Module 1 Lab: Measurement

The purpose of this lab is twofold:

- To introduce you to your textbook and your CHEM 101 practice problems.
- To introduce you to making measurements in the lab.

Directions

1) Read the Introduction on pages 1-4 which provides information from your textbook.

2) Then watch the seven-minute video which further explains how to make measurements.
https://youtu.be/-Ue-o_txQAw

3) Proceed to page 5 where you will find a data table for recording measurements. Use the images shown on pages 6-10 for completing the data table. Submit page 5 for grading. (You may print out page 5, complete the table and scan it. OR you can word process directly on page 5 and submit the whole document.)

4) Watch a two-minute video comparing accuracy and precision.
https://youtu.be/TzLnO04uO30

5) You are now ready to complete your first CHEM 101 assignment on measurement.

From Textbook; 2.1 Introduction to Measurements

Measurements provide the macroscopic information that is the basis for most of the hypotheses, theories, and laws that describe the behavior of matter. Every measurement provides three kinds of information:

1. the magnitude expressed as a number;
2. a standard of comparison included as units; and
3. a representation of the precision, or uncertainty.

The number included in a measurement indicates magnitude, but that number is meaningless without a standard of comparison, the units. For instance, the distance between Washington DC and New York City can be expressed as 230. The meaning of this number is not clear. Is it 230 kilometers? 230 blocks? 230 miles? In order to express the distance in a meaningful way, units must be included. The distance between Washington DC and New York City is *230 miles*.

From Textbook; 2.5 Significant Figures: Measurements

When conducting an experiment, a scientist must determine how precise all the measurements are by looking at what possible errors or sources of uncertainty exist. The amount of uncertainty depends both upon the skill of the scientist and the quality of the measuring tool or instrument. While some balances are capable of measuring masses only to the nearest 0.1 g, highly sensitive analytical balances are capable of measuring to the nearest 0.001 g or better. Many measuring tools such as rulers and graduated cylinders have small lines which need to be examined carefully when reading a measurement. A scientific measurement consists of **certain digits** plus one uncertain **or estimated digit**.

Consider the gray box in Figure 2.4. A ruler can be used to measure the length of the box. The box is a little longer than 2 cm. Each small division on the ruler represents one-tenth of a centimeter, and the edge of the box falls very close to the first line past 2 cm. This means that the length of the box is around 2.1 cm. The ruler has a mark or gradation at the 2.1 cm point, so both digits are **certain**. The actual measurement should also include one estimated digit. Because the edge of the box is exactly at the 2.1 cm mark, the length is 2.10 cm. Look again at the gray box. Does it make sense to report the length of box as simply 2 cm? What about 2.1000 cm? A measurement of 2 cm is approximate does not convey the precision to which the measurement was made. A measurement of 2.1000 cm is not possible with the detail on the given ruler.

The purple box in Figure 2.4 starts at the 3.0 cm mark and ends after the 3.8 cm mark. For the length of the box, the estimated digit falls between 3.8 cm and 3.9 cm. This means that the purple box is somewhere between 0.8 and 0.9 cm long. The edge of the purple box appears to fall half-way between 0.8 and 0.9, so the correct measurement is 0.85 cm.

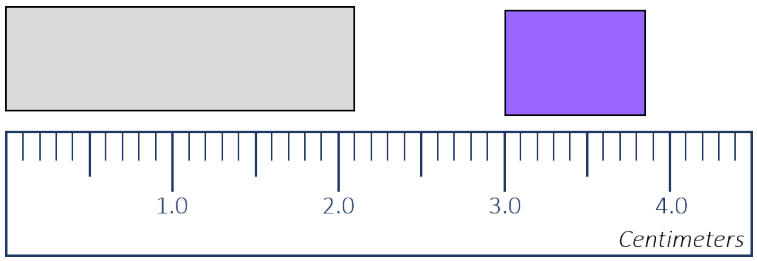


Figure 2.4 A ruler can be used to measure the length of the gray box and the purple box. The length of the gray box can be measured to three significant figures and is 2.10 cm. The length of the purple box can be measured to two significant figures and is 0.85 cm.

Example 2.6

A machmeter is used by pilots to determine airspeed as a Mach number. The Mach number is the ratio of the true airspeed to the speed of sound. What is the Mach number displayed on the machmeter?

