Experiment (4)

Effect of Temperature on the Rate Reaction

(Calculation the Activation Energy and Frequency Factor)

Theory: *Bromide is reacted with bromate according to the following equation:*

$$KBrO_3 + 5KBr + 3H_2SO_4 \longrightarrow 3Br_2\uparrow + 3K_2SO_4 + 3H_2O$$

The rate equation of this reaction is represented by:

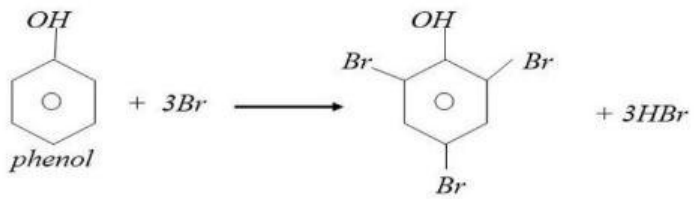
$$-d[BrO^{-3}] / dt = k\,[BrO^{-3}]^x\,[Br^-]^y\,[H^+]^z$$

In order to better understand the bromate-bromide reaction, it is important to take note of the stoichiometric equation, which is noted as:

$$BrO^{-3} + 5Br^- + 6H^+ \longrightarrow 3Br_2\uparrow + 3H_2O$$

This reaction couples with the reaction of Br_2 and methyl orange, which produces bleach. By combining the two reactions, the basis is built for determining the rate of the reaction. As bromate BrO^{-3} and bromide Br^- react, they produce Br_2, which then reacts with methyl orange to dissipate the color of the solution and show completion of the reaction. This dissipation of color can be timed and used for calculation.

However, this reaction happens very quickly, and under normal circumstances would not be able to be timed. <u>By adding phenol to the solution, the reaction of Br_2 with methyl orange can be slowed down with the following side reaction:</u>



This reaction of Br_2 with phenol slows down the reaction with methyl orange enough that it is able to be timed and indicate the end of the reaction by change the mixture color.

The rate constant can be calculated by (Arrhenius equation):

$$k = A.e^{-Ea/RT} \quad \Longrightarrow \quad Ln\ k = Ln\ A - E_a / RT$$

the time required to remove the color of reagent after mixing the reactants is inversely proportional with the rate of reaction:

$$Rate\ \alpha\ 1/t$$

When this reaction takes place at different temperature, its activation energy can be calculated as follows:

$$Rate = A.e^{-Ea/RT} \quad \Longrightarrow \quad 1/t = A.e^{-Ea/RT}$$

$$Ln\ 1/t = Ln\ A - E_a / RT$$

Procedure:

1- *Add (2.5)ml of [KBr + $KBrO_3$]mixture and (2.5)ml of (0.01)N phenol to the test tube number 1.*

2- *Add (6)ml of (0.3)N H_2SO_4 and 2 drops of red methyl indicator to the test tube number 2.*

3- *Put the two test tubes in water bath at (40)°C until reaching the thermal equilibrium, then add the test tube number 2 to the test tube number 1 and note the time until disappearance of red color to yellow.*

4- *Repeat steps (1-3) by different temperatures (50, 60, 70)°C.*

Calculations and graph:

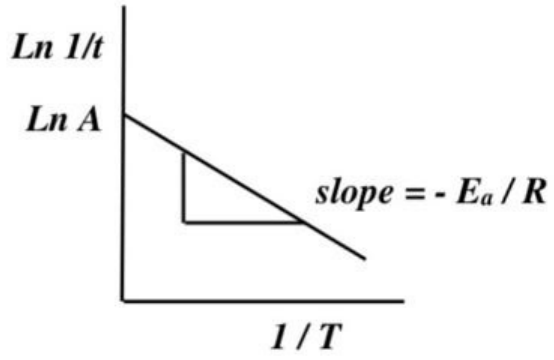
1- *Arrange the results according to the following table:*

Temperature (°C)	*Temperature (K)*	*1 / T* $(K)^{-1}$	*t (time)*	*1 / t* $(time)^{-1}$	*Ln (1 / t)*
40					
50					
60					
70					

2- *Plot a graph of [Ln 1 / t] against [1 / T] and from the slope calculate the activation energy(E_a) and determine frequency factor (A).*

Where:

k: rate constant
t: time
E_a : activation energy (J/mol) or (kJ/mol)
R : gases constant (8.314 J/mol.K)
T: temperature
A: frequency factor ($time^{-1}$)



Discussion:

1- Define the activation energy and *Arrhenius equation.*

2- What is the purpose of adding the phenol to the reaction between bromate & bromide?