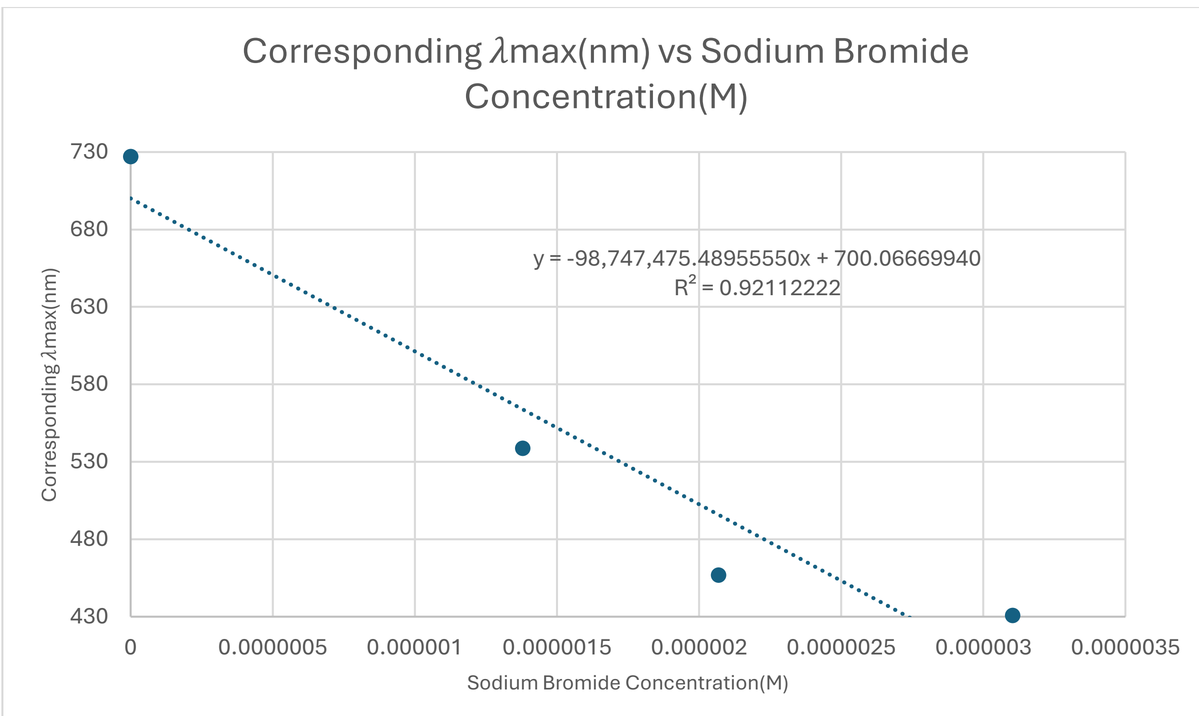
λ_{max} of Nanoparticle Solutions

1. Insert a table of your sodium bromide concentration (in M) and their corresponding λ_{max} values.

Table 1. Sodium Bromide Concentration(M) and Corresponding λ_{max}(nm)

Sodium Bromide Concentration(M)	Corresponding λ_{max}(nm)
0	727.0
$1.37931*10^{-6}$	538.7
$2.06897*10^{-6}$	456.9
$3.10345*10^{-6}$	430.7

2. Insert a graph of λ_{max} vs. sodium bromide concentration.



Graph 1. Corresponding λmax(nm) vs Sodium Bromide Concentration(M)

3. Based on your data, make a conclusion about the relationship between the amount of sodium bromide added, the λ_{max}, and the size of the nanoparticles.

We can observe that as the concentration of sodium bromide increased, the max decreased. This suggests that there is an inverse relationship between concentration and lambda max.

4. Your nanoparticle solutions should be very distinct colors. Use your data to rank these solutions from lowest energy **absorbed** to highest energy **absorbed**. Include a thorough explanation for your ranking. How does it relate to nanoparticle size?

Vial 4 > Vial 3 > Vial 2 > Vial 1

Vial 4(yellow) absorbed violet and blue light, which has the shortest wavelength, meaning most energy absorbed. Vial 3(orange) absorbed blue and green light, slightly longer wavelengths but still high energy. Vial 2(purple) absorbed green and yellow light, absorbing wavelengths in the mid-range of the visible spectrum, so third highest. Vial 1(blue) absorbed red, orange light, which have the longest wavelength, and the lowest amount of energy absorbed. In relation to nanoparticle size, larger nanoparticles absorb light at longer wavelengths, meaning at lower energy. So, Vial 1(blue) has the largest nanoparticles with the lowest energy absorption (longest wavelength), while Vial 4 contains the smallest.

