Experiment Time: 2019 / 04 / 30 18 : 30 ~ 22 : 10 Laboratory: DS2B4

Experimental Report

Experiment Course Title: Experimental of College Chemistry I

Experimental Project Name:

Chemical Reaction Rate and Activation Energy

Name: 易弘睿 Yi Hongrui Student No.: 20186103

College: JCI Specialty: Mechanical Engineering

Class: ME01 Mentor: Chen Gang

Score: _____

Teacher Comments: _____

_____

_____

_____

1. Purpose

(1) Understand the influence of concentration and temperature on chemical reaction rate.
(2) Learn to use graphing to manipulate experimental data.

2. Principle and Method

1) Effect of concentration on chemical reaction rate:
In acidic solution, KIO_3 can react with Na_2SO_3:
$2KIO_3 + 5Na_2SO_3 + H_2SO_4 = K_2SO_4 + 5Na_2SO_4 + I_2 + H_2O$

However, the actual reactions are:

$$HIO_3 + H_2SO_3 = HIO_2 + H_2SO_4 \quad (1)$$
$$HIO_2 + 2H_2SO_3 = HI + 2H_2SO_4 \quad (2)$$
$$5HI + HIO_3 = 3I_2 + 3H_2O \quad (3)$$
$$I_2 + H_2SO_3 + H_2O = H_2SO_4 + 2HI \quad (4)$$

In the four step reaction, the first step is the slowest, and the fourth one is finished. Therefore, as long as the presence of sulfurous acid in the solution, iodine quickly reacts with sulfurous acid. Only after the reaction of sulfurous acid, the iodine produced by reaction 3 could exist, and react with starch to become blue. Thus, the presence of blue in solution can be used as a marker of using up H_2SO_3. The longer it takes to appear blue, the smaller the reaction rate.

2) Effect of temperature on reaction rate

Temperature is one of the important factors affecting the reaction rate. The effect of temperature on the reaction rate can be expressed by the Arrhenius formula:

$$k = Ae^{\frac{-E_a}{(RT)}}$$

k -- Rate constant of reaction;
E_a -- Activation energy of reaction;
R -- Molar gas constant;
T -- Thermodynamic temperature;
A -- Characteristic constant of a given reaction;

$$E_a = 2.303R(\frac{T_2T_1}{T_2 - T_1}) \lg\frac{t1}{t2}$$

3. Materials and Instruments

(1) Instruments:
Cylinder($20cm^3$) *2; Cylinder($50cm^3$) *1; Conical flask($100cm^3$) *1;
Boiling tube *1; Wash bottle *1； Thermometer *1； Water bath *1;
Stopwatch *1;

(2) Materials:
0.01 mol/dm^3 KIO_3;
0.01 mol/dm^3 Na_2SO_3(include starch and 0.018 mol/dm^3 H_2SO_4);

