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Date:19/10/2025

Density Measurement of Water and Glass Rod

Chen Shuyu Gao Jiayue

19 Oct 2025

1 Objective

1. To measure the density of water according to the density formula.
2. To understand the different in accuracy of different instruments.
3. To calculate the density of glass rod.

2 Results

2.1 Part A

50 mL Graduated Cylinder	**Trial**		
	1	**2**	**3**
Mass of empty dry 50 mL beaker (g)	40.9339	37.3970	33.5365
Mass of 50 mL beaker + water (g)	50.5674	46.7676	42.9987
Mass of water only (g)	9.6335	9.3706	9.4622
Actual volume of water used (mL)	10.0	10.0	10.0
Density of water (g/mL)	0.96335	0.93706	0.94622
Average density of sample (g/mL)	0.94887		

Table 1: Measurements using a 50 mL Graduated Cylinder

10 mL Pipette	**Trial**		
	1	**2**	**3**
Mass of empty dry 50 mL beaker (g)	38.3421	40.1839	34.0252
Mass of 50 mL beaker + water (g)	48.1179	50.1269	43.9292
Mass of water only (g)	9.7758	9.9430	9.9040
Actual volume of water used (mL)	9.95	11.20	10.00
Density of water (g/mL)	0.9824	0.8877	0.9904
Average density of sample (g/mL)	0.9535		

Table 2: Measurements using a 10 mL Pipette

50 mL Burette	Trial		
	1	**2**	**3**
Mass of empty dry 50 mL beaker (g)	35.6262	40.3338	34.2187
Mass of 50 mL beaker + water (g)	45.2787	50.1973	44.1147
Mass of water only (g)	9.6525	9.8635	9.8960
Final burette reading (mL)	10.05	20.00	30.00
Initial burette reading (mL)	0.25	10.05	20.00
Actual volume of water used (mL)	9.80	9.95	10.00
Density of water (g/mL)	0.9849	0.9913	0.9896
Average density of sample (g/mL)	0.9886		

Table 3: Measurements using a 50 mL Burette

50 mL Breaker	Trial		
	1	**2**	**3**
Mass of empty dry 50 mL beaker (g)	40.0169	34.9209	43.7316
Mass of 50 mL beaker + water (g)	51.4991	44.9226	52.2398
Mass of water only (g)	11.4822	10.0017	8.5082
Actual volume of water used (mL)	10	10	10
Density of water (g/mL)	1.14822	1.00017	0.85082
Average density of sample (g/mL)	0.99973		

Table 4: Measurements using a 50 ml Breaker

2.2 Part B

Glass Rod	Trial		
	1	**2**	**3**
Mass of glass rod (g)	3.5783	3.5783	3.5783
Volume of water (mL)	24.9	25.0	25.0
Volume of water + sample (mL)	26.3	26.6	26.8
Volume of sample (mL)	1.4	1.6	1.8
Density of sample (g/mL)	2.5559	2.2360	1.9879
Average density of sample (g/mL)	2.2596		

Table 5: Measurements regarding Glass Rod

3 Calculations

3.1 Graduated Cylinder

In trial 1,

$$\begin{aligned} m_{\text{water}1} &= m_{\text{water+beaker}1} - m_{\text{beaker}1} \\ &= 50.5614 \text{ g} - 40.9329 \text{ g} \\ &= 9.6335 \text{ g} \end{aligned}$$

$$\begin{aligned} \rho_{\text{water}1} &= \frac{m_{\text{water}1}}{V_{\text{water}1}} \\ &= \frac{9.6335 \text{ g}}{10.0 \text{ mL}} \\ &= 0.96335 \text{ g/mL} \end{aligned}$$

In trial 2,

$$\begin{aligned} m_{\text{water}2} &= m_{\text{water+beaker}2} - m_{\text{beaker}2} \\ &= 46.1616 \text{ g} - 37.3970 \text{ g} \\ &= 9.3706 \text{ g} \end{aligned}$$

$$\begin{aligned} \rho_{\text{water}2} &= \frac{m_{\text{water}2}}{V_{\text{water}2}} \\ &= \frac{9.3706 \text{ g}}{10.0 \text{ mL}} \\ &= 0.93706 \text{ g/mL} \end{aligned}$$

