DENSITY LAB

EQUIPMENT

You will need one 30 mL beaker, one 150 mL beaker, one digital thermometer, one 10.00 mL volumetric pipette with bulb, and one set of calipers.

CHEMICALS

Just water and brass (the cylinder).

WASTE DISPOSAL

There is no waste (other than water).

SAFETY

Take all normal precautions necessary in a chemistry lab.

PROCEDURE

Density of Water

Obtain a clean, dry 30 mL beaker. Place the beaker on a balance and tare the balance. Using a volumetric pipet transfer 10.00 mL of D.I. water into the beaker and reweigh the beaker with the water in it. Record the mass of the water to three places past the decimal. Repeat this 4 more times. After each trial pour the water into a 150 mL beaker. Make sure the beaker is dry before you place it back on the balance. After all 5 trials are complete measure the temperature of the water in the 150 mL beaker using a digital thermometer and record this in your data table to one place past the decimal.

Density and Composition of a Piece of Brass

Brass is an alloy (a mixture) composed of copper and zinc. We will assume that those are the only two components in our brass. You will determine the average density of a cylinder of brass, which will be the right hand term in equation (e) of the calculations section, $d_{cyclinder}$. You then solve for x, which is the fraction of the cylinder that is copper, and y which is the fraction that is zinc. Multiply each fraction by 100 and you have the percent composition.

Obtain a cylinder of brass and weigh it on a balance. Record this mass in your data table. Measure the diameter and the height of your cylinder using a set of calipers. Record these measurements, in centimeters, in your data table

Data Quality

Perform the following calculations before leaving lab. If your data quality or results are not satisfactory, rerun any portion of the experiment required to get good data. Remember, 40% of your grade is for the quality of your data.

Calculations

Density of Water

Calculate the density of 10.00 mL of water for each of your five trials.

Calculate the average density of the five trials.

Calculate the standard deviation for the five trials.

The smaller the standard deviation, the more **precise** you were.

Calculate the percent error using the table on the next page to find the true value for the density of water at your temperature (the temperature you measured in the 150 mL beaker after weighing all five samples).

The percent error is a measure of the accuracy of your measurements. The smaller the percent error, the more **accurate** you were. The percent error is given by:

$$\text{Percent Error} = \frac{|\text{Experimental Value} - \text{True Value}|}{\text{True Value}} \times 100 \quad \text{(a)}$$

Here "Experimental Value" is the average of your five trials. The "True Value" is the value that you read from the following table. To read the density of water at your temperature ("True Value") find the temperature of your water to the ones place in the left column and the tenths in the top row. Where that column and row intersect is your value. For example at 14.7 °C density of water is 0.999144 g/mL.

Density of Water (g/mL) as a Function of Temperature (°C)

	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0	0.999841	0.999847	0.999854	0.999860	0.999866	0.999872	0.999878	0.999884	0.999889	0.999895
1	0.999900	0.999905	0.999909	0.999914	0.999918	0.999923	0.999927	0.999930	0.999934	0.999938
2	0.999941	0.999944	0.999947	0.999950	0.999953	0.999955	0.999958	0.999960	0.999962	0.999964
3	0.999965	0.999967	0.999968	0.999969	0.999970	0.999971	0.999972	0.999972	0.999973	0.999973
4	0.999973	0.999973	0.999973	0.999972	0.999972	0.999972	0.999970	0.999969	0.999968	0.999966
5	0.999965	0.999963	0.999961	0.999959	0.999957	0.999955	0.999952	0.999950	0.999947	0.999944
6	0.999941	0.999938	0.999935	0.999931	0.999927	0.999924	0.999920	0.999916	0.999911	0.999907
7	0.999902	0.999898	0.999893	0.999888	0.999883	0.999877	0.999872	0.999866	0.999861	0.999855
8	0.999849	0.999843	0.999837	0.999830	0.999824	0.999817	0.999810	0.999803	0.999796	0.999789
9	0.999781	0.999774	0.999766	0.999758	0.999751	0.999742	0.999734	0.999726	0.999717	0.999709
10	0.999700	0.999691	0.999682	0.999673	0.999664	0.999654	0.999645	0.999635	0.999625	0.999615
11	0.999605	0.999595	0.999585	0.999574	0.999564	0.999553	0.999542	0.999531	0.999520	0.999509
12	0.999498	0.999486	0.999475	0.999463	0.999451	0.999439	0.999427	0.999415	0.999402	0.999390
13	0.999377	0.999364	0.999352	0.999339	0.999326	0.999312	0.999299	0.999285	0.999272	0.999258
14	0.999244	0.999230	0.999216	0.999202	0.999188	0.999173	0.999159	0.999144	0.999129	0.999114
15	0.999099	0.999084	0.999069	0.999054	0.999038	0.999023	0.999007	0.998991	0.998975	0.998959
16	0.998943	0.998926	0.998910	0.998893	0.998877	0.998860	0.998843	0.998826	0.998809	0.998792
17	0.998774	0.998757	0.998739	0.998722	0.998704	0.998686	0.998668	0.998650	0.998632	0.998613
18	0.998595	0.998576	0.998558	0.998539	0.998520	0.998501	0.998482	0.998463	0.998444	0.998424
19	0.998405	0.998385	0.998365	0.998345	0.998325	0.998305	0.998285	0.998265	0.998244	0.998224
20	0.998203	0.998183	0.998162	0.998141	0.998120	0.998099	0.998078	0.998056	0.998035	0.998013
21	0.997992	0.997970	0.997948	0.997926	0.997904	0.997882	0.997860	0.997837	0.997815	0.997792
22	0.997770	0.997747	0.997724	0.997701	0.997678	0.997655	0.997632	0.997608	0.997585	0.997561
23	0.997538	0.997514	0.997490	0.997466	0.997442	0.997418	0.997394	0.997369	0.997345	0.997320
24	0.997296	0.997271	0.997246	0.997221	0.997196	0.997171	0.997146	0.997120	0.997095	0.997069
25	0.997044	0.997018	0.996992	0.996967	0.996941	0.996914	0.996888	0.996862	0.996836	0.996809
26	0.996783	0.996756	0.996729	0.996703	0.996676	0.996649	0.996621	0.996594	0.996567	0.996540
27	0.996512	0.996485	0.996457	0.996429	0.996401	0.996373	0.996345	0.996317	0.996289	0.996261
28	0.996232	0.996204	0.996175	0.996147	0.996118	0.996089	0.996060	0.996031	0.996002	0.995973
29	0.995944	0.995914	0.995885	0.995855	0.995826	0.995796	0.995766	0.995736	0.995706	0.995676
30	0.995646	0.995616	0.995586	0.995555	0.995525	0.995494	0.995464	0.995433	0.995402	0.995371
	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9