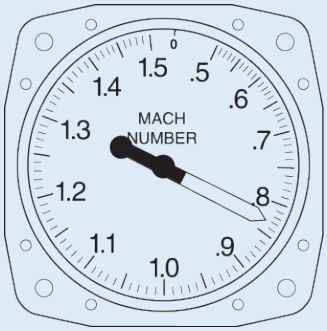


Image Credit: Wikimedia Commons by the Federal Aviation Administration

Solution

The numbers 0.83 are certain digits. The third decimal place can be estimated. A reasonable answer for the Mach number is 0.832 or a number close to 0.832 as long as it contains three significant figures. The Mach number is a ratio and therefore dimensionless.

The precision of a measurement is conveyed by the number of significant figures reported. For instance, the current population of the United States is 326,000,000. This number is an estimate because the population is not *exactly* 326 million people. The population can be expressed in scientific notation as 3.26×10^8 and the fact that there are only three significant figures is clear.

This concept of significant figures holds true for all measurements, even if an estimate is not made. If a sample is placed on an analytical balance and a reading of 0.1502 g is obtained (Figure 2.5), the digits 1, 5, and 0 are certain. The last digit, 2, indicates that the mass of the sample is likely between 0.1501 g and 0.1503 g. The sample therefore has a mass of 0.1502 g with a nominal uncertainty in the measurement of ±0.001 gram. All digits in a measurement, even the last or uncertain digit, are significant.

Figure 2.5 An analytical balance can be used to take the mass of samples in a chemistry lab. In this figure, a sample with a mass of 0.1502 grams has been placed in the flask on the balance. The mass of the flask would have been subtracted, or tared, before the sample was added to it. *Image Credit: Mettler-Toledo.*

Example 2.7

What is the volume of the liquid in the graduated cylinder before the piece of metal is added?
What is the volume after the metal is added?

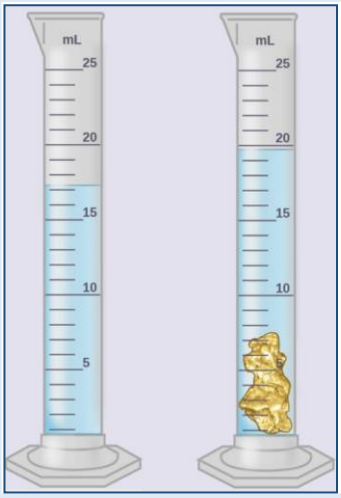


Image Credit: OpenStax Chemistry

Solution

The graduated cylinder to the left has a volume of 17.1 mL. The 17 is certain because there is a graduation mark as 17 on the cylinder. The third digit is estimated by the reader. The level of the liquid is slightly above the 17 mark, so 17.1 mL is a reasonable answer. The graduated cylinder containing liquid and metal has a volume of 19.8 mL.

Measurement Lab: Data Table

Use the images on pages 6-10 to complete the table below:
When you record the measurement, remember to include:

1) The estimated digit between the dashes.
2) The units.

The following seven-minute video further explains how to make measurements with an estimated digit. **https://youtu.be/-Ue-o_txQAw**

Figure	Measuring Device - Property	Record the measurement here.	Uncertainty	Number of significant figures
A	Ruler- Length	9.50 cm	.01 cm	3
B				
C				
D	Graduated cylinder - Volume			
E				
F				
G	Beaker - Volume	590 mL	10 mL	2
H				
I	Thermometer – Temperature			
J				
K	Pressure Gauge- Pressure			
L				

After you complete this table, submit it for grading. Then go to page 10 for the CHEM 101 connection.

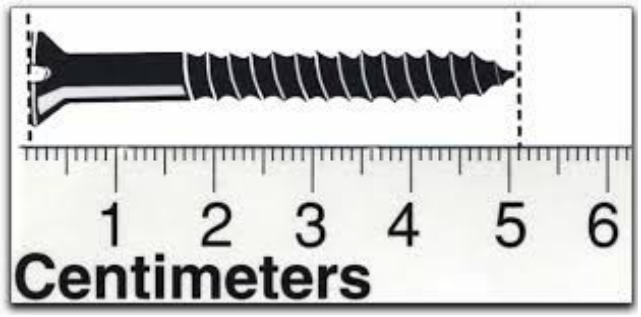
Figure A

The smallest division on this ruler is 0.1 cm. Therefore when making this measurement you must estimate to 1 place of uncertainty which is 0.01cm. The length of the pencil would be recorded as 9.50cm.

