

# Crystal violet activation of energy - lab report example

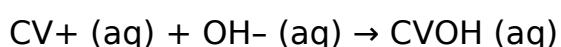


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## Crystal Violate activation of energy

Rate Determination and Activation Energy Activation energy is the energy required to initiate and otherwise spontaneous chemical reaction to continue to react without any need for additional energy. Determination of activation energy,  $E_a$  is vital part in chemical kinetic analysis of reactions. Combustion of a paper is an excellent example of activation. The reaction of oxygen and cellulose is spontaneous, but initiation of combustion is required by addition of activation energy from the lit match.

The purpose of this experiment was to investigate the reaction of sodium hydroxide with crystal violet, an indicator in biochemical testing. This reaction is as below in a simplified form by abbreviating the crystal violets chemical formula as CV.



The violet-colored  $\text{CV}^+$  reactant slowly faded to a colorless product as the reaction proceeded, following the typical behavior of any indicator. The colour change were be measured by a Vernier Colorimeter set at 565 nm of wavelength in assumption that absorbance is directly proportional to the concentration of crystal violet according to Beer's law.

The molar concentration of the sodium hydroxide, NaOH, solution was much greater than that of crystal violet. This ensured that the reaction, which is first order with respect to crystal violet, was first order overall throughout the practical experiment. The reactions were monitored at different temperatures, while maintaining the initial concentrations of the reactants the same for each of the trial. The effects of temperature change on the rate of reaction were observed and measured. Finally, the activation energy,  $E_a$ ,

for the reaction was calculated.

## OBJECTIVES

This experiment had three key objectives. These are;

Reacting the solutions of crystal violet and sodium hydroxide at four different temperatures.

Measuring and recording the effect of temperature on the reaction rate and rate constant.

Calculating the activation energy,  $E_a$ , for the reaction

## Apparatus and Materials

In this lab Experiment the apparatus and materials used included Lab Quest , Lab Quest App Temperature Probe, Vernier Colorimeter, Temperature Probe, 5 plastic cuvettes, 0.10 M sodium hydroxide, NaOH, solution,  $2.5 \times 10^{-5}$  M crystal violet solution, 1 liter beaker, ice, watch with a second hand, two 10 mL graduated cylinders, two 100 mL beakers and 50 mL beaker.

## PROCEDURE

In this experiment, the procedure was as follow. The initial step involved obtaining and wearing goggles. This was followed by connecting the Colorimeter to Channel 1 of LabQuest and the Temperature Probe to Channel 2 of LabQuest and choosing New from the File menu.

The next step involved changing the data-collection rate to 1 samples /second and the length to 200 seconds. The colorimeter was the calibrated and the calibration used for all the four trials in the done in the experiment.

In calibrating the colorimeter, a blank was prepared by filling an empty cuvette 3/4 full with distilled water and the blank placed in the cuvette slot of the Colorimeter then the lid was closed. Finally, the wavelength on the

Colorimeter was set to 565 nm (Green) and the CAL button pressed.

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Calibration was complete when the LED stopped flashing. The next step was preparing a cool-water bath,  $\sim 25^{\circ}\text{C}$ , in a 1-liter beaker. This bath was shallow because it was to be used to cool the two 10.0 mL aliquots of reactants. The tip of the Temperature Probe was then immersed in the cool-water bath. The NaOH and crystal violet solutions were prepared ready for the first trial by using a 10 mL graduated cylinder to obtain 10.0 mL of 0.10 M NaOH solution and transferred to a 100 mL beaker with caution as Sodium hydroxide solution is caustic by avoiding spilling it on skin or clothing. 10.0 mL of  $2.5 \times 10^{-5}$  M crystal violet solution were transferred to a second 100 mL beaker using the other 10 mL graduated cylinder. This was done with caution, as Crystal violet is a biological stain by avoiding its spillage on skin or clothing. The two 100 mL beakers of reactants were then placed in the water bath ensuring that the levels of the solutions on the beakers were below the level of the water bath. The beakers were left in the water bath for at two minutes. The next step was conducting the first trial. This was done by checking the temperature of the water bath; steady at or near  $25^{\circ}\text{C}$  then the NaOH and crystal violet solutions were poured into the 50 mL beaker. The Stopwatch App was then opened and timing the reaction then started. The reaction was allowed to run for one minute before closing the Stopwatch App and recording the temperature of the mixture while stirring the reaction mixture with the Temperature Probe. The blank cuvette was then removed from the Colorimeter and a clean, dry cuvette was filled about 3/4 full with the reaction mixture and, placed in the Colorimeter. The lid was then closed then on the Colorimeter and data collection started where both the Absorbance and Temperature were plotted. This data was collected for 180 seconds as the the progress of the reaction in the beaker were being