In trial 3,

$$\begin{aligned} m_{\text{water}3} &= m_{\text{water+beaker}3} - m_{\text{beaker}3} \\ &= 42.9987 \text{ g} - 33.5365 \text{ g} \\ &= 9.4622 \text{ g} \end{aligned}$$

$$\begin{aligned} \rho_{\text{water}3} &= \frac{m_{\text{water}3}}{V_{\text{water}3}} \\ &= \frac{9.4622 \text{ g}}{10.0 \text{ mL}} \\ &= 0.94622 \text{ g/mL} \end{aligned}$$

Average density:

$$\bar{\rho} = \frac{0.96335 + 0.93706 + 0.94622}{3} \text{ g/mL} = 0.94887 \text{ g/mL}$$

3.2 Pipette

In trial 1,

$$\begin{aligned} m_{\text{water}1} &= m_{\text{water+beaker}1} - m_{\text{beaker}1} \\ &= 48.1179 \text{ g} - 38.3421 \text{ g} \\ &= 9.7758 \text{ g} \end{aligned}$$

$$\begin{aligned} \rho_{\text{water}1} &= \frac{m_{\text{water}1}}{V_{\text{water}1}} \\ &= \frac{9.7758 \text{ g}}{9.9511 \text{ mL}} \\ &= 0.9824 \text{ g/mL} \end{aligned}$$

In trial 2,

$$\begin{aligned} m_{\text{water}2} &= m_{\text{water+beaker}2} - m_{\text{beaker}2} \\ &= 50.1269 \text{ g} - 40.1839 \text{ g} \\ &= 9.9430 \text{ g} \end{aligned}$$

$$\begin{aligned} \rho_{\text{water}2} &= \frac{m_{\text{water}2}}{V_{\text{water}2}} \\ &= \frac{9.9430 \text{ g}}{11.2011 \text{ mL}} \\ &= 0.8877 \text{ g/mL} \end{aligned}$$

In trial 3,

$$\begin{aligned} m_{\text{water}3} &= m_{\text{water+beaker}3} - m_{\text{beaker}3} \\ &= 43.9292 \text{ g} - 34.0232 \text{ g} \\ &= 9.9060 \text{ g} \end{aligned}$$

$$\begin{aligned} \rho_{\text{water}3} &= \frac{m_{\text{water}3}}{V_{\text{water}3}} \\ &= \frac{9.9060 \text{ g}}{10.0011 \text{ mL}} \\ &= 0.9904 \text{ g/mL} \end{aligned}$$

Average density:

$$\bar{\rho} = \frac{0.9824 + 0.8877 + 0.9904}{3} = 0.9535 \text{ g/mL}$$

3.3 Burette

In trial 1,

$$\begin{aligned} m_{\text{water}1} &= m_{\text{water+beaker}1} - m_{\text{beaker}1} \\ &= 45.2787 \text{ g} - 35.6262 \text{ g} \\ &= 9.6525 \text{ g} \end{aligned}$$

$$\begin{aligned} V_{\text{water}1} &= V_{\text{final}1} - V_{\text{init}1} \\ &= 10.05 \text{ mL} - 0.25 \text{ mL} \\ &= 9.80 \text{ g} \end{aligned}$$

$$\begin{aligned} \rho_{\text{water}1} &= \frac{m_{\text{water}1}}{V_{\text{water}1}} \\ &= \frac{9.6525 \text{ g}}{9.80 \text{ mL}} \\ &= 0.9849 \text{ g/mL} \end{aligned}$$

In trial 2,

$$\begin{aligned} m_{\text{water}2} &= m_{\text{water+beaker}2} - m_{\text{beaker}2} \\ &= 50.1973 \text{ g} - 40.3338 \text{ g} \\ &= 9.8635 \text{ g} \end{aligned}$$

$$\begin{aligned} V_{\text{water}2} &= V_{\text{final}2} - V_{\text{init}2} \\ &= 20.00 \text{ mL} - 10.05 \text{ mL} \\ &= 9.95 \text{ mL} \end{aligned}$$

$$\begin{aligned} \rho_{\text{water}2} &= \frac{m_{\text{water}2}}{V_{\text{water}2}} \\ &= \frac{9.8635 \text{ g}}{9.95 \text{ mL}} \\ &= 0.9913 \text{ g/mL} \end{aligned}$$