The author read this as 9.50 cm. I think it looks a little over – like 9.51 cm. The last digit is an estimate, so we don't need to agree. If you think it is right on the dash, you need to use a zero for your estimated digit as the author did.

Figure B.

If you record this correctly, there will be 3 sig.figs.



41.5, 41.6, 41.7.

Figure C.

The reading is between 41.6 and 41.7. The uncertainty is .01 cm. Include an estimated digit in the .01 place when you record this measurement.

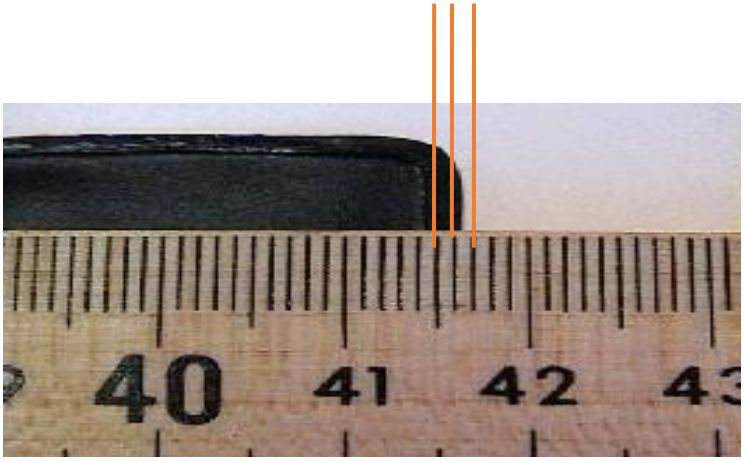
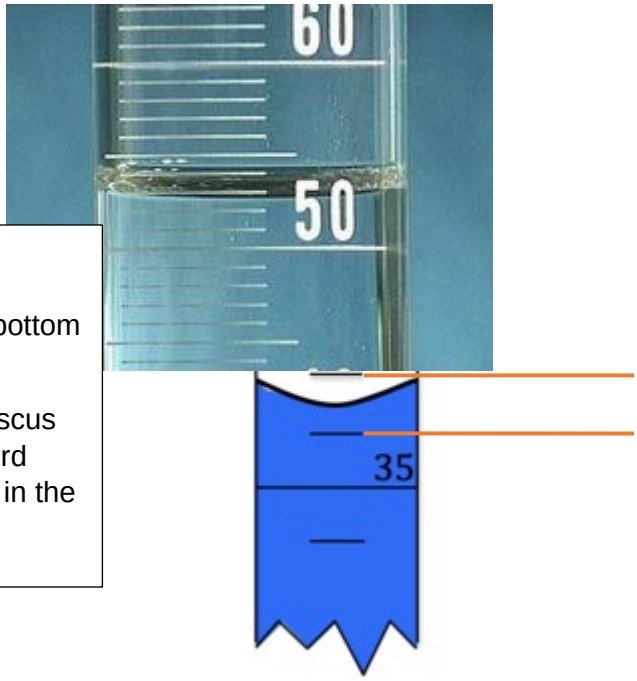


Figure D



In narrow spaces, like graduated cylinders, water will “dip” to form a meniscus. Read the volume at the bottom of the meniscus.

In this case, the bottom of the meniscus is between 36 mL and 37 mL. Record your measurement with uncertainty in the tenths place.

Figure E.

