AP LAB 04b: Iodine Clock Reaction Simulation

(Adapted from an original document by John Gelder, former Chief Reader AP Chemistry)

Aim To investigate concentration and temperature as factors that affect rates of reaction

Background You will investigate a series of three chemical reactions given below.

- Reaction 1: $3I^-_{(aq)} + S_2O_8^{2-}{}_{(aq)} \rightarrow 2SO_4^{2-}{}_{(aq)} + I_3^-{}_{(aq)}$
- Reaction 2: $I_3^-{}_{(aq)} + S_2O_3^{2-}{}_{(aq)} \rightarrow 3I^-_{(aq)} + S_4O_6^{2-}{}_{(aq)}$
- Reaction 3: $2I_3^-{}_{(aq)}$ + starch solution $\rightarrow$ blue-black complex + $I^-_{(aq)}$

Reaction 1 produces $I_3^-{}_{(aq)}$, and that ion is *instantaneously* used up in the reaction 2 by reaction with $S_2O_3^{2-}{}_{(aq)}$ ions. Once all of the $S_2O_3^{2-}$ ions have been used up, any I_3^- ions that are still being produced in reaction 1, will now react with the starch solution in reaction 3. This produces the distinctive blue-black color of the complex. Thus, when the blue-black color is observed, we know all of the $S_2O_3^{2-}{}_{(aq)}$ has been used up, and reaction 2 has come to an end.

Method

1. Go to the simulation that can be found at bit.ly/1Z4U0mP

2. Set radio buttons 3, 4 and 5 for the variables shown to the following values;
   Volume of $KI_{(aq)}$ = 12 mL
   Volume of $(NH_4)_2S_2O_{8(aq)}$ = 30 mL
   Temperature = 25°C

3. Next, adjust the volume of water (radio button 1), so that the *total* volume of all the solutions combined = 100 mL.

4. Click the pink start button. *When the final solution has been completely added, start the timer by clicking on the arrow button*.

5. Watch the beaker carefully, and pause the timer when the reaction solution changes color. Record your data in 'Expt. 1." in Table 1 in the results section.

6. Repeat the experiment a further five times, each time adjusting the settings to match those in Table 1.

Results

TABLE 1

Expt.	Volume of 1.0M $KI_{(aq)}$	Volume of 0.1M $(NH_4)_2S_2O_{8(aq)}$	Time taken for the reaction at 25ºC in seconds	Time taken for the reaction at 45 ºC in seconds
1	12 mL	30 mL		
2	6 mL	30 mL		
3	12 mL	15 mL		

Using the data in the Table 1, and the fact that the total volume of the reaction mixture in each case was 100. mL, fill in the concentrations columns for $[I^-]$ and $[S_2O_8^{2-}]$ in Table 2.

Knowing that *except for zero order reactions* the rate of a chemical reaction changes over the course of the reaction, and that the *average rate* can be defined as the time taken for the completion of the whole experiment and is inversely proportional to the time taken (half the time means twice the rate), fill in the three columns for average rate below.

TABLE 2

Expt.	$[I^-]$ in M	$[S_2O_8^{2-}]$ in M	The average rate of reaction at 25°C in units of sec^{-1}	The average rate of reaction at 45°C in units of sec^{-1}
1				
2				
3				

Conclusion/Calculation

1 Determine the order with respect to $[I^-]$ and $[S_2O_8^{2-}]$, and explain how you reached your conclusion.

2 Describe the role of temperature in rates of reaction. Include references to activation energy, Maxwell-Boltzmann distribution, and the rate constant.

3. The Arrhenius equation relates the rate constant, k, to other factors such as collision frequency (A), activation energy (E_a), the gas constant (R = 8.314 J/K mol) and temperature (T in Kelvin). One form of the equation is given below.

$$\ln k = \left(-\frac{E_a}{R}\right)\left(\frac{1}{T}\right) + \ln A$$

Describe the data needed, and the treatment required, in order to use this version of the Arrhenius equation to graphically calculate a value for the activation energy.