5. A student prepares some silver nanoparticles. They add all the reagents to a vial using proper technique. Then they add an aliquot of that solution to a cuvette and measure λ_{max} at 460 nm. What color would this nanoparticle solution have? Based on your data, calculate the sodium bromide concentration required to make these specific nanoparticles.

   460nm is very close to the recorded orange value of 456.9. So, I would say that it would most likely have a very similar color to vial 3, which was orange.

   $\boldsymbol{\lambda_{max} = -98{,}747{,}475.48955550x + 700.06669940}$

   $\boldsymbol{460 = -98{,}747{,}475.48955550x + 700.06669940}$

   $\boldsymbol{x = (460 - 700.06669940) / -98{,}747{,}475.48955550}$

   $\boldsymbol{x = 2.43011*10^{-6}}$

Behavior of Nanoparticles

6. First, explain why it is acceptable to calculate the concentration of nanoparticles while excluding the volume of the added sodium bromide solution.

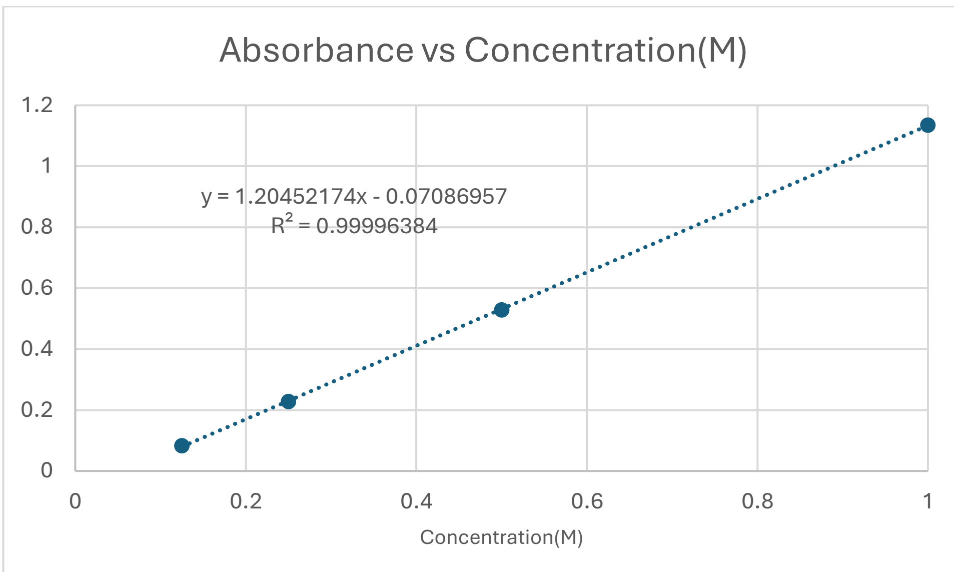
In all practicality, the added sodium bromide solution is 0-45 µL, which compared to the total solution is 14.50mL, equivalent to 14,500 µL, so even the most of 45 µL is a maximum of a .31% of the total solution, barely doing anything. So, excluding the sodium bromide volume simplifies calculations, without introducing much meaningful error.

7. Insert a table of your calibration curve data (absorbance vs. concentration) for the blue nanoparticle solution using your **actual concentrations**.

Table 2.*Absorbance vs Concentration(M)*

Concentration(M)	Absorbance
1.000	1.135
.500	.529
.250	.228
.125	.083

8. Insert a graph of your calibration curve data.



Graph 2. Absorbance vs Concentration(M) of Blue Nanoparticle Solution

9. Based on your data, do the silver nanoparticles obey Beer's law?

Yes, they do obey Beer's Law. Beer's law states a direct, proportionate relationship between absorbance and concentration. We see this in our data, going from .125M -> 1M, absorbance increased from .083 to 1.135.

10. We've been referring to these nanoparticles as a solution, but they are technically a suspension. You've had plenty of experience with solutions in both lab and lecture, but we haven't talked about suspensions at all. Use your academic resources to explain the similarities and differences in a solution vs. a suspension. Cite your sources.

https://study.com/academy/lesson/comparing-solutions-suspensions-colloids-properties-examples.html#:~:text=Difference%20between%20Solution%20and%20Suspension,not%20dissolve%2C%20and%20will%20separate.

The differences are that a solution is a homogenous mixture, meaning the solute is uniformly distributed throughout solvent, it looks the same throughout. A suspension, however, has dispersed particles that can be seen and may settle out, like a deposit of salt in a glass of water. So, solutions have smaller particles, so they mix uniformly, and they are generally invisible.

11. Reconcile why your nanoparticles are a suspension but exhibit properties of a solution.

Although nanoparticles have the size range of suspensions, they are in a unique range that allows them to stay suspended longer than regular suspension particles. So, although they are a suspension, they give the appearance of a solution. Nanoparticles are stabilized with capping agents, which prevent them from settling out, showing the characteristics of a suspension.

