Name: ________________________________ Section: ____________________

Table 1. Reaction Rate Data

Reaction Mixture	Time (sec) for color change	Relative Rate = 1/t	$[I^-]_{ini}$	$[BrO_3^-]_{ini}$	$[H^+]_{ini}$	Room Temp (°C)
1						
2						
3						
4						
5						

Varying conditions for Mixture 2	Time (sec) for color change	Temp (°C)
Hot: ~ 40 °C		
Cold: ~ 10 °C		
With a catalyst		

The reactant concentrations in the reaction mixture are not those of the stock solutions, since the reagents were diluted by the other solutions. The final volume of the reaction mixture is 25 mL in all cases. We can calculate the concentrations of all reactants in the table above ($M_1V_1 = M_2V_2$).

Determination of the Orders of the Reaction

Given the data in the table, the problem is to find the order for each reactant and the rate constant for the reaction. Since we are dealing with relative rates, we can modify Equation 2 to read as follows:

$$\text{relative rate} = k' [I^-]^m [BrO_3^-]^n [H^+]^p \quad (5)$$

We need to determine the relative rate constant k' and the orders m, n and p in such a way as to be consistent with the data in Table 1.

The solution to this problem is quite simple once you make a few observations on the reaction mixtures. Each mixture (2 to 4) differs from Reaction Mixture 1 in the concentration of only one species (see table). This means that for any pair of mixtures that includes reaction Mixture 1, there is only one concentration that changes. We can then find the order for the reactant whose concentration was changed.

Name: ______________________________ Section: ____________________

Write Equation 5 below for Reaction Mixtures 1 and 2, substituting the relative rates and the initial concentrations of I^-, BrO_3^-, and H^+ from Table 1.

Relative rate 1 = ______________ = k [$]^m$ [$]^n$ [$]^p$

Relative rate 2 = ______________ = k [$]^m$ [$]^n$ [$]^p$

Solve for m, the order of the reaction with respect to the I^-, to two decimal places and then round off to the nearest integer.

m = ________ (2 decimal places) m = ________ (nearest integer)

Apply the same approach to find the value of n, the order of the reaction with respect to the BrO_3^- ion. Show your set-up.

n = ________ (2 decimal places) n = ________ (nearest integer)

Apply the method once again to find p, the order with respect to the H^+ ion. Show your set-up.

p = ________ (2 decimal places) p = ________ (nearest integer)

Having found m, n, and p (nearest integers, the rate law is written as:

rate = ______________________________

Name: ________________________________ Section: ____________________

<u>Determination of the Value of Relative Rate Constant</u>

The relative rate constant, k' can be calculated by substitution of m, n, p and the known rates and reactant concentrations into Equation 5. Fill Table 2 below by calculating k for Reaction Mixtures 1 – 4.

Table 2. Reaction Constant, k

Reaction	1	2	3	4	Average	Units of k
k						

Calculations for each k value:

Briefly explain why k should have nearly the same value for each of the Mixtures 1 – 4.

Why? ____

<u>Determination of Relative Rate and Reaction Time for Mixture 5</u>

For Reaction Mixture 5, use k_{ave} from Table 2 above and the appropriate concentrations from Table 1 in Equation 5 to predict (calculate) the relative rate. Then use this value to predict (calculate) the reaction time, t, for Mixture 5. Show your calculations below.

relative $rate_{predicted}$ ____________ $t_{predicted}$ ____________ $t_{observed}$ ____________

Calculate the percent difference of your reaction times.

% difference ______________

Name: ________________________________ Section: ____________________

The Effect of Temperature on Reaction Rate: The Activation Energy

To find the activation energy for the reaction, transfer the reaction times and temperatures onto Table 3 and fill in the remaining boxes using Mixture 2. Since the reactions at the different temperatures all involve the same reactant concentrations, the rate constants, k, for two different mixtures will have the same ratio as the reaction rates themselves for the two mixtures. This means that in the calculation of E_a, we can use the observed relative rates instead of rate constants.

Table 3. Reaction Rate at Different Temperatures for Mixture 2.

	Room Temp	Hot: ~ 40 °C	Cold: ~ 10 °C
Time (sec) for color change			
Actual Temp (°C)			
Actual Temp (Kelvin)			
1 / Temp (Kelvin^{-1})			
Relative Rate = 1/time			
ln (Relative Rate)			

Use the appropriate values from Table 3 and plot ln(relative rate) vs 1 / T in Microsoft Excel.® Insert a linear trendline and display both the equation and r^2 value of the trendline on the graph. Copy these in the space below. **Make certain to include your Arrhenius plot with this report**.

Trendline Equation: ______________________

r^2 = ________________

The slope of the line equals $-E_a / R$, where R = 8.314 Joules / (mole K). Use this relationship to calculate the activation energy, E_a, for your reaction in kJ/mol.

E_a = ________________ kJ / mol

Name: ________________________________ Section: ____________________

The Effect of a Catalyst on Reaction Rate

	Room Temperature Mixture 2	Catalyzed Mixture 2
Time for color to appear (sec)	____________________	____________________

Would you expect the activation energy, E_a, for the catalyzed reaction to be greater than, less than, or equal to the activation energy for the uncatalyzed reaction? Briefly explain.

Name: ______________________________ Section: ____________________

Pre-Lab Questions: Iodine Clock Reaction

1. A student studied the clock reaction described in this experiment. She set up a reaction mixture by mixing 10.0 mL of 0.010 M KI, 10.0 mL of 0.0010 M $Na_2S_2O_3$, 20.0 mL of 0.040 M $KBrO_3$ and 10.0 mL of 0.10 M HCl using the procedure given. It took 40.0 seconds for the color to turn blue.

   a. She found the concentration of each reactant in the reacting mixture by realizing that the number of moles of each reactant did not change when that reactant was mixed with the others, but that its concentration did. The volume of the mixture was 50.0 mL. Find the initial concentration of each reactant.

   $[I^-]_{ini}$ = __________ M; $[BrO_3^-]_{ini}$ = __________ M; $[H^+]_{ini}$ = __________ M

   b. What is the relative rate of the reaction (1/time)?

   ____

2. The student repeated the experiment using reaction mixture 1 by mixing 10 mL of 0.010 M KI, 10 mL of 0.0010 M $Na_2S_2O_3$, 10 mL of 0.040 M $KBrO_3$, 10 mL of 0.10 M HCl and 10 mL of H_2O. It took 75 seconds to turn blue.

   Find the initial concentration of each reactant after mixing:_

   $[I^-]_{ini}$ = __________ M; $[BrO_3^-]_{ini}$ = __________ M; $[H^+]_{ini}$ = __________ M

   What is the relative rate of the reaction (1 / time)?

   ____

3. Use the information above to determine the order with respect to BrO_3^-.

   n = ________ (2 decimal places) n = ________ (nearest integer)