Experiment 20

Conversion Factors

Problem
How can measured values be converted from one type of unit to another?

Introduction
In this experiment you will be introduced to the derivation and use of *conversion factors*. As the name implies, conversion factors are a means to change from one unit of measure to another. Some of these factors are familiar from everyday use: there are seven days in one week, twelve inches equals one foot, and so on. In each case, the same quantity is represented in two different ways. While seven days is the same length of time as one week, no one would suggest that the numbers themselves, seven and one, are equal--that would be absurd! Thus,

7 days =	1 week	but	$7 \neq 1$
12 inches =	1 foot	but	$12 \neq 1$
100 centimeters =	1 meter	but	$100 \neq 1$

In each example you find the same quantity represented by two different measurements. But *are* they different? No, and it is **this distinction between numbers and measurements** that is the focus of this experiment. You are to include the units in all reported measurements; without the units, all you have is a number--no physical quantity has been represented.

Graphs are a powerful tool for showing the relationship between measured quantities. As part of your Analysis and Conclusions, you will graph the data you have collected. The graph will then be used to determine values that were not included in your Observations and Data.

Prelaboratory Assignment
✓ Read the **Introduction** and **Procedure** before you begin.
✓ Answer the Prelaboratory Questions.

1. Describe the procedure for determining the slope of a straight-line graph.
2. Explain the difference between a *measurement* and a *number*.
3. Every conversion factor can be written in two ways. Complete the table below.

7 days	=	1 week	1 day	=	0.143 week ($1 \div 7 = 0.143$)
12 inches	=	1 foot	1 inch	=	________ foot
100 cm	=	1 m	1 cm	=	________ m
$1	=	10 dimes	1 dime	=	$________

Materials

Apparatus

Milligram or centigram balance
Thin-stem pipet
30-mL beaker (for holding water)
10-mL graduated cylinder
Lab apron
Safety goggles

Reagents

Distilled water

Safety

1. Wear safety goggles and aprons at all times in the laboratory.
2. No food or drink is allowed in the laboratory at any time.

Procedure

1. Find the mass of a clean, dry 10-mL graduated cylinder to the nearest milligram. If the only cylinder available is wet inside, you should dry it completely before you begin. Record this mass and all subsequent measurements in a Data Table.

2. Use a beaker of distilled water and a thin-stem pipet to add precisely 1.50 mL of water to your graduated cylinder. The low point of the curved liquid surface (the *meniscus*) should just line up with the 1.50-mL mark on the scale. Read at eye level to be certain that you gauge the volume correctly. Hold the pipet vertically so that the drops will fall freely to the bottom of the cylinder. If drops are left on the side walls of the graduate, your results will be inaccurate.

3. Find the mass of the cylinder containing the 1.50 mL of water, and record the total mass in your Data Table.

4. Now fill the graduate to exactly 3.00 mL and find the total mass once again. Repeat for 5.00 mL.

5. Use the thin-stem pipet to add 20 more drops of water to the contents of the cylinder. Estimate the volume to the nearest 0.01 mL, and record it in the data table. (Do not determine the mass of the cylinder and contents.)

6. Finally, add an additional 20 drops to the cylinder and read the volume once again, estimating as before to the nearest 0.01 mL.

Cleaning Up

1. Pour the water down the sink.
2. Return the glassware to its proper location.
3. Dispose of the pipet as your teacher directs.
4. Wash your hands thoroughly before leaving the laboratory.

Analysis and Conclusions

Complete the **Analysis and Conclusions** section for this experiment either on your Report Sheet or in your lab report as directed by your teacher.

1. Use the information in your Data Table to calculate the mass of water in 0.00 mL, 1.50 mL, 3.00 mL, and 5.00 mL. Show your calculations and enter the results in a Summary Table.
2. Use the graph paper to plot the data from 1. Label the axes, with mass on the vertical axis and volume on the horizontal axis. Draw the best-fit straight line through the four data points.
3. Determine each of the following (a through e). Summarize your results in a second Summary Table.
   a. Graphing your data allows you to find values you didn't actually measure. Use your graph to find (i) the mass of 2.40 mL of water and (ii) the volume of 4.25 g of water.
   b. Calculate the *slope* of your graph. This is the density of water.
   c. Based on your results for steps 5 and 6 of the procedure, what is the average volume for the number of drops listed: Drops = 20, 100, 50, 10, 1
   d. Use the density you determined for water to find:
      (i) the total mass of water in the graduate after the first 20-drop addition
      (ii) the total mass of water in the graduate after the second 20-drop addition.
      (iii) the average mass of 20 drops of water?
   e. What is the mass of:
      (i) 1 drop of water?
      (ii) 10^6 drops ?
      (iii) 6.02×10^{23} drops?
4. Use your experimental results to complete the following conversions.
   a. 1 drop of water = __________ g = __________ mL
   b. 1 gram of water = __________ mL = __________ drops
   c. 1 milliliter of water = __________ g = __________ drops
5. If you did not start with a completely dry graduated cylinder in step 1, would this affect your answers? If so, what part of the answer would be incorrect: the mass of water, the volume of water, or both? Explain.
6. If the drops of water from the pipet hit the sides of the graduate, how could this affect your answers? Again, be specific in describing what can go wrong.
7. The density of water is often assumed to be exactly one gram per milliliter. How close to that value is the slope of your graph? If your value was not within 5% of the accepted value, that is, within the range of $0.95 \text{ g/mL} \leq \text{density} \leq 1.05 \text{ g/mL}$, was there anything about the procedure that made it difficult for you to get a precise result? Explain.

