**How Does Temperature and Concentration Affect Rate: A Kinetics Lab**

**Introduction**
The iodination of acetone proceeds according to the equation:

         O                                            O
         ||                                             ||
 CH3-C-CH3(aq)  + I2(aq)  🡪  CH3-C-CH2I(aq)  + HI(aq)

The rate of the reaction is found to depend on the hydrogen ion concentration in the solution (acting as a catalyst) as well as the concentration of acetone. Concentration measured in molarity (mol/L) can be expressed using [ ]. In the equation below [acetone], means the molarity of the acetone. Because all of the solutions are being added together, the solutions are being diluted and the actual concentration will need to be calculated. The rate equation for the reaction is:

         **Rate = k[acetone]X[HCl]Y[I2]Z**
X, Y, and Z represent the order with respect to acetone, HCl, and I2. The order of the reaction gives the extent the reactant affects the rate of the reaction. For example if the order of a reactant was zero, then that reactant has no effect on the rate. The higher the order the more of an effect on the rate. The order can be negative and instead of speeding up the reaction, that substance retards the reaction. The values for the exponents, X, Y, and Z have to be determined experimentally.

**Safety and Disposal**
1. Wear Safety Goggles
2. Flush all solutions down the drain with large amounts of water.

**Materials:**

|  |  |
| --- | --- |
| 4 M Acetone1 M HCl0.0012 MIodine solution | starch suspension24-well plate (2)Beral pipets (4)Cotton swabsTiming Device |

**Procedure**

**How Concentration Affects Rate:**

1. Using 5 wells of the 24 well plate, mix water, HCl, iodine and starch solutions in the proportions indicated on the table below
2. As you begin to add the drops of acetone, start timing the reaction. Add the correct number of drops and stir to thoroughly mix the reagents.
3. Continue stirring until the dark blue color disappears.  Record the time it takes for the color to disappear in the data table. A piece of white paper placed beneath the plate is helpful.
4. Repeat this procedure for experiment 2, 3, and 4. Do NOT perform experiment 5 until instructed.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Experiment** | **4 M Acetone (drops)** | **1 M HCl (drops)** | **Starch Soln (drops)** | **0.0012 M I2 (drops)** | **Time (sec)** |
| **1** | 10 | 10 | 10 + 10 H2O | 10 |  |
| **2** | 20 | 10 | 10 | 10 |  |
| **3** | 10 | 20 | 10 | 10 |  |
| **4** | 10 | 10 | 10 | 20 |  |
| **5** | 15 | 15 | 10 | 15 |  |

**How Temperature Affects Rate:**

1. Place your pipettes, bulb down, in the hot water bath for 3 minutes. Record the temperature of the bath.
2. Repeat experiment 1 using the procedure above and record the rate.
3. Place your pipettes in the cold water bath for 3 minutes. Record the temperature of the bath.
4. Repeat experiment 1 using the procedure above and record the rate.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Experiment** | **4 M Acetone (drops)** | **1 M HCl (drops)** | **Starch Soln (drops)** | **0.0012 M I2 (drops)** | **Time (sec)** |
| **1 – Rm Temp** | 10 | 10 | 10 + 10 H2O | 10 |  |
| **1 – Hot** | 10 | 10 | 10 + 10 H2O | 10 |  |
| **1 - Cold** | 10 | 10 | 10 + 10 H2O | 10 |  |

**Teacher Initials:\_\_\_\_\_\_\_\_\_\_\_\_**

**Calculations:**

1. Calculate the concentration of the solutions used by using the following equation.

**(# Drops Added)conctrated\*Molarityconcentrated = (# total drops)\*MolarityDiluted**

1. Approximate the average rate of this reaction by dividing the initial concentration of iodine in the experiment by the time obtained in this experiment. There is an assumption that the iodine concentration goes to zero.  Therefore,

$$Rate\_{ave}=\frac{-\left[I\_{2}\right]\_{o}}{time}$$

 Record the rate in the data table.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Experiment** | **[Acetone]** | **[HCl]** | **[I2]** | **Rate x 10-6** |
| **1** |  |  |  |  |
| **2** |  |  |  |  |
| **3** |  |  |  |  |
| **4** |  |  |  |  |
| **5** |  |  |  |  |

**Teacher Initials:\_\_\_\_\_\_\_\_\_\_\_\_**

**Calculations**

1. To find the value of X in the rate equation, compare the rate of experiment 2 to that of experiment 1.  Notice that the concentration of acetone in experiment 2 is twice that of experiment 1. Calculate the ratio of rate of experiment 2/rate of experiment 1. What the value of X? Explain your reasoning.

$$\frac{rate\_{2}=k\left[acetone\right]\_{2}^{x}\left[HCl\right]\_{2}^{y}\left[I\_{2}\right]\_{2}^{z}}{rate\_{1}=k\left[acetone\right]\_{1}^{x}\left[HCl\right]\_{1}^{y}\left[I\_{2}\right]\_{1}^{z}}$$

$$\frac{rate\_{2}=k\left[acetone\right]\_{2}^{x}\left[HCl\right]\_{2}^{y}\left[I\_{2}\right]\_{2}^{z}}{rate\_{1}=k\left[acetone\right]\_{1}^{x}\left[HCl\right]\_{1}^{y}\left[I\_{2}\right]\_{1}^{z}}$$

$$\frac{rate\_{2}=\left[acetone\right]\_{2}^{x}}{rate\_{1}=\left[acetone\right]\_{1}^{x}}$$

$$\frac{rate\_{2}}{rate\_{1}}=\left(\frac{[acetone]\_{2}}{[acetone]\_{1}}\right)^{x} $$

$$x=\frac{log\left(\frac{rate\_{2}}{rate\_{1}}\right)}{log\left(\frac{[acetone]\_{2}}{[acetone]\_{1}}\right)}$$

x =

1. To find the value of Y in the rate equation, compare the rate of experiment 3 to that of experiment 1.  Notice that the concentration of HCl in experiment 3 is twice that of experiment 1. Calculate the ratio of rate of experiment 3/rate of experiment 1. What the value of Y? Explain your reasoning.

Y =

1. To find the value of Z in the rate equation, compare the rate of experiment 4 to that of experiment 1.  Notice that the concentration of iodine in experiment 4 is twice that of experiment 1. Calculate the ratio of rate of experiment 4/rate of experiment 1. What the value of Z? Explain your reasoning.

Z =

1. What is the rate equation? Substitute the correct orders for X, Y, and Z.

rate =

1. Find the value of k in the rate equation.

k =

1. Using this approximation of average rates, calculate X, Y, Z and k in the rate equation. Using this rate equation predict the rate expected for experiment 5.  Experimentally determine the average rate for experiment 5 using the procedure previously described.

rate =

**Teacher Initials:\_\_\_\_\_\_\_\_\_\_\_\_**

**Analysis:**

|  |
| --- |
| Claim: How does temperature and concentration affect the rate of a reaction? |
| Evidence: | Reasoning: |

1. Use what you know about reaction rates and the kinetic molecular theory of matter to explain why lowering the temperature of a reaction or diluting the concentration of the reactants in a reaction will decrease the rate of a chemical reaction.