Lab 1: An Introduction to Good Analytical Lab Technique

Questions

Part A

Delivery instrument	Sample #	Mass (Analytical Balance, g)	Mass (Top Loading Balance, g)
P-1000	1	1.0037	1.007
	2	1.0106	1.008
	3	1.0168	1.010
10 mL graduated cylinder	1	0.9670	0.900
	2	0.9595	1.008
	3	0.9167	1.049
P-200	1	1.0064	1.030
	2	1.0154	1.034
	3	1.0191	1.030

1.

Delivery instrument	Average density (g/mL) ± std. dev.	
	Analytical Balance	Top Loading Balance
P-1000	1.0104 ± 0.0066	1.008 ± 0.002
10 mL graduated cylinder	0.9477 ± 0.0271	0.986 ± 0.077
P-200	1.0136 ± 0.0065	1.031 ± 0.002

- P-1000:
  - Analytical:
    - Average: $\overline{x} = \frac{\sum x_i}{N} = \frac{1.0037\frac{g}{\text{mL}} + 1.0106\frac{g}{\text{mL}} + 1.0168\frac{g}{\text{mL}}}{3} = 1.0104$ g/mL
    - Standard Deviation: s = $\sqrt{\frac{\sum (x_i - \overline{x})^2}{N-1}} =$

      $\sqrt{\frac{\left(1.0037\frac{g}{mL} - 1.0104\frac{g}{mL}\right)^2 + \left(1.0106\frac{g}{mL} - 1.0104\frac{g}{mL}\right)^2 + \left(1.0168\frac{g}{mL} - 1.0104\frac{g}{mL}\right)^2}{3-1}} = 0.0066$ g/mL
  - Top-Loading:
    - Average: $\overline{x} = \frac{\sum x_i}{N} = \frac{1.007\frac{g}{\text{mL}} + 1.008\frac{g}{\text{mL}} + 1.010\frac{g}{\text{mL}}}{3} = 1.008$ g/mL
    - Standard Deviation: s = $\sqrt{\frac{\sum (x_i - \overline{x})^2}{N-1}} =$

      $\sqrt{\frac{\left(1.007\frac{g}{mL} - 1.008\frac{g}{mL}\right)^2 + \left(1.008\frac{g}{mL} - 1.008\frac{g}{mL}\right)^2 + \left(1.010\frac{g}{mL} - 1.008\frac{g}{mL}\right)^2}{3-1}} = 0.002$ g/mL
- 10 mL graduated cylinder:
  - Analytical:
    - Average: $\overline{x} = \frac{\sum x_i}{N} = \frac{0.9670\frac{g}{\text{mL}} + 0.9595\frac{g}{\text{mL}} + 0.9167\frac{g}{\text{mL}}}{3} = 0.9477$ g/mL

- Standard Deviation: s = $\sqrt{\frac{\sum(x_i - \overline{x})^2}{N-1}} =$

$$\sqrt{\frac{\left(0.9670\frac{g}{mL} - 0.9477\frac{g}{mL}\right)^2 + \left(0.9595\frac{g}{mL} - 0.9477\frac{g}{mL}\right)^2 + \left(0.9167\frac{g}{mL} - 0.9477\frac{g}{mL}\right)^2}{3-1}} = 0.0271 \text{ g/mL}$$

- Top-Loading:
  - Average: $\overline{x} = \frac{\sum x_i}{N} = \frac{0.900\frac{g}{\mathrm{mL}} + 1.008\frac{g}{\mathrm{mL}} + 1.049\frac{g}{\mathrm{mL}}}{3} = 0.986$ g/mL
  - Standard Deviation: s = $\sqrt{\frac{\sum(x_i - \overline{x})^2}{N-1}} =$

$$\sqrt{\frac{\left(0.900\frac{g}{mL} - 0.986\frac{g}{mL}\right)^2 + \left(1.008\frac{g}{mL} - 0.986\frac{g}{mL}\right)^2 + \left(1.049\frac{g}{mL} - 0.986\frac{g}{mL}\right)^2}{3-1}} = 0.077 \text{ g/mL}$$

- P-200:
  - Analytical:
    - Average: $\overline{x} = \frac{\sum x_i}{N} = \frac{1.0064\frac{g}{\mathrm{mL}} + 1.0154\frac{g}{\mathrm{mL}} + 1.0191\frac{g}{\mathrm{mL}}}{3} = 1.0136$ g/mL
    - Standard Deviation: s = $\sqrt{\frac{\sum(x_i - \overline{x})^2}{N-1}} =$

$$\sqrt{\frac{\left(1.0064\frac{g}{mL} - 1.0136\frac{g}{mL}\right)^2 + \left(1.0154\frac{g}{mL} - 1.0136\frac{g}{mL}\right)^2 + \left(1.0191\frac{g}{mL} - 1.0136\frac{g}{mL}\right)^2}{3-1}} = 0.0065 \text{ g/mL}$$

