# Determination of the Density of liquids

## Introduction

Density is an intensive physical property of matter that requires measurements of two quantities: the mass, *m*, and the volume, *V*, of a given amount of a substance. The ratio of these two quantities, the mass per unit volume, is the density. Stated in equation form, $d = m / V$ .

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## Purpose

To determine the density of liquids .

## Apparatus

1.100-mL (or 50 mL) graduated cylinder or volumetric flask.
2. Sample of known liquid.
3. Digital gram scale.
4. Heater.

## What affects density?

### Temperature

A material's volume and state changes with temperature. Temperature therefore has an important influence on the density. Consequently, an accurate density measurement requires accurate temperature determination and good temperature stability.

An excellent example of the temperature dependence of density is the thermometer. With increasing temperature, the volume of alcohol inside the thermometer expands and rises. Same mass but more volume means less density.

### Air pressure and altitude

The local air pressure and altitude also have an impact on the density of liquids and modern density meters compensate for these influencing factors so they do not affect the results.



 

## Pure Water

The density of liquid water is approximately 1.0 g/mL. The chart at right give the density in $kg/m^3$. Divide by $10^3$ to get the density in g/mL.

Let's look at the density of water at 25 deg C and compare that to a higher temperature, 80 deg C. The density decreases from 0.9970 g/mL to 0.9718 as it is heated. This makes sense because, as heat is added to the liquid water, there is greater kinetic energy of the molecules and there are also more vibrations of the water molecules. Together these mean that each $H_2O$ unit in liquid water takes up more space as the temperature increases.
We see the same trend in going from liquid water at 25 deg C (0.9970 g/mL) to liquid water at 4 deg C (0.99997 g/mL). Density increase as the temperature decreases.
Below 4 deg C, however, the density decreases again. *How can we explain this?*

| Temp(ºC) | Density($g/cm^3$) |
|---|---|
| +100 | .9584 |
| +80 | .9718 |
| +60 | .9832 |
| +40 | .9922 |
| +30 | .9956 |
| +25 | .99704 |
| +22 | .9977 |
| +20 | .9982 |
| +15 | .9991 |
| +10 | .9997 |
| +4 | .99997 |
| 0 | .99983 |
| -10 | .9981 |
| -20 | .9935 |
| -30 | .9838 |
| The values below 0ºC refer to supercooled water | |

Table No.1

Typical density of liquid water

Remember that liquid water and solid water have the same network of bonds. Liquid water at 25 deg is so rapidly breaking bonds between $H_2O$ units and reforming them that extra water molecules get trapped inside the water lattice. This is the reason why liquid water is more dense than solid water. The bonds in water break more slowly as temperature decreases and the structure tend to trap fewer extra water molecules. At low temperature, more of the water has the same lattice as ice.



 

## Density units

A physical property like density is investigated for several reasons and is therefore reported in several units. The most frequent density unit is kilogram per cubic meter ($kg/m^3$), used in petrochemistry, for example. In other industries, density is reported in gram per cubic centimeter ($g/cm^3$). The conversion factor in this case is 1000 ($1\ g/cm^3 = 1000\ kg/m^3$). Density might also be reported in kilogram per liter (kg/L) or gram per liter (g/L)

# Procedure

1. Obtain approximately 30 mL of known liquid using a small beaker.

2. Place a clean, dry and empty 50 to 100 mL beaker onto a digital scale. To "Zero" the digital scale with the graduated cylinder on it, press the "Re-Zero" or "Tare" button.

3. Read and record the liquid volume from the marks on the pipette, using the correct number of significant figures.

4. Repeat the procedure, for different temperatures of liquid.

5. Using your mass and volume measurements, determine the density of the liquid.

## Questions to guide discussions

1. Why density gets affected by temperature variation?
2. If the density of liquid is 50 $kg/m^3$,what is the density in kilogram per liter?
3. Are density, temperature, and Air pressure related? Explain.



 