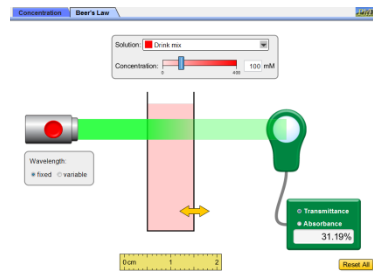
Name: ____ Period: ______

Light Spectroscopy and Beer's Law

Directions:
In studying the rates of chemical reactions it is necessary to measure the concentrations of reactants and/or products over a period of time. If our reaction is occurring in aqueous solution, it is often possible to correlate the concentration of reactants or products to the amount of light that the solution is able to absorb (or transmit) at a given time. In this activity, you will investigate the relationship between concentration and absorbance of light and one of the instruments used to measure it.

To begin, go to: http://phet.colorado.edu/en/simulation/beers-law-lab



Part 1: Transmittance and Absorbance.

- Click on the Beers Law tab, reset the simulation and turn on the light source.
- The % of light that is transmitted through a sample depends upon four variables. First, just play around a bit. Manipulate these variables to see what their impact on % transmittance is.
- The % of light transmitted will simultaneously tell us the amount of light absorbed. For example, what is the absorbance when the transmittance is "1" (100%)?

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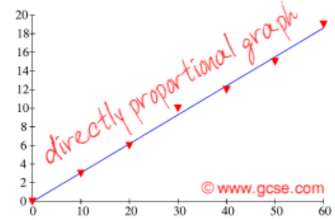
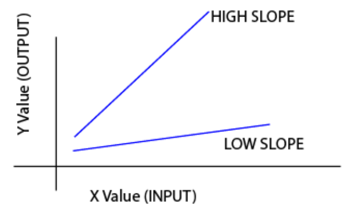
- For this investigation we will examine all measurements of light in terms of Absorbance. The relationship between Absorbance and Transmittance is mathematically expressed as $A = -\log_{10} T$
- **Remember:** if you are testing/manipulating a variable and want to see the change it causes, then you must keep the other variables unchanged.
- Use the simulation to answer the questions in the table below:

What impact does each variable have on the measured concentration of a solution, as given by Absorbance?				
Variable:	**Concentration** **c** (keep the same solute and the same sample length)	**Sample Length** **b** (keep the same solute and concentration)	**Molar absorptivity** **Type of Solute** **ε** (keep the same concentration and sample length)	**Wavelength of Light** (keep all other variables constant)
	For all of these tests maintain the default *fixed* wavelength of light			
Relationship of Variable to Absorbance: (Direct, inverse or random)				

Part 2: Beer's Law



- According to your observations, the measured absorbance will increase if you increase either the actual concentration or the sample cell length. In fact, these measurements are directly proportional and should produce a straight line when graphed!



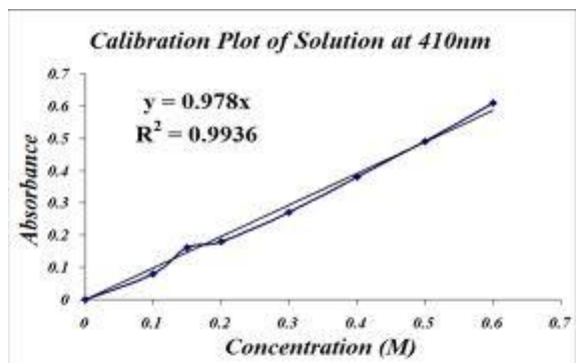
- The rate of absorbance also depends upon the slope (type of solute examined), which is described by the "Molar Absorbance", ε .
- A substance that "absorbs a lot of light" will result in a steeper slope when graphed because of the greater molar absorbance.

- This also means that if you are looking at a particular solute using a particular sample length, **b**, the slope, **ε·b,** is constant.

- Following the equation for a linear line, **y = mx,** we get **A = εbc.** This is known as "Beer's law".

- This equation can be applied to determine the concentration of almost any solute through its absorbance.

- **<u>For example:</u>** If the following plot and equation of **A *vs* c** was obtained, then what would be the concentration of the solute for an unknown sample that has an absorbance of .55? Show work:



- Based on your earlier observations, it shouldn't surprise you that the graph above only applies to a particular wavelength of light, 410 nm. Although patterns of Wavelength *vs* Absorbance can be useful in identifying the substance, the pattern is so unique and random it is impractical for Beer's Law.

- Although Beer's Law can only be applied to a "fixed" wavelength, it is a good idea to first determine which wavelength will be most suitable and then to conduct a Beer's Law analysis at that wavelength.

- Determine which wavelength would be the best to use if you were to graph the A *vs* c for each of these substances.

Drink mix
$Co(NO_3)_2$: Cobalt (II) nitrate
$CoCl_2$: Cobalt chloride
$K_2Cr_2O_7$: Potassium dichromate
K_2CrO_4: Potassium chromate
$NiCl_2$: Nickel (II) chloride
$CuSO_4$: Copper sulfate
$KMnO_4$: Potassium permanganate