Density and Composition of a Cylinder of Brass

In this portion of the experiment you determine the average density and percent composition of a cylinder of brass. Brass is normally composed of copper and zinc. While it may contain small amounts of other metals, we will assume it is comprised solely of copper and zinc. The density of a piece of brass is therefore the weighted average of the density of copper and the density of zinc. The weights are the fraction of the cylinder that is each metal. For example if a piece of brass were 85.41% copper and 14.59% zinc, the density of the brass would be given by:

$$\mathrm{d_{cylinder}} = 0.8541 \times 8.960 \frac{\mathrm{g}}{\mathrm{cm^3}} + 0.1459 \times 7.140 \frac{\mathrm{g}}{\mathrm{cm^3}} = 8.694_4 \frac{\mathrm{g}}{\mathrm{cm^3}} \quad \text{(b)}$$

Here **8.960 g/cm^3** is the density of pure **copper** and **7.140 g/cm^3** is the density of pure **zinc**.

You will not initially know the fraction of the cylinder that is copper and the fraction that is zinc, so we can write:

$$\mathrm{d_{cylinder}} = (x) \times 8.960 \frac{\mathrm{g}}{\mathrm{cm^3}} + (y) \times 7.140 \frac{\mathrm{g}}{\mathrm{cm^3}} \qquad \text{(c)}$$

Where x is the fraction of the cylinder that is copper and y is the fraction that is zinc. That is 2 unknowns and one equation; we need another equation to solve the problem. Because there are only 2 metals, we know that their fractions must add up to 1 (their percentages must add up to 100). That means we have our second equation:

$$x + y = 1, \text{ or } y = 1 - x \qquad \text{(d)}$$

Substituting equation (d) into equation (c) we get:

$$\mathrm{d_{cylinder}} = (x) \times 8.960 \frac{\mathrm{g}}{\mathrm{cm^3}} + (1 - x) \times 7.140 \frac{\mathrm{g}}{\mathrm{cm^3}} \qquad \text{(e)}$$

Calculate the density of your cylinder, $d_{cylinder}$, by dividing the mass of the cylinder you used by it's volume. To calculate it's volume use the formula for the volume of a cylinder:

$$\mathrm{Volume_{cylinder}} = \pi \mathrm{r^2 h} \qquad \text{(f)}$$

where *r* is the radius of your cylinder and *h* is the height of your cylinder (**both in centimeters**). Remember $\mathrm{r} = \frac{\mathrm{diameter}}{2}$.

The density of your cylinder ($d_{cyclinder}$) will then be given by:

$$\mathrm{d_{cylinder}} = \frac{\mathrm{mass_{cylinder}}}{\mathrm{volume_{cylinder}}} \qquad \text{(g)}$$

Use this value in equation (e) to find the fraction copper (x), and substitute into equation to equation (d) to find the fraction zinc (y). Multiply each fraction by 100 to get the percent composition of the cylinder.

CONCLUSION

Density of water

Report

- your average density of water
- your percent error
- your standard deviation

Density and composition of brass

Report

- the density of your brass cylinder
- the percent composition of your cylinder.

Determine and analyze one source of potential experimental error. Please read "How to Determine and Analyze a Source of Experimental Error", the first link in the Laboratory Experiments module on Canvas.