In trial 3,

$$
\begin{aligned}
m_{\text{water}3} &= m_{\text{water+beaker}3} - m_{\text{beaker}3} \\
&= 44.1137\text{ g} - 34.2187\text{ g} \\
&= 9.8960\text{ g}
\end{aligned}
$$

$$
\begin{aligned}
V_{\text{water}3} &= V_{\text{final}3} - V_{\text{init}3} \\
&= 30.00\text{ mL} - 20.00\text{ mL} \\
&= 10.00\text{ mL}
\end{aligned}
$$

$$
\begin{aligned}
\rho_{\text{water}3} &= \frac{m_{\text{water}3}}{V_{\text{water}3}} \\
&= \frac{9.8960\text{ g}}{10.00\text{ mL}} \\
&= 0.9896\text{ g/mL}
\end{aligned}
$$

Average density:

$$
\bar{\rho} = \frac{0.9849 + 0.9913 + 0.9896}{3}\text{ g/mL} = 0.9886\text{ g/mL}
$$

3.4 Beaker

In trial 1,

$$
\begin{aligned}
m_{\text{water}1} &= m_{\text{water+beaker}1} - m_{\text{beaker}1} \\
&= 51.4991\text{ g} - 40.0169\text{ g} \\
&= 11.4822\text{ g}
\end{aligned}
$$

$$
\begin{aligned}
\rho_{\text{water}1} &= \frac{m_{\text{water}1}}{V_{\text{water}1}} \\
&= \frac{11.4822\text{ g}}{10\text{ mL}} \\
&= 1.14822\text{ g/mL}
\end{aligned}
$$

In trial 2,

$$
\begin{aligned}
m_{\text{water}2} &= m_{\text{water+beaker}2} - m_{\text{beaker}2} \\
&= 44.9226\text{ g} - 34.9209\text{ g} \\
&= 10.0017\text{ g}
\end{aligned}
$$

$$\begin{aligned}\rho_{\text{water}2} &= \frac{m_{\text{water}2}}{V_{\text{water}2}}\\ &= \frac{10.0017\text{ g}}{10.0\text{ mL}}\\ &= 1.00017\text{ g/mL}\end{aligned}$$

In trial 3,

$$\begin{aligned}m_{\text{water}3} &= m_{\text{water+beaker}3} - m_{\text{beaker}3}\\ &= 52.2398\text{ g} - 43.7316\text{ g}\\ &= 8.5082\text{ g}\end{aligned}$$

$$\begin{aligned}\rho_{\text{water}3} &= \frac{m_{\text{water}3}}{V_{\text{water}3}}\\ &= \frac{8.5082\text{ g}}{10.0\text{ mL}}\\ &= 0.85082\text{ g/mL}\end{aligned}$$

Average density:

$$\bar{\rho} = \frac{1.14822 + 1.00017 + 0.85082}{3} = 0.99973\text{ g/mL}$$

3.5 Glass Rod

In trial 1,

$$\begin{aligned}V_{\text{sample}_1} &= V_{\text{water+sample}_1} - V_{\text{water}1}\\ &= 26.3\text{ mL} - 24.9\text{ mL}\\ &= 1.4\text{ mL}\end{aligned}$$

$$\begin{aligned}\rho_{\text{sample}_1} &= \frac{m_{\text{sample}_1}}{V_{\text{sample}_1}}\\ &= \frac{3.5783\text{ g}}{1.4\text{ mL}}\\ &= 2.5559\text{ g/mL}\end{aligned}$$

In trial 2,

$$
\begin{aligned}
V_{\text{sample}_2} &= V_{\text{water+sample}_2} - V_{\text{water2}} \\
&= 26.6 \text{ mL} - 25.0 \text{ mL} \\
&= 1.6 \text{ mL}
\end{aligned}
$$

$$
\begin{aligned}
\rho_{\text{sample}_2} &= \frac{m_{\text{sample}_2}}{V_{\text{sample}_2}} \\
&= \frac{3.5783 \text{ g}}{1.6 \text{ mL}} \\
&= 2.2360 \text{ g/mL}
\end{aligned}
$$

In trial 3,

$$
\begin{aligned}
V_{\text{sample}_3} &= V_{\text{water+sample}_3} - V_{\text{water3}} \\
&= 26.8 \text{ mL} - 25.0 \text{ mL} \\
&= 1.8 \text{ mL}
\end{aligned}
$$

$$
\begin{aligned}
\rho_{\text{sample}_3} &= \frac{m_{\text{sample}_3}}{V_{\text{sample}_3}} \\
&= \frac{3.5783 \text{ g}}{1.8 \text{ mL}} \\
&= 1.9879 \text{ g/mL}
\end{aligned}
$$

Average density:

$$
\bar{\rho} = \frac{2.5559 + 2.2360 + 1.9879}{3} \text{ g/mL} = 2.2596 \text{ g/mL}
$$

4 Discussion

During the measurement, we found that the liquid surface showed a concave shape and we also observed that when pouring water, the water will stay on the wall of the container, making it impossible to measure the volume of water completely and accurately.

