Sample Calculation: Trial One

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1. Volume of cyclohexane added:

$V_{final} = 6.20 mL$

$V_{Initial} = 5.20 mL$

$V_{added} = ?$

$V_{added} = V_{final} - V_{Initial}$

$V_{added} = 6.20 mL - 5.20 mL$ ✓ 1

$V_{added} = 1.00 mL$

∴ The volume added is 1.00 mL.

2. Volume per drop of cyclohexane:

$V_{added} = 1.00 mL$

# of drops = 83 drops

V / Drop = ?

$$V/drop = \frac{V_{added}}{\# \text{ of drops}}$$

$$V/drop = \frac{1.00 mL}{83 \text{ drops}}$$ ✓ 1

$V/drop = 0.0120 mL/drop$

∴ There is about 0.0120 mL/drop of cyclohexane.

Average Volume per drop of cyclohexane:

Trial 1 = 0.0120 mL/drop

Trial 2 = 0.0120 mL/drop

Avg = ?

$$Avg = \frac{\text{Trial } 1 + \text{Trial } 2}{2}$$

$$Avg = \frac{0.0120 mL/drop + 0.0120 mL/drop}{2}$$

$Avg = 0.0120 mL/drop$

∴ The average mL/drop for both trials is 0.0120 mL/drop.

3. Volume of solution required to form a monolayer:

of drops = 4 drops

V/drop = 0.0120 mL/drop

$V_{monolayer} = ?$

$V_{monolayer} = \# \text{ of drops} \times V/drop$

$V_{monolayer} = (4 \text{ drops})(0.0120 mL/drop)$ ✓ 1

$V_{monolayer} = 0.0480 mL$

∴ The volume it takes to form a monolayer is about 0.0480 mL

4. Mass of stearic acid in that volume:

$V_{monolayer} = 0.0480 mL$

$C_{stearic\ acid} = 1.36 \times 10^{-4} g/mL$

$m_{stearic\ acid} = ?$

$m = VC$

$m = (0.0480 mL)(1.36 \times 10^{-4} g/mL)$ ✓

$m = 6.53 \times 10^{-6} g$ 1

∴ The mass of stearic acid is 6.53×10^{-6} grams.

Volume of Stearic acid:

$m_{stearic\ acid} = 6.53 \times 10^{-6}$ g

$D_{stearic\ acid} = 0.847$ g/mL

$V_{stearic\ acid} = ?$

$V = \frac{m}{D}$

$V = \frac{6.53 \times 10^{-6} g}{0.847 g/mL}$ ✓ 1

$V = 7.71 \times 10^{-6} mL$

∴ The Volume of stearic acid is 7.71×10^{-6} mL.

6. Area of the monolayer:

$r_{monolayer} = 4.05$ cm

$A_{monolayer} = ?$

$A = \pi r^2$

$A = \pi (4.05 cm)^2$ ✓ 1

$A = 51.5 cm^2$

∴ The area of the monolayer is $51.5 cm^2$.

7. Thickness of the monolayer:

$V_{stearic\ acid} = 7.71 \times 10^{-6}$ mL

$A_{monolayer} = 51.5 cm^2$

$t_{monolayer} = ?$

$t = \frac{V}{A}$

$t = \frac{7.71 \times 10^{-6} mL}{51.5 cm^2}$ ✓ 1

$t = 1.50 \times 10^{-7} mL/cm^2$ or cm

∴ The thickness of the monolayer is about 1.50×10^{-7} cm.

8. Diameter of the carbon atom from A.:

$t_{monolayer} = 1.50 \times 10^{-7}$ cm

$l_{stearic\ acid} = 20$ atoms

$D_{carbon\ atom} = ?$

$D = \frac{t}{l}$

$= \frac{1.50 \times 10^{-7} cm}{20 \text{ atoms}}$ ✓ 1

$= 7.50 \times 10^{-9}$ cm

∴ The diameter of 1 carbon atom is 7.50×10^{-9} cm

9. Volume of the carbon atom from A.:

$r_{carbon\ atom} = 3.75 \times 10^{-9}$ cm

$V_{carbon\ atom} = ?$

$V = 4/3 \pi r^3$ ✓ 1

$= 4/3 \pi (3.75 \times 10^{-9} cm)^3$

$= 2.21 \times 10^{-25} cm^3$

∴ The volume of a carbon atom is about $2.21 \times 10^{-25} cm^3$.

Avogadro's number from A.:

$Vol/mol = 3.42\ cm^3/mol$

$Vol/Atom = 2.21 \times 10^{-25} cm^3/Atom$

$N_A = ?$

$$N_A = \frac{Vol/mol}{Vol/Atom}$$

$$N_A = \frac{3.42\ cm^3/mol}{2.21 \times 10^{-25} cm^3/Atom}$$

$$N_A = 1.55 \times 10^{25}\ Atom/mol$$ ✓ 1

∴ Avogadro's number for part A. is 1.55×10^{25} Atoms per mole.

