14.2A Effect of temperature on rates of reaction– Blue food coloring and Bleach

Subjects: Kinetics, Arrhenius analysis

Description: Two samples of blue food dye in water each with the same concentration of dye, but at different temperatures. Bleach is added to both samples and the time until the blue color disappears is recorded.

Materials:
2 400 mL beakers
water
blue food coloring
1 10 mL graduated cylinder
1 100 mL graduated cylinder
household bleach, undiluted‡
hot plate*
thermometer
funnel
glass stir rod

*Shared item: Located in the top drawer opposite the chemical storage cabinets.
‡Bleach is located in the refrigerator.

Pre-Class preparation:
1. Add 300 mL of water to one of the beakers.
2. Add three drops of blue food dye.
3. Pour half of the solution into the second 400 mL beaker.

Procedure:
1. Place one beaker on the hot plate and heat the water to a steady temperature. Do not boil.
3. Record the temperature.
5. Add 10 mL of bleach solution to the room temperature solution.
6. Measure the time it takes for the blue color to disappear.
7. Repeat steps 5 and 6 for the heated solution.

Discussion:
The reaction order for the blue food dye could have been calculated during demo 14.2, in which the effect of concentration on rate was explored. From there, k could have been calculated.

This demo focuses on the effect of temperature on the rate of the reactions. The reactant concentrations are kept constant, but the reaction is performed at different temperatures.

An Arrhenius analysis can follow these reactions. The Arrhenius equation relates rate constant with activation energy, frequency of collisions, and temperature and demonstrates that the rate constant can change with temperature. The equation is given below:

k = rate constant = $Ae^{-Ea/RT}$

Where:
k=rate constant
Ea=activation energy
R=ideal gas constant
T=temperature
A = frequency factor and is given in L/mol-s.

Taking the natural logarithm of both sides gives:

$\ln k = \ln A + (-E_a/RT)$.

Rearranging the expression gives:

$\ln k = (-Ea/R)(1/T) + \ln A$.

This shows that lnk and 1/T are related linearly, where –Ea/R is the slope and lnA is the intercept. Thus, plotting lnk vs 1/T at different temperatures (Kelvin) can be used to calculate activation energy.

In 14.2, it was determined that the rate was first order with respect to dye and that the rate constant was approximately 1.4/min.

Using $\ln([R]_t/[R]_0) = -kt$ for 1st Order reactions, we can determine the rate constant at different temperatures, and then plot lnk vs 1/T to determine the activation energy.

Safety: Use caution when handling bleach solutions. Use gloves to prevent skin contact.

Disposal: Solutions can be flushed down the drain with water

References:
1. Prof. Fermann