When measuring liquid, there are bubbles floating on the surface of the concave liquid surface, which affects the measurement.

In the experiment,we found that the density of the water measured by the beaker was closest to the expected value.The measured value is 0.99973(g/ml) The second close to the true value is 50ml burette and the third is pipette,the last one is graduated cylinder.

We think the reasons that may lead to errors in experimental results are when we measuring the weight of some empty beakers, due to the irregular measurement operation, such as putting hands on the table during measurement, resulting in inaccurate readings.

We expect the beaker measurement to be the most inaccurate.But on the contrary, the density measured by the beaker is closest to the real value.We think the possible reasons for this phenomenon are as follows.

For the beaker group we think the reasons for the error are as bellow:

1. The experiment was only repeated three times,and there was a chance.
2. According to the experimental data,there is a large error in the quality of the beaker group,but the error is offset after the average.So the most accurate measurement group is beaker group is an illusion.

For the graduated cylinder group we think that the reasons for the error are as bellow:

1. We measured 10ml of water,but when we poured water,some of the water remained on the wall of the container,resulting is less than the theoretical value of the actual water used for density calculation.
2. The accuracy of the graduated cylinder is not enough, and the volume of water can only be roughly estimated as 10ml.The fact is that the volume of water measured three times can not be all 10ml.It has caused an error in volume measurement.

For the pipette group we think that the reasons for the error are as follows:

1. In the second trial,the measurement of actual volume of water used has a large error,but we did not rounded it
2. In the first trial, the actual measured mass of water used (9.7785g) was significantly lower than the average value(9,8750g). We did not round this measurement, and this oversight may lead to inaccuracies.

trial of measuring glass rod density: We found that under the condition that the volume of water is roughly the same,the volume of the water plus the sample increases one after another.(In the first trail the volume of water plus sample is 26.3ml,the second one is26,6ml,the last one is 26.8ml)Show a significantly increase.

We think the reason of this phenomenon is in the process of repeating experiments,we use wet graduated cylinder and wet glass rod,which oversight may lead to inaccuracies.

Inspiration for future experiments

In this series of experiments, we realize that we should ensure that the experimental instruments are dry when repeating experiments to avoid affecting the experimental results.

For data with large errors, it should be rounded directly to ensure the accuracy of the result.

We realize that the accuracy of the instrument itself will affect the experimental results.So in future experiments, we should choose and use good instruments correctly.

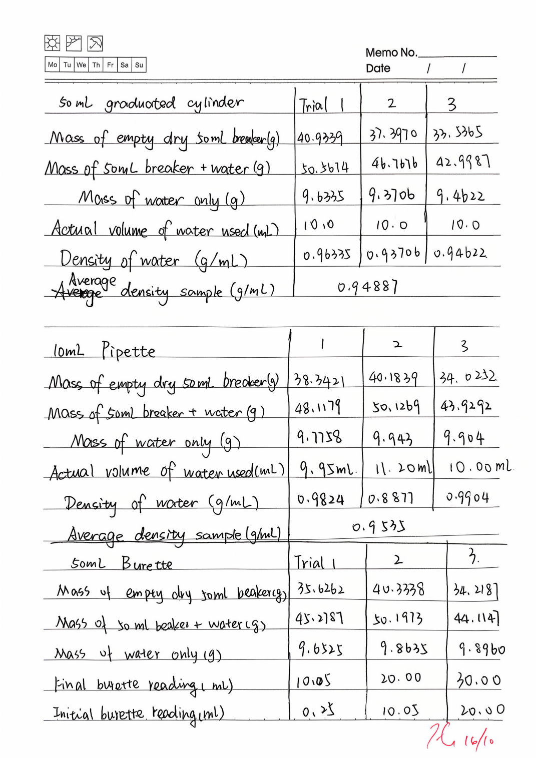
We realize that there is still an accident in repeating only three sets of data. If conditions allow, we should repeat as many times as possible to avoid chance.