  - Top-Loading:
    - Average: $\overline{x} = \frac{\sum x_i}{N} = \frac{1.030\frac{g}{\mathrm{mL}} + 1.034\frac{g}{\mathrm{mL}} + 1.030\frac{g}{\mathrm{mL}}}{3} = 1.031$ g/mL
    - Standard Deviation: s = $\sqrt{\frac{\sum(x_i - \overline{x})^2}{N-1}} =$

$$\sqrt{\frac{\left(1.030\frac{g}{mL} - 1.031\frac{g}{mL}\right)^2 + \left(1.034\frac{g}{mL} - 1.031\frac{g}{mL}\right)^2 + \left(1.030\frac{g}{mL} - 1.031\frac{g}{mL}\right)^2}{3-1}} = 0.002 \text{ g/mL}$$

2. The data suggests that the most precise combination was using either the P-200 or the P-1000 with the top-loading balance; with both having a standard deviation of 0.002. The most accurate combination was the P-1000 and the top-loading balance, with the average being 1.008 g/mL, which is 0.011 g/mL away from the true density of water at 21.3°C, 0.997 g/mL (as computed using the table in the lab handout from Table 1.5 R.A. Ray, Jr.; A.L. Underwood. Quantitative Analysis Laboratory

Manual. Prentice-Hall: N.J., 1986.). Thus, the most reliable combination by both metrics is the P-1000 and the top-loading balance.

1. The results for the delivery instruments agrees with what was expected. The 10 mL graduated cylinder was less precise and less accurate since it is not a volumetric tool. The precisions of the P-1000 and P-100 were comparable. An unexpected result of the lab was the top-loading balance outperforming the analytical balance in terms of both accuracy and precision.

Part B

1. | Sample | Weight delivered (g) | Calc. volume delivered (μL) |
   |---|---|---|
   | 0 | 0.4828 | 482.8 |
   | 1 | 0.4942 | 494.2 |
   | 2 | 0.4940 | 494.0 |
   | 3 | 0.4942 | 494.2 |
   | 4 | 0.4953 | 495.3 |

   According to the manufacturer, the % error of the mean for the P-1000 pipette is 0.8%, which means the range for 500 μL is 496 μL - 504 μL. This does not compare well with the average of the data, 0.4921 μL, indicating the accuracy of the pipette is not within manufacturer specifications. This systemic underestimate of weight may be a result of the extremely dry conditions in the lab causing water to evaporate while in the weigh boat. The manufacturer specifies the standard deviation should be 3.0 μL. This compares well with the experimental standard deviation, 0.0052 μL
2. To test the contributions of operator error as compared to equipment error, one can repeat the procedure with a different piece of equipment and see if the error remains, or alternately, have a different experimenter repeat the procedure using the same micropipette.

Lab Notebook

Exp. No. 1	Experiment/Subject Introduction to Good Analytical Lab Technique	Date 1/23	
Name Nathaniel White	Lab Partner N/A	Locker/ Desk No.	Course & Section No. AChem

Fisher Science Education ALF203

A

Volume of 1mL delivered using	Sample number	Analytical Balance (g)	Top Loading Balance (g)
P-1000	1	1.0037	1.007
	2	1.0106	1.008
	3	1.0168	1.010
10mL graduated cylinder	1	0.9670	0.900
	2	0.9595	1.008
	3	0.9167	1.049
P-200	1	1.0064	1.030
	2	1.0154	1.034
	3	1.0191	1.030

B

Pipette: ~~Fisher Brand~~ #19 Fisher Brand Finnipette II #8

volume: 500 μL

Temp: 21.5°C

Sample	Weight delivered (g)	Calculated Volume delivered (μL)
1	0.4429	482.8
2	0.4442	444.2
3	0.4440	444.0
4	0.4442	444.2
5	0.4453	445.3

Balance: Ohaus Pioneer

Purpose: Determine density of gatorade (A) and calibrate pipette (B)

Procedure: (A) Use different measuring devices ~~and~~ for mass and volume to ~~compute~~ measure mass of 1mL gatorade

(B) Deliver a consistent volume of water from the pipette and record its mass as determined by an analytical balance

Signature Nathaniel White | Date 1/23 | Witness/TA Andresa Lima | Date