

## Reference Sheet: Calculating Rates of Reaction

Rates are based on the slope of a graph or set of data. There are two types of rates: average and instantaneous.

### Slope

Slope is calculated given the equations:

$$\text{slope} = \frac{\text{rise}}{\text{run}} = \frac{\Delta y}{\Delta t} = \frac{y_2 - y_1}{t_2 - t_1}$$

In these equations,  $y$  can be concentration, mass, or volume. It is important to include the proper units and to ensure that the sign is correct. Generally, the sign will be negative for a reactant rate and positive for a product rate.

### Average Rates

An average rate is the change that occurs between two defined points. For example, a question may ask for the reaction rate of the reactants between 2 seconds and 7 seconds.

One way to determine this is to use the information in a data table, if these points are recorded, and plug the values into the slope formula. Otherwise, a secant line must be drawn on a graph, connecting the two points, and the slope of this line determined using rise over run. This is shown to the right in Figure 1. *Pay careful attention to the scale on the axes, as it may not be the same for each!*

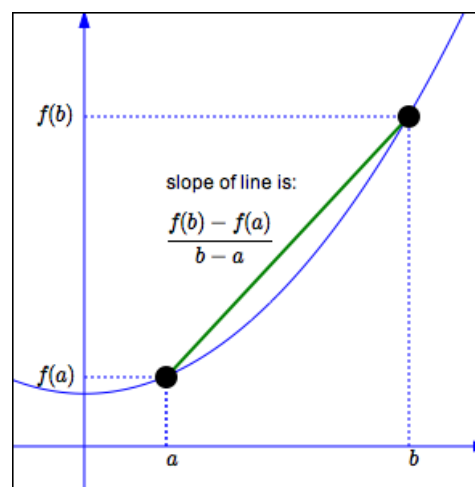


Figure 1: Secant Line for Determining Average Rate

### Instantaneous Rates

Instantaneous rates give a picture of a reaction at a specific point in time. These rates must be determined from a graph using a tangent line, which touches the curve at just one point, as shown in Figure 2.

To draw a tangent line, use a ruler to make a line that is approximately equal distance from the curve on either side of the point in question. It will be easier to calculate slope of this line if it extends well across the graph. Identify two points on the tangent line, then calculate slope using rise over run.

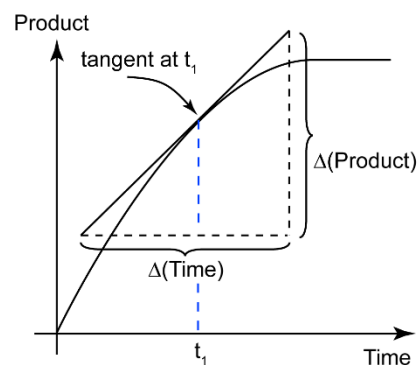


Figure 2: Tangent Line for Determining Instantaneous Rate

Again, be careful about the scale on the axes.