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observed. The cuvette was removed carefully from the Colorimeter when data collection was complete and the contents of the beaker and cuvette disposed as directed. A graph of absorbance vs. time was then displayed by choosing Show Graph ►Graph 1 from the Graph menu. The rate constant,  $k$ , was determined by plotting a graph of  $\ln$  Absorbance vs. time because the reaction is first order with respect to crystal violet. This was done by tapping Table to display the data table then New Calculated Column from the Table menu was chosen. The Name ( $\ln$  Abs) was entered and the Units field left blank. The equation,  $\ln(X)$  was the selected the Absorbance was selected as the column for  $X$  and 1 entered as the value for  $A$ . The OK Key was selected and a graph of  $\ln$  Abs vs. time was displayed. The Curve Fit from the Analyze menu was the chosen and Linear as the Fit Equation selected. From the slope value, the rate constant,  $k$ , was determined and recorded in the data table finally OK then selected. From this stem, the next step was to collect data for another trial, the data from the first trial were stored by tapping the File Cabinet icon in readiness another trials at  $\sim 20^\circ\text{C}$ ,  $\sim 15^\circ\text{C}$ , and  $\sim 10^\circ\text{C}$ . The next water bath,  $\sim 20^\circ\text{C}$ , was prepared by adding warm water to the 1-liter beaker while monitoring the live temperature readings by tapping Meter. This was made by adding 10 mL of NaOH and 10 mL of crystal violet solutions to their respective 100 mL beakers, and lowered into the water bath as it was done did before. After the the reactants were cooled to the temperature of the water bath, the contents of both beakers were poured into the 50 mL beaker. This was followed by stirring the contents of the 50 mL beaker with the Temperature Probe. After one minute, the temperature of the mixture was then recorded. A clean, dry cuvette was filled about  $3/4$  full with the reaction mixture and then placed in the Colorimeter and,

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Colorimeter lid was closed and the data collection was started. The cuvette was carefully removed from the Colorimeter when the data collection was complete and the contents of the beaker and cuvette were disposed as directed. A graph was shown by Choosing Show Graph ►Graph 1 from the Graph menu and Curve Fit from the Analyze menu was chosen and, Linear was selected as the Fit Equation. Finally, the rate constant,  $k$ , was determined from the slope value and recorded on data table and, OK key Selected. For the last two steps using water bath at  $\sim 15^{\circ}\text{C}$  and at  $\sim 10^{\circ}\text{C}$ , the above steps were repeated. A graph of concentration vs. volume showing all four data trials were viewed by tapping Run 4 and choosing All Runs where all four trials were displayed on the same graph axis. Finally, a graph of  $\ln$  absorbance vs. time, with all four trials displayed on the graph was printed.

#### DATA TABLE

#### DATA ANALYSIS

In this section, data analysis involved responding to a series of instructions as follow.

. In calculating the activation energy,  $E_a$ , for the reaction, the slope,  $m$ , of the linear fit from Step 2 was used to calculate the activation energy,  $E_a$ , in units of  $\text{kJ/mol}$  Where  $E_a = m \times R$ .

#### Response

Using trials two (2) and four( 4), which were performed at temperatures  $20^{\circ}\text{C}$  and  $10^{\circ}\text{C}$ , respectively, it is seen that the rate constant doubles to indicate that the rate constant is directly proportional to the rate. The rate constant of trial 4 is  $3.449 \times 10^{-3}$  while the rate constant of trial 2 is  $5.067 \times 10^{-3}$ . This is close to two. The the difference can be accounted for by the experimental error.

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## Response

$$k_2 = 1.02 \times 10^{-2}$$

The ratio of the rate constant at  $\sim 25^\circ\text{C}$  to the rate constant at  $\sim 15^\circ\text{C}$ .

5. Using the rate constant and precise temperature value for the trial that was done at room temperature ( $\sim 20^\circ\text{C}$ ), as well as the  $E_a$  value you obtained in Step 3 above, calculate what the rate constant would be at  $40^\circ\text{C}$ .

## Discussion:

In The Rate and Order of a Chemical Reaction, the concept of rate law and order of reaction had been demonstrated in the laboratory. Order of reaction is the power to which the concentration of a reactant in a rate law expression is raised to. Rate law links reaction rate and concentration. This is determined using various concentrations of each reactant. In the Rate Determination and Activation Energy lab, activation energy is the main concept. The activation energy is determined from the measurements of the effect of different temperatures on the rate of reaction and constant. The Arrhenius equation is used to connect activation energy with the rate constant. The activation energy does not change since it is not temperature dependent.

## Experimental Sources of Error:

A source of error in this experiment could have been misreading of measurements. Since we were working with such small numbers of moles, any wrong measurement could have a large impact on the results. Also, a source of error could be fingerprints on the cuvettes. They would cause light to scatter and affect the measured absorbance, which is why we use lint-free wipes before using the cuvettes. In the Rate Determination and Activation <https://assignbuster.com/crystal-violet-activation-of-energy-lab-report-example/>

Energy lab, maintaining the water bath at the required temperature was a difficult task, as the temperature would fluctuate. This affects our results.

Finally, error could lie in the colorimeters themselves, causing the absorbance values to be inaccurate.

#### Work Cited

Simon, Eric & Jean, Liason. Campbell Essential Chemistry (5th Edition). 2013.

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