Experiment 14

Date: 4-7-2006

To Investigate the Kinetics of the Reaction between Permanganate and Ethanedioate Ions by Colorimetry

Objective

To study the kinetics of the reaction between permanganate and ethanedioate ions by colorimetry.

Introduction

Ethanedioate ions and permanganate ions react according to the following equation under acid conditions.

$$2MnO_4^-(aq) + 18H^+(aq) + 5C_2O_4^{2-}(aq) \text{-------} \rightarrow 2Mn^{2+}(aq) + 8H_2O(l) + 10CO_2(g)$$

The color of the solution would turn from purple to pale pink, due to the lowered concentration of permangate ions. The change in color of the solution can be detected by a colorimeter.

Before we can use the colorimeter to study the kinetics of the reaction, we should use a filter that is suitable. The filter which has a complimentary color to the purple color of permanganate should be used. Complementary colors are colors when mixed together, give a grey color. This ensures the highest level of absorption of light by the filter and the solutions.

Also, we need to draw a calibration curve, so that we can know the level of absorbance of the solution at different concentrations.

Procedure

(* Throughout the procedures, the test tube had the same alignment while it was inserted into the colorimeter*)

Part I: Selecting a suitable filter

1. The colorimeter was turned on for a few minutes for warm up.
2. A small tube with 10 cm^3 of distilled water was inserted into the colorimeter.
3. A colored filter was inserted into the colorimeter. The colorimeter was adjusted to give 100% transmittance.
4. Another small tube, with 0.5cm^3 of permanganate solution and 9.5cm^3 of distilled water added, was inserted into the colorimeter. The absorption percentage was then recorded.
5. Steps 2 to 5 were repeated until all the colored filters were tried.
6. The filter with the lowest percentage of absorption was chosen as the filter in the experiment.

Part II: Calibration of the meter

1. The filter found the most suitable was inserted into the colorimeter.

2. A test tube with 10cm^3 of distilled water was inserted into the colorimeter. The transmittance percentage was adjusted to maximum.
3. 0.1 cm^3 of $KMnO_4$ solution was added continuously, and the readings on the colorimeter were recorded, until 1cm^3 of the solution was added.

Part III: Investigation of the kinetics of the reaction

1. 10 cm^3 of 0.5M ethanedioate solution was added into the small test tube.
2. 0.5cm^3 of the permanganate solution was added into the test tube, and the timer was started. The test tube was shaken to ensure well mixing.
3. The test tube was inserted into the colorimeter.
4. The reading of the colorimeter was taken at 30 second intervals. But when the reading starts changing, the readings were taken at 10 second interval.
5. The readings were taken until there are no more changes in the absorption percentage.

Data and Calculation

Part I

The results were obtained below:

Filter number	2	3	4	5	6	7	8
Percentage of transmittance	6%	1%	0.1%	1.5%	8%	30%	58%

As shown, filter number 4 has the highest level of absorption and is the best filter. It has the color of dark green.

Part II

Concentration of permanganate solution: 0.02M

Concentration of MnO_4^- (M)	1.98×10^{-4}	3.92×10^{-4}	5.83×10^{-4}	7.69×10^{-4}	9.52×10^{-4}
Transmittance %	40	12	4	3	3

Concentration of MnO_4^- (M)	1.13×10^{-3}	1.31×10^{-3}	1.48×10^{-3}	1.65×10^{-3}	1.81×10^{-3}
Transmittance %	2	2	2	2	2

Time passed (s)	30	60	90	100	110	120	130	140	150	160	170	180	190	200	210
Transmittance (%)	3	3	4	5	7	10	18	31	48	68	80	81	82	82	82
Concentration of MnO_4^- ($x10^{-4}$ M)	6.4	6.4	5.8	5.5	4.9	4.3	3.2	2.2	1.4	0.7	0.3	0.3	0.25	0.25	0.25
Gradient (M per second)	0	$-1.25x10^{-6}$	$-2.19x10^{-5}$	$-3.1x10^{-5}$	$-4.6x10^{-5}$	$-6.3x10^{-5}$	$-8.3x10^{-5}$	$-9.5x10^{-5}$	$-6.7x10^{-5}$	$-4.0x10^{-5}$	$-1.4x10^{-5}$	$-7.1x10^{-6}$	$-5.0x10^{-6}$	0	0

Part III

Conclusion

The reaction rate first increases, then it drops to zero.

Discussion

1. Assuming that the colorimeter functions properly, errors would rarely result in the experiment procedures. But one could easily create errors by adding an incorrect amount of permanganate ions during the calibration process. During the calibration, only a small amount of permanganate ions, $0.1cm^3$ at a time, is added. So, the error percentage created would be enormous.
2. Another error created is in the calibration process. A calibration curve is drawn during this process. It is impossible to draw a perfect curve that suits all the points in the graph. The determination of the concentration of permanganate ions is affected. So, the accuracy of part III of the experiment is affected. Also, in part 3, in order to find out the gradient of the curve, a tangent is drawn a every point of the curve. Not only does this cause inconvenience, the accuracy of using this method is quite low. Human errors were easily found in this part of the experiment, from the drawing of tangents to the calculation of the gradients.

   In order to tackle these problems, a data logger could be used. The data logger directly inputs the data into the computer and all the graphs can be

drawn without human efforts.

3. When we are using the colorimeter, we should align the test tube in the same way. This is because the test tube is not perfectly round. A same alignment can ensure the same conditions for measurement.
4. We choose the filter with the lowest transmittance percentage because this filter is the complimentary color with the solution being tested. The two complimentary colors ensure that the lowest amount of light passes through to the receiving end of the colorimeter.
5. Apart from using a colorimeter, the measurement of the volume of carbon dioxide given off can be used to study the rate of reaction. But this method is unreliable, because the carbon dioxide given off is soluble in water.
6. We use distilled water to calibrate the colorimeter to 100% transmittance in part I. Distilled water must be added to the test tube, so as to have the same conditions with test tube with permanganate solution. Both the distilled water and the permanganate solution will diffract off some light inside the colorimeter. So, it is inappropriate to use a test tube without distilled water in part I.
7. The rate of reaction increases at the first half of the reaction. Afterwards, it drops quickly. The increase in the rate of reaction may be due to the reaction being exothermic. As the temperature of the solution increases, the reaction rate increases. At the second half, most of the reactants are used up, and the rate of reaction drops quickly.
8. To test whether my hypothesis is correct, the solutions are mixed together inside foam cups and the temperature change is recorded. The second half need not be proven because the rate of every reaction decreases when the amount of reactants drops.