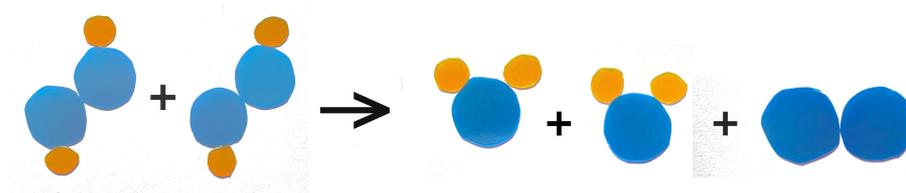


# How does temperature affect the rate of decomposition of hydrogen peroxide in the presence of catalase?

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# Introduction

The aim of my investigation was to determine the effect temperature has on the rate of the decomposition of hydrogen peroxide when catalyzed by catalase from potatoes. Hydrogen peroxide is a harmful oxidizing agent produced as a side product of the metabolism of many organisms. Catalase is an enzyme which facilitates the breakdown of hydrogen peroxide into harmless water and oxygen by the reaction below.



# Experimental design

Catalase is present in most vegetables. I chose potatoes as my source for uniform texture.

The reaction rate was determined by measuring the rate of pressure increasing in a sealed reaction vessel, where 6% hydrogen peroxide solution was in the presence of 6 potato cubes.

As the hydrogen peroxide decomposes, the volume of gas in the vessel increases. The change in pressure due to the added gas was measured by a pressure sensor.

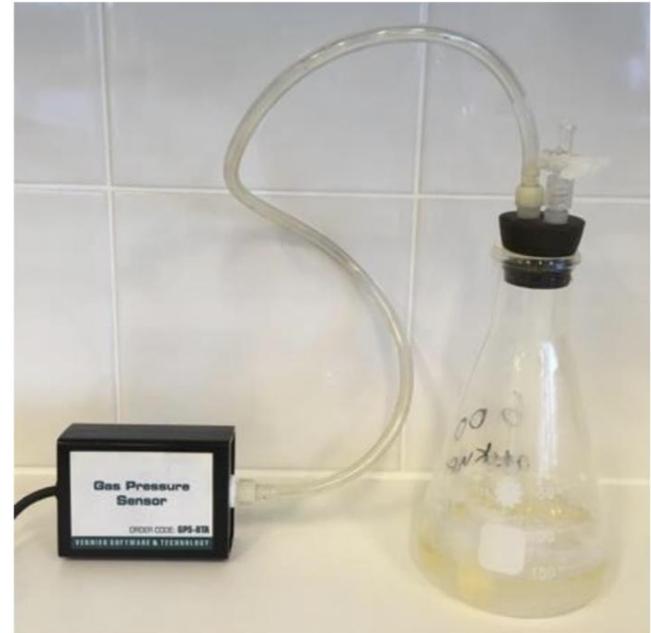


Figure 1. Experimental set-up

# Experimental design

The experiment was repeated five times at six unique temperatures.  
The range of temperatures was 18 - 62°C.

For data sets above and below room temperature, the reaction vessel was held in a cold or hot water bath, respectively.



Figure 2a. Cold water bath



Figure 2b. Hot water bath



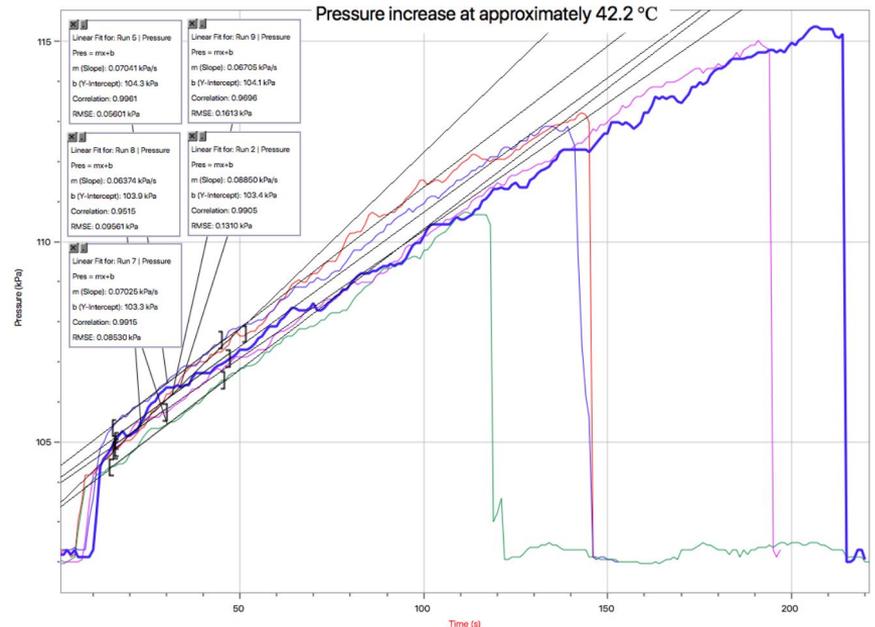
# Calculations

The initial rate of pressure increase was read from the gradient of the tangent of the collected pressure vs. time graph, visualized below. The corresponding reaction rate was found using the ideal gas law.

