.

4. Use the tangent method to determine the instantaneous rate at 1 minute, 5 minutes, 15 minutes and 20 minutes.

5. Explain why the rate changes as it does over time.