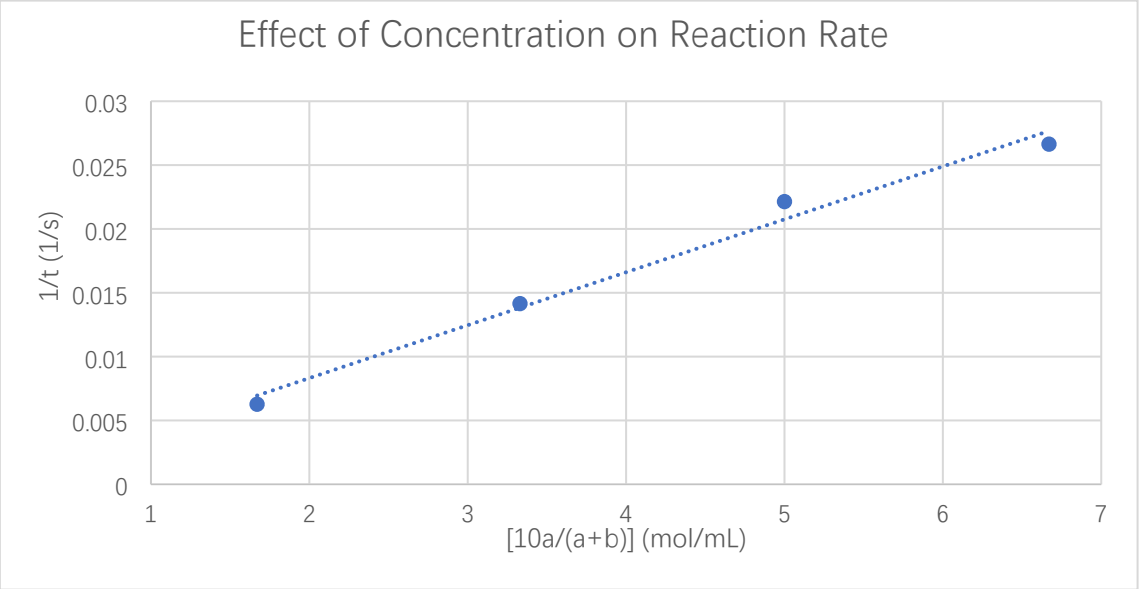
4. Experimental Records and Calculation

1) Effect of concentration on chemical reaction rate:

At the room temperature, the volume of each solution was taken by using the same number of measuring cylinders as given in the table below. First pour 0.01mol·dm^{-3} into 100cm^3 conical flask, then quickly pour Na_2SO_3-starch solution into the same flask. Record the time and shake the flask. When the solution turns to blue, stop the timer.

Vol(ml)		C_{KIO3} 10a/(a+b)	t(s)	1/t
KIO_3(a)	H_2O(b)			
5.0	25.0	1.67	159.33	0.00627
10.0	20.0	3.33	70.69	0.01415
15.0	15.0	5.00	45.16	0.00221
20.0	10.0	6.67	37.54	0.02664

(Form 1)



(Figure 2)

Conclusion:

From the figure, wen know, if the concentration increases, the chemical reaction rate will also increase.

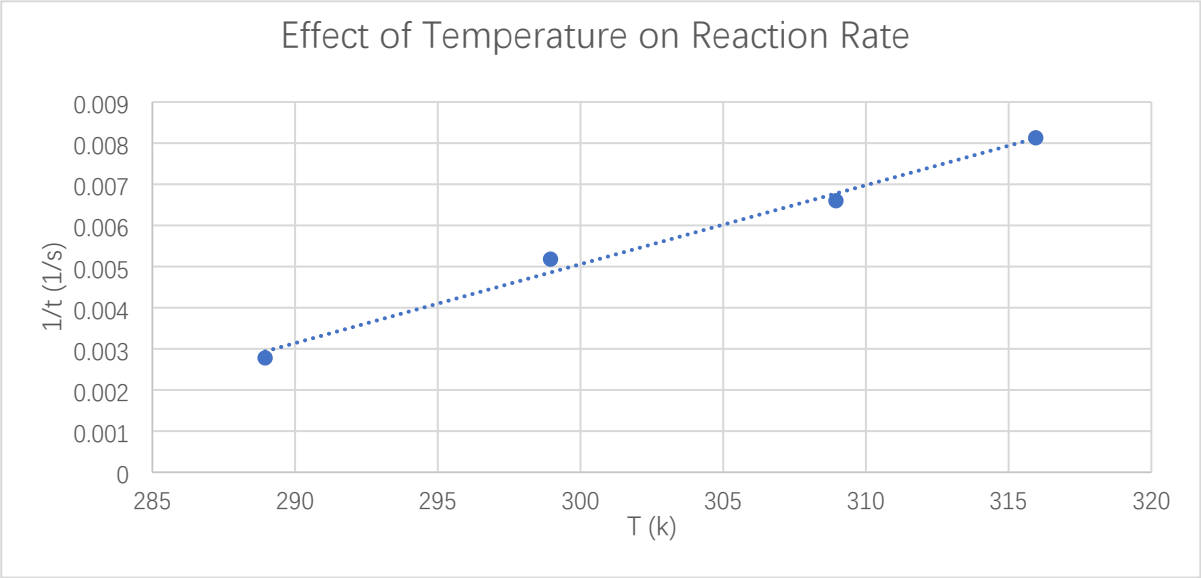
2) Effect of temperature on reaction rate

Pour 20.0cm^3 0.01mol ·dm^{-3} KIO_3 aq and 20cm^3 H_2O to 100cm^3 conical flask. Pour 20.0cm^3 0.01mol·dm^{-3} Na_2SO_3- starch solution to 20cm^3 test tube. Put the conical flask, large tube and the thermometer in the water bath at the same time, when the temperature is achieved required standard, pour the Na_2SO_3 solution to the flask quickly. Record the time and shake the flask. When the solution turns to blue, stop the timer.