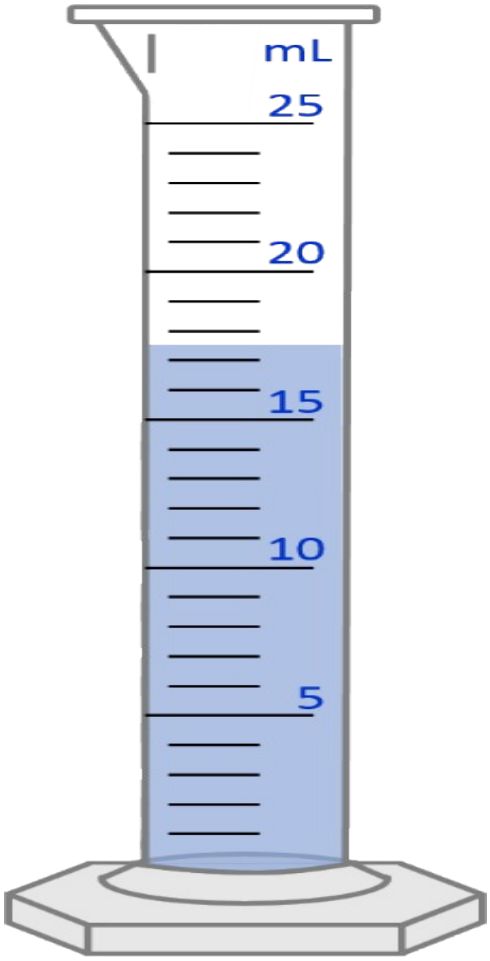


Figure F.

Figure G,

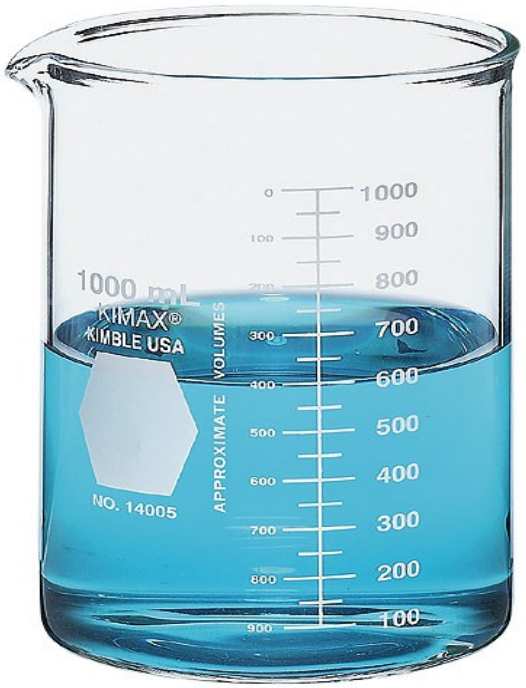


Figure H.

Note: When working in the lab, beakers work well for mixing chemicals and heating chemicals. They are not great for measuring chemicals.