Something Extra

1. The values obtained by the class for the density of water will be listed on the board. Use the posted information to calculate the mean value for water's density, the average deviation and percent deviation.
   a. The mean is simply the arithmetic average of all the individual results. Show your calculations.

b. Deviation refers to the difference between the mean and each individual value. Deviations are reported as absolute values, so do not include signs. Show two sample calculations of deviations, one for a value greater than the mean and one for a value less than the mean.

c. As the name implies, the average deviation is the arithmetic mean of the individual deviations. Show your calculations.

d. Combine your answers to **1a** and **1c** to express the experimental value for the density of water in the form (mean) ± (average deviation). Round both portions of the answer to the appropriate decimal place.

2. Use your graphing calculator to determine both the mean value for the density of water and the standard deviation from that mean. Report the density of water in the form: (mean) ± (standard deviation). Round both portions of the answer to the appropriate number of decimal places.

Name________________________

Section________Date__________

Report for Experiment 20

Conversion Factors

Prelaboratory Questions

1. Describe the procedure for determining the slope of a straight-line graph.

2. Explain the difference between a *measurement* and a *number*.

3. Every conversion factor can be written in two ways. Complete the table below.

7 days = 1 week	1 day = 0.143 week (1 ÷ 7 = 0.143)
12 inches = 1 foot	1 inch = ________ foot
100 cm = 1 m	1 cm = ________ m
$1 = 10 dimes	1 dime = $ ______

Data/Observations

Table 1

Mass of empty, dry graduated cylinder	________	g
Mass of graduate + 1.50 mL distilled water	________	g
Mass of graduate + 3.00 mL distilled water	________	g
Mass of graduate + 5.00 mL distilled water	________	g
Volume after 1st 20 drops is added	________	mL
Volume after 2nd 20 drops is added	________	mL

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Analysis and Conclusions

1. Use the information in Table 1 to calculate the mass of water in 0.00 mL, 1.50 mL, 3.00 mL, and 5.00 mL. Show your calculations below and enter the results in Table 2.

Table 2

Volume of water	Mass of water
0.00 mL	
1.50 mL	
3.00 mL	
5.00 mL	

2. Use the grid below to plot the data from Table 2. Label the axes, with mass on the vertical axis and volume on the horizontal axis. Draw the best-fit straight line through the four data points.

Use Logger Pro

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3. Use the space provided to show the results for a through e. Enter each result in Table 4.

   a. Graphing your data allows you to find values you didn't actually measure. Use your graph to find (i) the mass of 2.40 mL of water and (ii) the volume of 4.25 g of water.

   b. Calculate the *slope* of your graph. This is the density of water.

   c. Based on your results for steps 5 and 6 of the procedure (see Table 1), what is the average volume for the number of drops listed below:

Table 3

Drops	Average volume
20	
100	
50	
10	
1	

   d. Use the density you determined for water to find:

   (i) the total mass of water in the graduate after the first 20-drop addition

   (ii) the total mass of water in the graduate after the second 20-drop addition.

   (iii) the average mass of 20 drops of water?

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e. What is the mass of:

(i) 1 drop of water?

(ii) 10^6 drops ?

(iii) 6.02×10^{23} drops?

Table 4

Mass of 2.40 mL of water	________	g
Volume of 4.25 g of water	________	mL
Density of water (from graph)	________	g/mL
Average volume of 20 drops of water	________	mL
Volume of 100 drops of water	________	mL
Volume of 50 drops of water	________	mL
Volume of 10 drops of water	________	mL
Volume of 1 drop of water	________	mL
Mass of water after 1st 20 drops	________	g
Mass of water after 2nd 20 drops	________	g
Average mass of 20 drops of water	________	g
Mass of 1 drop of water	________	g
Mass of 10^6 drops of water	________	g
Mass of 6.02×10^{23} drops of water	________	g

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4. Use your experimental results to complete the following conversions. Show calculations below.

a. 1 drop of water = __________ g = __________ mL

b. 1 gram of water = __________ mL = __________ drops

c. 1 milliliter of water = __________ g = __________ drops

5. If you did not start with a completely dry graduated cylinder in step 1, would this affect your answers? If so, what part of the answer would be incorrect: the mass of water, the volume of water, or both? Explain.

6. If the drops of water from the pipet hit the sides of the graduate, how could this affect your answers? Again, be specific in describing what can go wrong.

7. The density of water is often assumed to be exactly one gram per milliliter. How close to that value did the slope of your graph come? If your value was not within 5% of the accepted value, that is, within the range of 0.95 g/mL ≤ density ≤ 1.05 g/mL, was there anything about the procedure that made it difficult for you to get a precise result? Explain.

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Something Extra

1. The values obtained by the class for the density of water will be listed on the board. Use the posted information to calculate the mean value for water's density, the average deviation and percent deviation.
   a. The mean is simply the arithmetic average of all the individual results. Show calculation.

   Mean value for density of water: ______________

   b. Deviation refers to the difference between the mean and each individual value. Deviations are reported as absolute values, so do not include signs. Show two sample calculations of deviations, one for a value greater than the mean and one for a value less than the mean.

   c. As the name implies, the average deviation is the arithmetic mean of the individual deviations. Show your calculations.

   average deviation: ______________

   d. Combine your answers to 1(a) and 1(c) to express the experimental value for the density of water in the form (mean) ± (average deviation). Round both portions of the answer to the appropriate decimal place.

   Density of water: ________ ± _________ g/mL

2. Use your graphing calculator to determine both the mean value for the density of water and the standard deviation from that mean. Report the density of water in the form: (mean) ± (standard deviation). Round both portions of the answer to the appropriate number of decimal places.

   Density of water: ________ ± _________ g/mL