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BOCES Science Laboratory Investigation

BEER’S LAW AND STANDARD CURVES

**Introduction**

It is often very useful to have a standard to which one can compare an unknown substance. In the lab, one might use the accepted melting temperature of a substance as something to which the experimental melting temperature might be compared. If the two values are very closely matched, it is likely that the substances are similar, as well. However, a simple point-to-point comparison is not always adequate.

In these cases, a tool called a standard curve may be employed. The idea behind it is very simple. One can simply use a series of controlled experiments in the laboratory to create a series of points on a graph. Then, using that graph or the equation of the line on it, one can interpolate all the data needed. Consider this example: You measure the height of each student in the class as well as their weight. You might expect to find that as the height of the individual increases, so would their weight. Upon graphing this data, you find a graph with a positive slope. You can take any point on the X or Y axis (representing height or weight), follow it up to the line on the graph, then over to the opposite axis. So, if you started at 160 cm, you might go over to the line and find 67 kg on the opposite axis. So you would be able to, with some reasonable accuracy, predict the height or weight of an individual given one or the other number.

It is often very useful for chemists, carpenters or forensic scientists to be able to predict the behavior of one variable based on data known about another. For example, the degree that a piece of metal will contract given a certain temperature change, or the shape of a blood splatter given a distance it is found from the source.

Beer’s law states that there is a relationship between how much light is absorbed by a certain amount of a specific liquid, and the concentration of that liquid. While there are many other aspects of Beer’s law that can make a standard curve much more accurate, we’ll confine our discussion to the three factors listed in the Beer’s law formula below:

**A = εbc**

where A is the absorbance (no units), ε is the molar absorptivity (in L mol-1 cm-1), b is the path length (in cm) and c is the concentration (in mol/L). If you know all but one of these values, you can figure out the one you need with simple algebra. Today, we’re going to make a standard curve using Beer’s law and this formula.

We’re going to measure the absorbance, as well. We’ll do this with a spectrophotometer, and we’ll need this formula:

**A = log10 I0/I**

where A is the absorbance (no units), I0 is the light that comes in, and I is the light that comes out. We can obviate the need for this formula by using a computer to tell us the absorbance directly.

**Purpose**

The purpose of this investigation is to acquaint you with the idea of standard curves, and to provide you experience in creating them. You’ll also learn how to interpolate data from a standard curve, and hone your graph-making skillz on the computer and on paper.

**Materials**

PENCIL Red food dye

Micropipette Pipette tips

Meter sticks Graph paper

Computer Spectrophotometer

Cuvettes Volumetric flask

**Procedure**

PART I – SAMPLE STANDARD CURVE

In this section, you will practice making and using a standard curve using the measurements of people in this class. Then, you’ll be able to see how good your curve was by seeing how well you can predict your teacher’s height from his arm span.

1. Measure your height in cm, to the nearest 0.1 cm. Record your height in table 1.

2. Measure your arm span, from tip of middle finger to tip of middle finger, to the nearest 0.1 cm. Record this data in table 1.

3. Enter your data on the class website so that your teacher can graph it for you.

4. Using the class data, interpolate to find the height of your teacher given his arm span. Use both a graphical method and a formula.

PART II – USING BEER’S LAW

1. Your group will be assigned a specific concentration of a solution to prepare. CAREFULLY measure out the amount of food coloring you need and add it directly to the volumetric flask using a micropipette.

2. Add distilled water up to the line AND NOT OVER OR UNDER. It’s imperative that you fill the flask up exactly to the line!

3. Use the spectrophotometer to measure the absorbance of your solution.

4. Gather data the other groups, including their absorbance values and the concentration of their solutions, and create a plot of absorbance vs. concentration. You only need to make one graph per group, but make sure that everyone in your group gets their name on the graph! Each of you must turn in a lab.

QUESTION 1: What did you find the height of your teacher to be using the graphical method?

QUESTION 2: What did you find the height of your teacher to be using the formula method?

QUESTION 3: What is the actual height of your teacher?

QUESTION 4: Which method was better for interpolating an unknown value from a standard curve? Why?

QUESTION 5: What are two ways that you could use your graph to determine the concentration of a solution?

QUESTION 6: What application would this law have to your particular CTE class?

QUESTION 7: What are some possible sources of error when using this law?

QUESTION 8: Will the line on an absorbance vs. concentration graph always look the same if it’s always made with the same liquid? Explain.

QUESTION 9: What is one thing that you could do to make the line on an absorbance vs. concentration graph look different? (hint: think about your answer to question number 8)

QUESTION 9: What are two things about this lab that you would change if you could.