11. Percent error:

N_A calculated $= 1.55 \times 10^{25}$ Atom/mol

$N_A = 6.02 \times 10^{23}$ Atom/mol

%error = ?

$$\%error = \frac{N_A calculated - N_A}{N_A} \times 100$$

$$\%error = \frac{(1.55 \times 10^{25}) - (6.02 \times 10^{23} Atom/mol)}{6.02 \times 10^{23} Atom/mol} \times 100$$

$$\%error = 2470\ \%$$ ✓ 1

∴ The percent error is about 2470 %

12. Value of e from B.:

$t_{monolayer} = 1.50 \times 10^{-7} cm$

e = ?

$$e = \frac{1}{20} t$$

$$= \frac{1}{20}(1.50 \times 10^{-7} cm)$$ ✓ 1

$$= 7.50 \times 10^{-9} cm$$

∴ The value of e is $7.50 \times 10^{-9} cm$

13. Diameter of the carbon atom from the value of e from B.:

$e = 7.50 \times 10^{-9} cm$

$\theta = 55°$

d = ?

$$d = \frac{e}{\sin \theta}$$

$$= \frac{7.50 \times 10^{-9} cm}{\sin 55}$$ ✓ 1

$$= 9.16 \times 10^{-9} cm$$

∴ The diameter is $9.16 \times 10^{-9} cm$.

Volume of the Carbon Atom from B.:

$r = 4.58 \times 10^{-9} cm$

$V = ?$

$V = 4/3 \pi r^3$

$= 4/3 \pi (4.58 \times 10^{-9} cm)^3$

$= 4.02 \times 10^{-25} cm^3$

∴ The Volume of a carbon atom is $4.02 \times 10^{-25} cm^3$.

✓ 1

15. Avogadro's number from B.:

$Vol/mol = 3.42 cm^3/mol$

$Vol/Atom = 4.02 \times 10^{-25} cm^3/Atom$

$N_A = ?$

$N_A = \frac{Vol/mol}{Vol/Atom}$

$= \frac{3.42 cm^3/mol}{4.02 \times 10^{-25} cm^3/Atom}$

$= 8.51 \times 10^{24}$ Atom/mol

✓ 1

∴ The Avogadro's number from B is 8.51×10^{24} Atoms per mole

Comparing the Volumes of a carbon Atom from part 9 and part 14:

$V_{part 9} = 2.21 \times 10^{-25} cm^3$

$V_{part 14} = 4.02 \times 10^{-25} cm^3$

Difference = ?

$Difference = |V_{part 14} - V_{part 9}|$

$= |(4.02 \times 10^{-25} cm^3) - (2.21 \times 10^{-25} cm^3)|$

$= 1.81 \times 10^{-25} cm^3$

∴ The difference in Volume of the carbon atom is $1.81 \times 10^{-25} cm^3$

16. Percent error:

$N_A calculated = 8.51 \times 10^{24}$ atom/mol

$N_A = 6.02 \times 10^{23}$ atoms/mol

% error = ?

$\%error = \frac{N_A calculated - N_A}{N_A} \times 100$

$\%error = \frac{(8.51 \times 10^{24}) - (6.02 \times 10^{23} atoms/mol)}{6.02 \times 10^{23} atoms/mol} \times 100$

%error = 1310 %

✓ 1

∴ The Percent error is about 1310%

Discussion

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When determining Avogadro's number for both part A and B, the percent error was extremely large (over 100%) and therefore was not reasonable. However, both trials remained somewhat consistent when calculating these values. With any experiment conducted, there is always room for error and there can be a number of reasons that caused it.

In this experiment, a pipette was used to drop stearic acid solution onto the surface of water in a petri dish. We would then wait until the droplet disappeared until adding another. This would be repeated until the droplet took more than 30 seconds to disappear. This meant a monolayer had formed on the surface of the water. However, error can occur if the drop of stearic acid touches the side of the petri dish. Based on our observations, when this happens, the droplet dissolves at a significantly faster speed. This could result in us adding more drops than required to form a monolayer and therefore create a thicker layer of stearic acid. This could affect our results by giving us a smaller percent error. Not necessarily 1 ✓

Another source of experimental error could have came from us not inspecting the petri dish for any particles of dust or dirt on the surface of the water. So when stearic acid was added to the petri dish, the dust and/or dirt particles could have prevented a monolayer to form and therefore, more solution would have been added to form the monolayer. This would have increased the thickness of the monolayer and therefore given us a smaller percent error. 1 ✓

A third source of error that could have also significantly affected the percent error could have been the angle at which the pipette was held when adding stearic acid solution. If the pipette was not held perfectly vertical, the droplets might not have all been perfectly uniform. This could affect the actual volume per drop that was calibrated in the first part of the experiment and either increase or decrease the percent error in the final outcome. This could also accounted as to why our percent error was so high. 1 ✓

Another source of error that could have had a major effect of the percent error could have been if the stearic acid solution had sat out for a long time without the cap on the bottle. Since it is a very volatile solution, the concentration could have increased therefore when dropping it onto the surface of the water, a monolayer could have formed a lot sooner with less droplets of solution. This could result in a thinner monolayer and therefore increased the percent error which might account as to why our percent error was so high. 1 ✓

Conclusion

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For trial one, the value for Avogadro's number in part A was calculated as 1.55x10^25 mol^-1 with a percent error of 2470% and in part B, Avogardro's number was calculated as 8.51x10^24 mol^-1 with a percent error of 1310% respectfully. For trial two, the value for Avogadro's number in part A was calculated as 1.03x10^25 mol^-1 with a percent error of 1610% and in part B, Avogardro's number was calculated as 5.64x10^24 mol^-1 with a percent error of 837% respectfully.