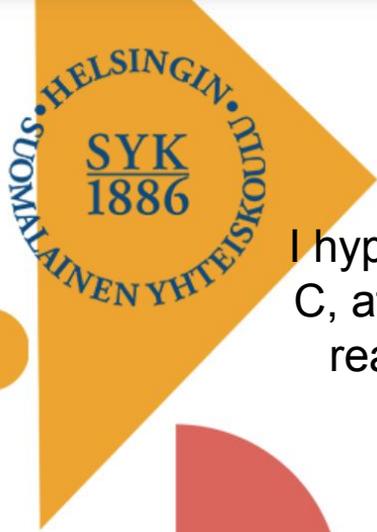
$$\text{rate} = k \frac{\Delta p}{\Delta t} \cdot \frac{1}{RT}$$

where  $\Delta p/\Delta t$  is rate of pressure increase,  $k$  and  $R$  are constants, and  $T$  is the absolute temperature

The unit of reaction rate is  $\text{molm}^{-3}\text{s}^{-1}$ .

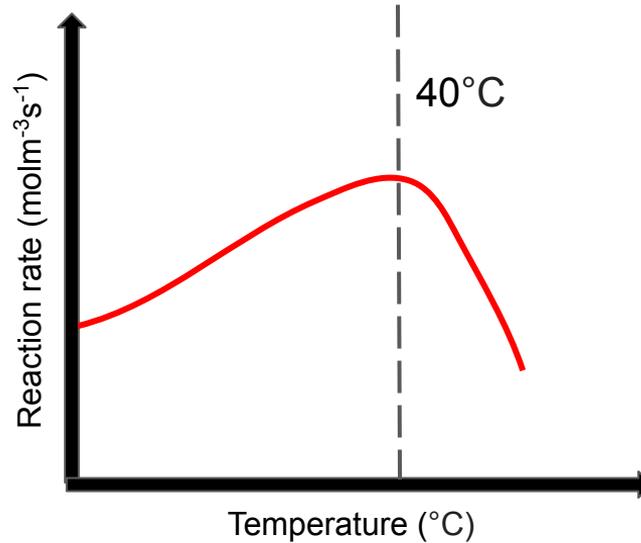


Graph 1. Pressure vs. time for 5 trials at 42 °C



# Hypothesis

I hypothesized that the reaction rate would increase linearly until 40° C, after which catalase loses its shape and is unable to catalyze the reaction. This would be visible as a sharp decline in the graph of reaction rate vs. temperature.



# Results

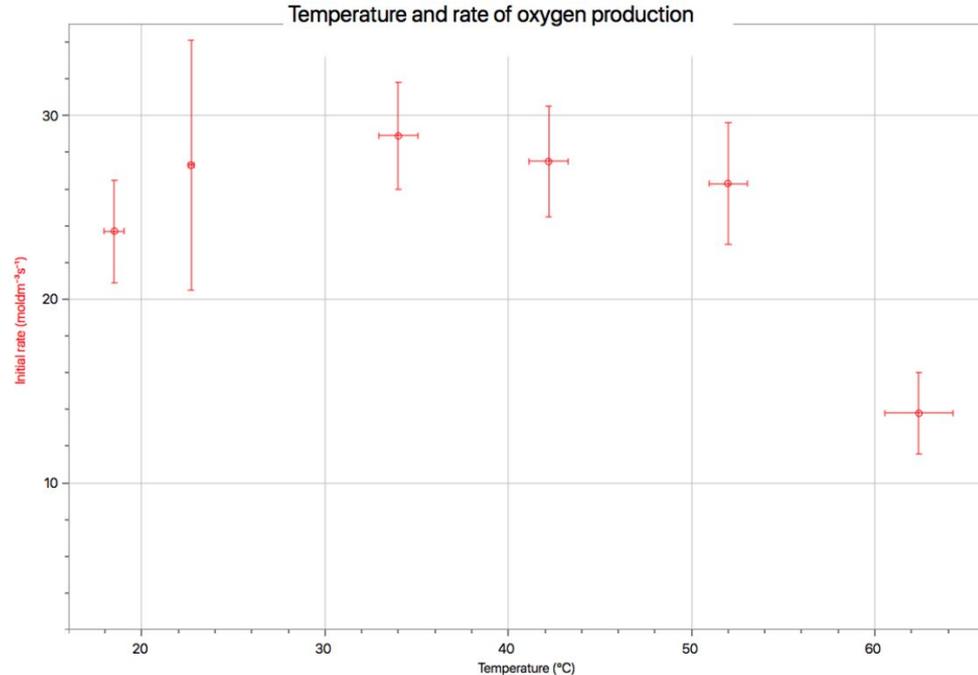
Red dots = data points  
Red lines = error bars

There is an increase in the reaction rate in the range 18-34°C, as expected.

The highest rate was measured at 34°C, instead of 40°C as hypothesized.

There is a slight decline in the reaction rates from 34°C to 52°C, and a significant drop at 62°C.

The results support the hypothesis to some extent, but a larger decline between 42°C and 52°C was expected.





# Evaluation

The error bars of the data points are relatively large, which made the comparison of experimental results to theoretical framework limited.

The uncertainty of the data was largely due to significant variance between the reaction rates of the 5 trials conducted at each temperature.

The data has smaller differences in reaction rates than hypothesized. One probable cause is the incomplete heating of the potatoes, resulting in them being closer to room temperature than reported.

Method could be improved by heating the potatoes in an oven to the desired temperature before conducting the experiment. Consistency between trials could be increased by using catalase powder instead of vegetables.

# Future

Further research should be conducted to more holistically answer the research question, and thus gain a better understanding of how organisms can optimize given reactions to support their metabolism.

A similar set-up could be used to study the rate of denaturation of catalase in different organisms and further compare values between different structures, such as animal cell tissue and plant cell tissue.