Pay attention to the concave liquid level when reading.

5 Conclusion

1. The density of water was measured in various experiments to be 0.99973, 0.94997, 0.9535 and 0.9886 g/mL (all approximately 1);
2. The accuracy of pipette and burette is the highest, followed by the graduated cylinder,and finally the beaker;
3. The density of glass rod is 2.2598(g/mL).

Appendices



Memo No.
Date / /

50 mL graduated cylinder	Trial 1	2	3
Mass of empty dry 50mL breaker(g)	40.9339	37.3970	33.5365
Mass of 50mL breaker + water (g)	50.5674	46.7676	42.9987
Mass of water only (g)	9.6335	9.3706	9.4622
Actual volume of water used (mL)	10.0	10.0	10.0
Density of water (g/mL)	0.96335	0.93706	0.94622
~~Average~~ Average density sample (g/mL)	0.94887		

10mL Pipette	1	2	3
Mass of empty dry 50mL breaker(g)	38.3421	40.1839	34.0232
Mass of 50mL breaker + water (g)	48.1179	50.1269	43.9292
Mass of water only (g)	9.7758	9.943	9.904
Actual volume of water used(mL)	9.95mL	11.20ml	10.00mL
Density of water (g/mL)	0.9824	0.8877	0.9904
Average density sample (g/mL)	0.9535		

50mL Burette	Trial 1	2	3
Mass of empty dry 50ml beaker(g)	35.6262	40.3338	34.2187
Mass of 50 ml beaker + water(g)	45.2787	50.1973	44.1147
Mass of water only (g)	9.6525	9.8635	9.8960
Final burette reading (ml)	10.05	20.00	30.00
Initial burette reading(ml)	0.25	10.05	20.00

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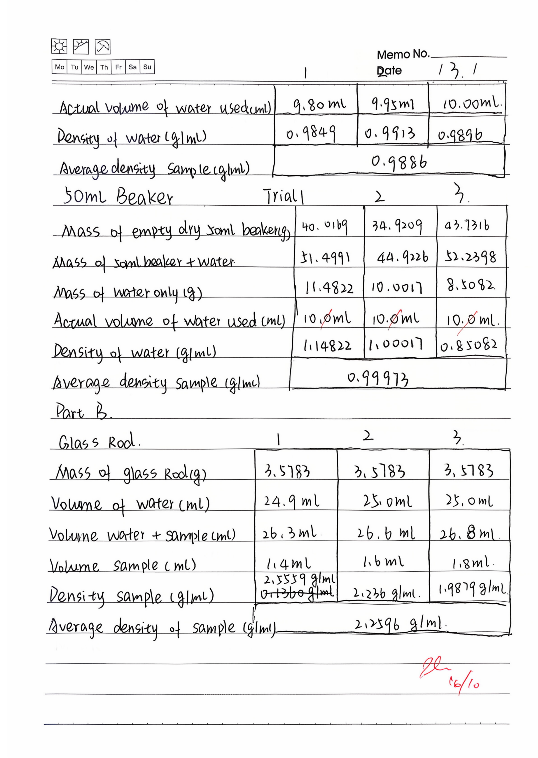

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	1	2	3
Actual volume of water used(ml)	9.80 ml	9.95ml	10.00ml.
Density of water (g/ml)	0.9849	0.9913	0.9896
Average density sample (g/ml)	0.9886		

50mL Beaker	Trial 1	2	3.
Mass of empty dry 50ml beaker(g)	40.0169	34.9209	43.7316
Mass of 50ml beaker + water	51.4991	44.9226	52.2398
Mass of water only (g)	11.4822	10.0017	8.5082.
Actual volume of water used (ml)	10.0ml	10.0ml	10.0ml.
Density of water (g/ml)	1.14822	1.00017	0.85082
Average density sample (g/ml)	0.99973		

Part B.

Glass Rod.	1	2	3.
Mass of glass Rod(g)	3.5783	3.5783	3.5783
Volume of water (ml)	24.9 ml	25.0ml	25.0ml
Volume water + sample (ml)	26.3ml	26.6 ml	26.8ml.
Volume sample (ml)	1.4ml	1.6ml	1.8ml.
Density sample (g/ml)	2.5559 g/ml ~~0.1360 g/ml~~	2.236 g/ml.	1.9879 g/ml.
Average density of sample (g/ml)	2.2596 g/ml.		

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Figure 1: Approved Data Sheets