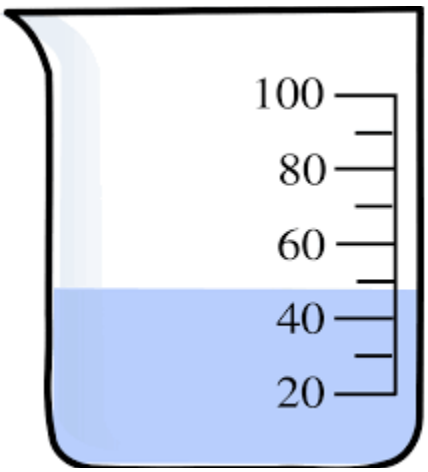
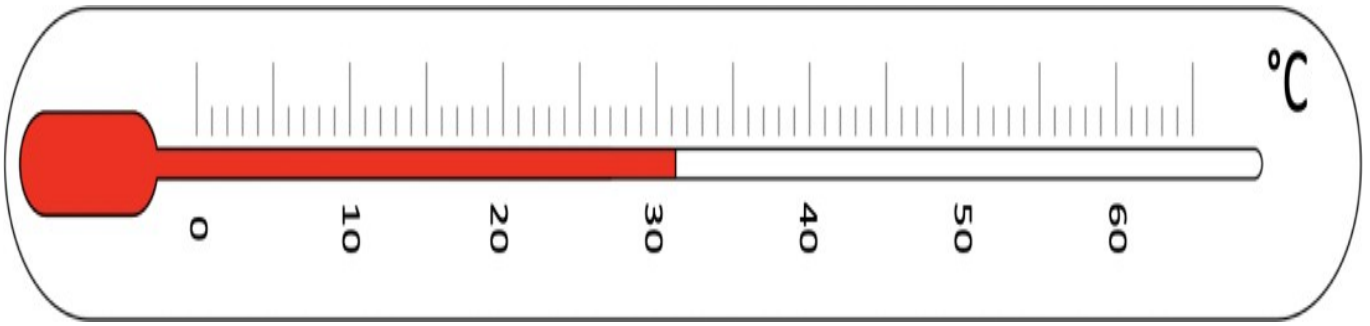
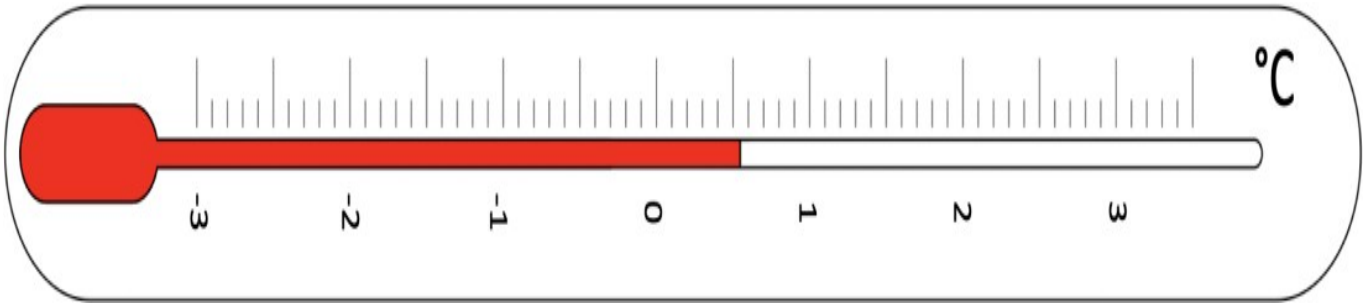
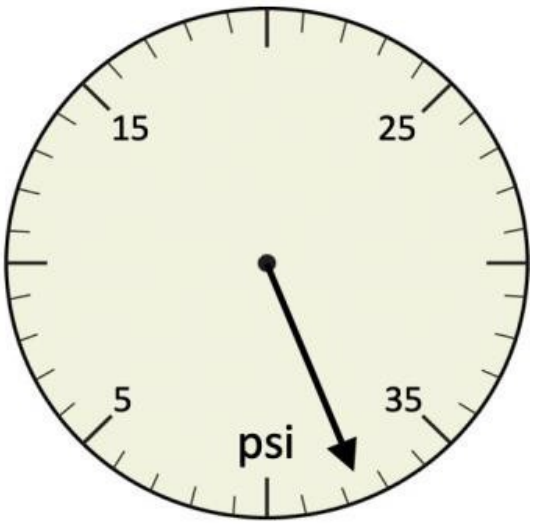


Figure I.

Figure J.







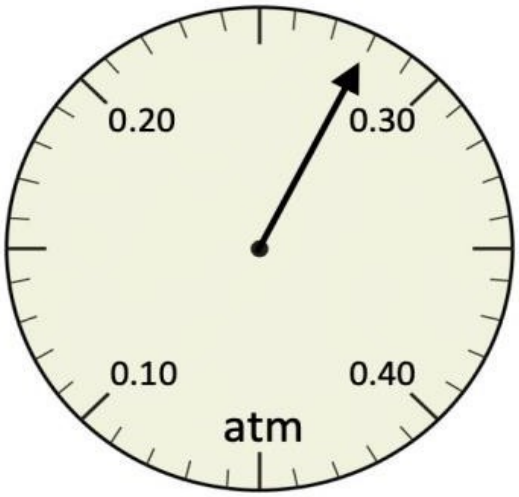


Figure K. **Figure L**

CHEM 101 Assignment

Precision is related to uncertainty as explained above. It is also related to reproducibility. Watch a two-minute video comparing precision to accuracy:

https://youtu.be/TzLnO04uO30

Now you are ready to do your first CHEM 101 assignment: Module 1; Measurements. There are ten problems for you to do to reinforce measurement concepts. Check your calendar for the due date.

http://www.chem101.co

(You may need to cut and paste this url into your chrome or firefox browser. Once you are into your class CHEM 101 website, save it as a bookmark to get there more quickly from now.)