Room temperature: 298.95K

No.	1	2	3	4
T(K)	288.95	298.95	308.95	315.95
t(s)	359.85	193.22	150.43	123.80
1/t	0.00278	0.00518	0.0066	0.00813

(Form 2)



(Figure 2)

Conclusion:

$$E_{a1}=2.303R\left(\frac{T2\cdot T1}{T2-T1}\right)\lg\frac{t1}{t2}=44671.17KJ/mol$$

$$E_{a2}=2.303R\left(\frac{T3\cdot T2}{T3-T2}\right)\lg\frac{t2}{t3}=19227.26KJ/mol$$

$$E_{a3}=2.303R\left(\frac{T4\cdot T3}{T4-T3}\right)\lg\frac{t3}{t4}=22593.34KJ/mol$$

$$E_{a4}=2.303R\left(\frac{T4\cdot T1}{T4-T1}\right)\lg\frac{t1}{t4}=30003.00KJ/mol$$

$$\overline{E}=(E_{a1}+E_{a2}+E_{a3})/3=28830.59KJ/mol$$

When the range of temperature is from 14.2℃ to 24.2℃, the activation energy is 44671.17KJ/mol.

When the range of temperature is from 24.2℃ to 34.2℃, the activation energy is 19227.26KJ/mol.

When the range of temperature is from 34.2℃ to 44.2℃, the activation energy is 22593.34KJ/mol.

When the range of temperature is from 14.2℃ to 44.2℃, the activation energy is 30003.00KJ/mol.

$\overline{E}$ is 28830.59KJ/mol

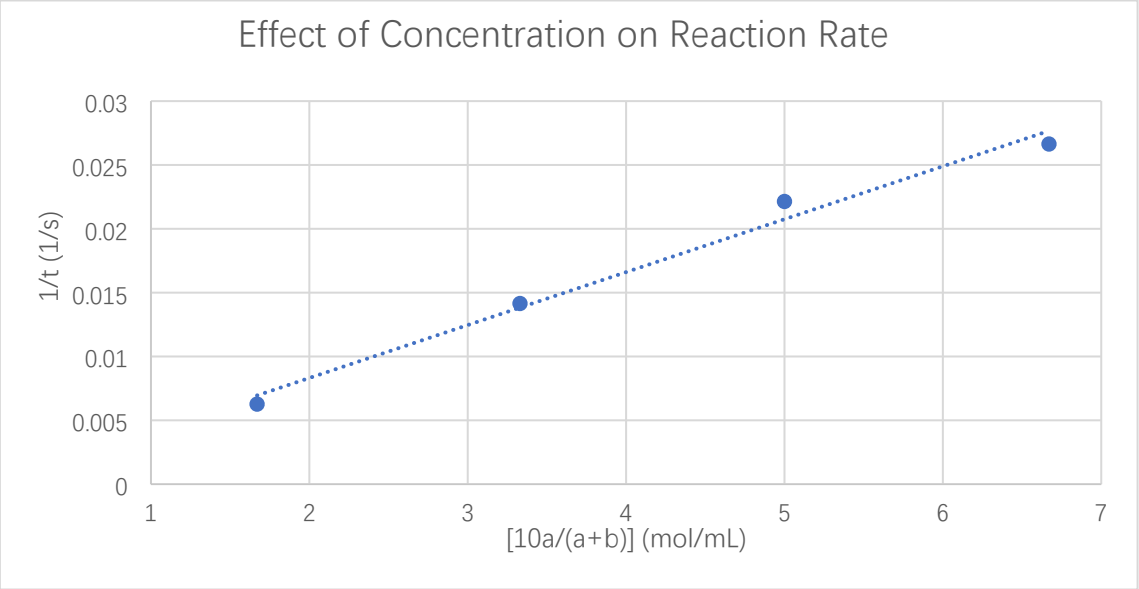
The calculated value of Ea is 28830.59KJ/mol. The measured value of Ea is 30003.00KJ/mol.