12. Centrifuges are used to separate solids from liquids. Let's say we put a sample of your nanoparticle suspension in a centrifuge, collect the liquid, and put that sample in the spectrophotometer. How would the absorbance for this sample compare to the absorbance for your original sample?

When the sample is centrifuged, the nanoparticles are forced to settle at the bottom, separating from the liquid. In the original suspension, the nanoparticles absorb a lot, but with no nanoparticles in the main liquid, there would be minimal to no absorbance at lambda max.

Lab Notebook

Submit ALL lab notebook pages for this experiment. Tag everything appropriately in Gradescope.

10/23/22 Manos Paa-lhrm

Nanoparticles Lab

Purpose: Introduce nanomaterials, reviewing spectrophotometry and Beer's Law

Safety: They all irritate the skin

: All waste goes into inorganic waste container

sodium citrate - skin, eye, irritant

silver nitrate - poisonous, corrosive, strong oxidizer

sodium bromide: harmful if swallowed, inhaled

sodium borohydride - corrosive, flammable solid, dangerous when wet, releases hydrogen

Chemicals:

millipore grade purity water

1.25×10^{-2} sodium citrate

3.75×10^{-4} m silver nitrate

5×10^{-2} hydrogen peroxide

1×10^{-3} m sodium bromide

5×10^{-3} sodium borohydride

Equipment:

4 x 20 mL vials

3 x 50 mL beakers

250 mL beaker (waste)

10 mL grad. cylinder

micro liter syringe (2 people)

5 mL volumetric flask

Labeling tape

spectrophotometer

kimwipes

Cuvettes

Part A:

All glassware rinse with MP water

Label vials 1-4

10mL sodium ~~hydroxide~~ citrate, 25mL ~~s~~ silver nitrate,
25mL hydrogen peroxide

Using grad cylinder, add 2 mL Sodium Citrate, 5mL silver nitrate,
5mL ~~s~~ hydrogen peroxide to each vial

Using micropipette - add this much of 1.00 mol^{-3} M sodium bromide

$V_1 = 0\mu L$, $V_2 = 20\mu L$, $V_3 = 30\mu L$, $V_4 = 45\mu L$

Rinse clean 50mL beaker with 5×10^{-3} sodium borohydride

add 25 mL 5×10^{-3} mL sodium borohydride to each vial

- Swirl gently, record color changes

Steps 3 - Beer's Law - → blue solution

Rinse 3 v. flasks, 15mL pipettes MP water

2. 5mL V_1 into flask one, add MP water to 10mL = 50%
   - take 5mL from F, into Flask 2, add MP water 10mL,
     25%
   - one more 12.5%
   - Label all 3 solutions

- 1

- connect to spectrophotometer
- MP water calibration
- rinse cuvettes with MP water
- measure absorption spectrum, λ_{max} solution colors
- Spectrum for F_1, F_2, F_3

Step 5 – Beer's Law -

1. place V, cuvette into , record absorbance,
do this for F_1 (50%) F_2 (25%), F_3 (12.5%)

- concentrations for each reagent
- λ for each of 4 solutions
- Absorbance values for stock, 3 dilutions of blue

Group 5 - Food Package

V_1 = ~~yellow~~ immediately yellow → blue, V_2 immediately yellow → purple

V_3 = ~~orange~~ orange, V_4 = yellow

Data:

	λ_{max}
B - Vial 1-B	727.0
P - Vial 2-P	534.7
O - Vial 3-O	456.9
Y - Vial 4-Y	430.7

Flask	Concentration ~~Absorbance~~	~~@ 727.0nm~~
1	1	1.135
2	.5	.529
3	.25	.228
	.125	.083

Volumes:

$Vial_1$: 2.5mL sodium citrate + 5mL sodium nitrate + 5mL hydrogen peroxide

$Vial_2$ = $Vial_1$ + 20μL sodium bromide

$Vial_3$ = $Vial_1$ + 30μL sodium bromide

$Vial_4$ = $Vial_1$ + 45μL sodium bromide

Vial	1.25×10^{-2} M	sodium Citrat	3.75×10^{-4} $NaNO_3$	5.00×10^{-2} H_2O_2	5.0×10^{-3} Sodium Bromate
1	2.0 mL	~~5.0 mL~~	5.0 mL	5.0 mL	0 mL
2	2.0 mL	~~8.0 mL~~	5.0 mL	5.0 mL	20 µL
3	2.0 mL	~~8.0 mL~~	5.0 mL	5.0 mL	30 µL
4	2.0 mL	~~5.0 mL~~	5.0 mL	5.0 mL	45 µL

X

Br