From the figure and calculating, we know, when the temperature increases the chemical reaction rate will also increase.

5. Results and Discussion

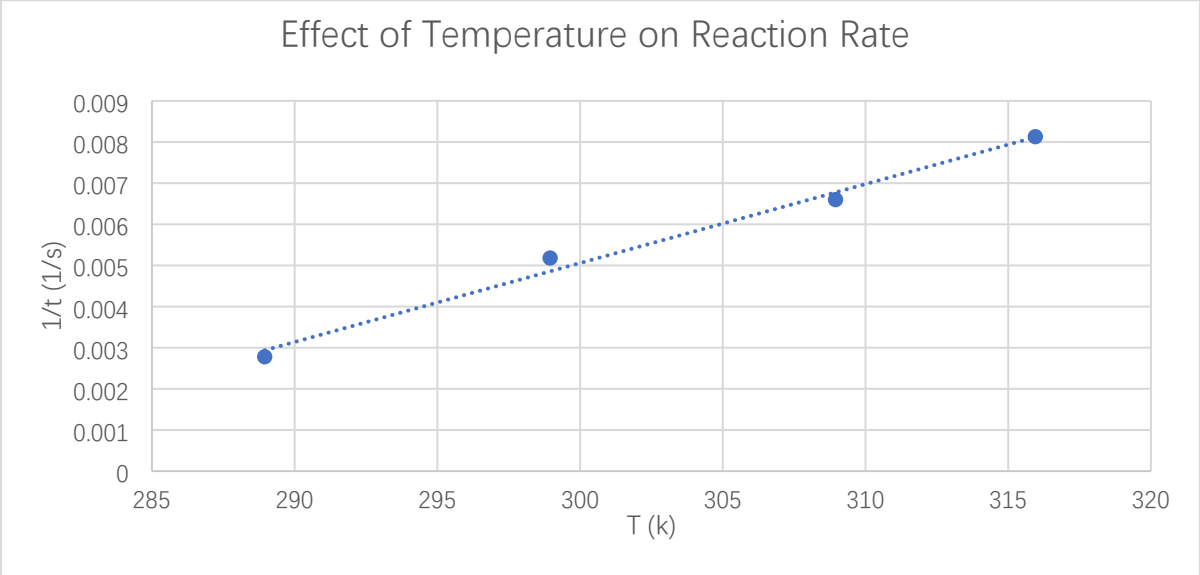
Results:

1) Effect of concentration on chemical reaction rate



From the figure, wen know, when the concentration increases, the chemical reaction rate will also increase.

2) Effect of temperature on reaction rate



When the range of temperature is from 14.2℃ to 24.2℃, the activation energy is 28522.60KJ/mol.

When the range of temperature is from 24.2℃ to 34.2℃, the activation energy is 8722.45KJ/mol.

When the range of temperature is from 34.2℃ to 44.2℃, the activation energy is 6858.22KJ/mol.

When the range of temperature is from 14.2℃ to 44.2℃, the activation energy is 15185.45KJ/mol.

$\overline{E}$ is 14701.09KJ/mol

The calculated value of Ea is 14701.09KJ/mol. The measured value of Ea is 15185.45KJ/mol.

From the figure, we know, when the temperature increases the chemical reaction rate will also increase.

Error analysis:

The calculated value of Ea and the measured value of Ea is close, but there is still an error. The error is 4.07%. The error analysis is below.

1. Reading error. When we get data by reading the temperature gauge, there might exist reading error.

2. When we measure the time it takes to become blue, we cannot measure the accurate time, so the time we measure exist error.

3. The SO_3^{2-} may be oxidized before the reaction, so the data we obtain is not accurate.

4. When we change the reaction temperature to the temperature we wanted, we cannot change the temperature to the accurate one.

Discussion:

(1) What are the factors that affect the rate of chemical reaction?

Concentration, pressure, temperature, catalyzer.

(2) In this experiment, why can we use the appearance of blue as a sign of running out of Na_2SO_3?

Because only after the reaction of sulfurous acid, the iodine produced by reaction 3 could exist, and react with starch to become blue.