Chapter 1

Introduction to Chemistry

Chemistry

- the study of the composition, properties, and changes of substances

Examples of early chemistry:

- Alchemy
- Gun powder
- Medicine

Scientific Method

1) make *observation*
2) ask *question*
3) form ***hypothesis*** – a prediction of what will happen
4) perform *experiment*
5) draw *conclusion*

Good Experimental Design

1) uses several **trials** (see if data is consistent)

2) has a **control** (a standard for comparison)

3) tests and changes only ***one*** variable at a time

4) all other possible variables are made "**constants**"

- so not interfere with variable being tested

- **independent variable** – variable that the experimenter changes
- "I decided to investigate the impact of ____"

- **dependent variable** – the variable that changes in response to the independent variable
  - "measured results"

Types of Data

- Qualitative data – information that *describes* color, odor, shape, or physical characteristic
- Quantitative data – *numerical* info that is measured

Review Step of the Scientific Method

Review of Scientific Method

- 1)
- 2)
- 3)
- 4)
- 5)

A) Perform experiment
B) Ask question
C) Make an observation
D) Draw conclusion
E) Make a hypothesis

Matching

Put the steps of the scientific method in order.

Review of Scientific Method

- 1) C
- 2) B
- 3) E
- 4) A
- 5) D

A) Perform experiment
B) Ask question
C) Make an observation
D) Draw conclusion
E) Make a hypothesis

Matching

Put the steps of the scientific method in order.

Review Experimental Design Diagrams

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Scenario A

A student investigated whether ants dig more tunnels in the light or in the dark. Ten ant colonies were set up in commercial ant farms with the same number and type of ants per ant farm. The same amount of food was given to each colony, and the colonies were in the same temperature. Five of the colonies were exposed to normal room light and five were covered with black construction paper so they did not receive light. Every other day for three weeks the length of the tunnels was measured in millimeter using a string and a ruler.

Scenario B

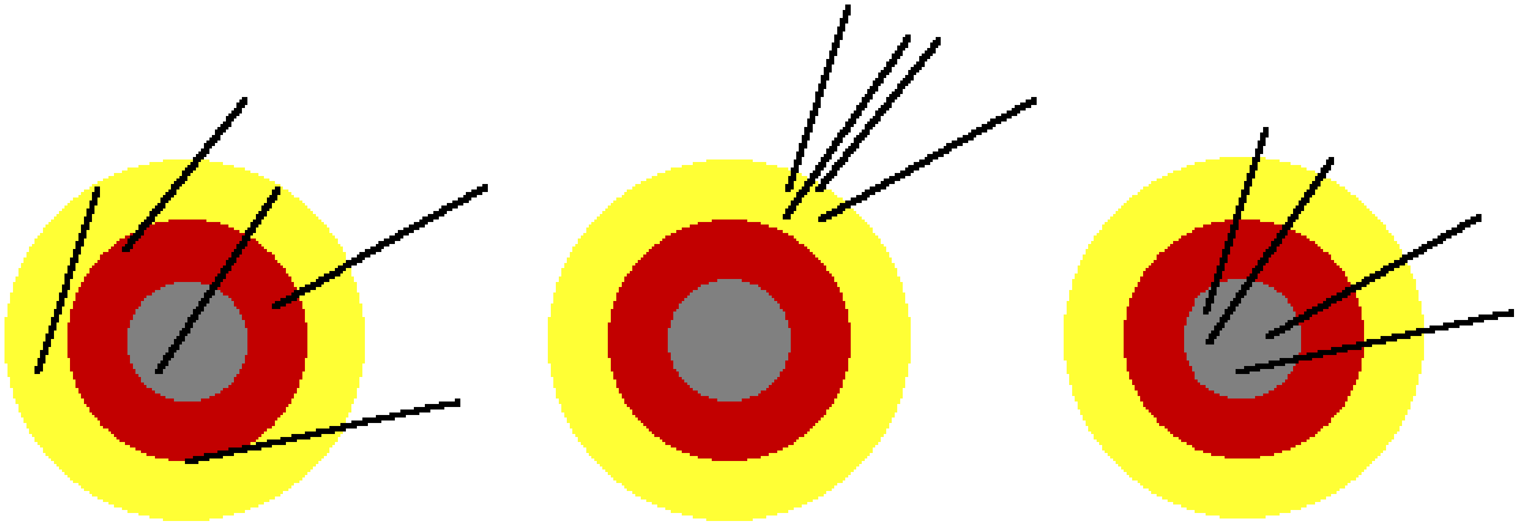
A student investigated the effect of radiation on the germination of bean seeds. He thought that exposure to radiation would limit the seeds ability to germinate (grow) much like ultra-violet light causing skin cancer.

Three hundred seeds were soaked in distilled water for one hour. They were then divided into three groups. One group was placed in a microwave oven on high for three seconds. Another group was microwaved on high for six seconds. The last group was not microwaved. The seeds were then planted in three separate flats and given the same amount of water. The flats were placed in a location with a constant temperature of 27^{o}C. Each day for two weeks the number of seeds that germinated in each group was recorded.

Precision & Accuracy

Precision & Accuracy

- Precision – Data is close to each other
- Accuracy – Data is close to the accepted value



Example 1: Density experiment

- Density data of copper obtained from experiment:
- Trial 1 = 7.82 g/ml
- Trial 2 = 7.81 g/ml
- Trial 3 = 7.84 g/ml
- True Value = 8.92 g/ml (AKA look it up in a book)
- Precise?? Accurate??

Example 2: Density experiment

- Density data of copper obtained from experiment:
- Trial 1 = 8.94 g/ml
- Trial 2 = 8.91 g/ml
- Trial 3 = 8.93 g/ml
- True Value = 8.92 g/ml
  (AKA look it up in a book)
- Precise?? Accurate??

Example 3: Density experiment

- Density data of copper obtained from experiment:
- Trial 1 = 8.34 g/ml
- Trial 2 = 6.71 g/ml
- Trial 3 = 10.22 g/ml
- True Value = 8.92 g/ml (AKA look it up in a book)
- Precise?? Accurate??

Percent Error

$$\text{Percent Error} = \frac{\text{experimental value} - \text{true value}}{\text{true value}} \times 100$$

- The greater the percent error, the less accurate the measurement.

Example 1: Percent Error of Density Data

- Density data of copper obtained from experiment:
- Trial 1 = 7.82 g/ml
- Trial 2 = 7.81 g/ml
- Trial 3 = 7.84 g/ml
- True Value = 8.92 g/ml
- What is the percent error?

Example 2: Percent Error of Density Data

- Density data of copper obtained from experiment:
- Trial 1 = 8.94 g/ml
- Trial 2 = 8.91 g/ml
- Trial 3 = 8.93 g/ml
- True Value = 8.92 g/ml
- What is the percent error?

Examples of Density Data Sets

<u>Red Set</u>

<u>Trial 1:</u> 2.21 mg
<u>Trial 2:</u> 2.23 mg
<u>Trial 3:</u> 2.20 mg

<u>Theoretical:</u>
3.21 mg

<u>Blue Set</u>

<u>Trial 1:</u> 4.74 g
<u>Trial 2:</u> 4.75 g
<u>Trial 3:</u> 4.71 g

<u>Theoretical:</u>
4.73 g

<u>Green Set</u>

<u>Trial 1:</u> 7.73 mL
<u>Trial 2:</u> 8.21 mL
<u>Trial 3:</u> 7.06 mL

<u>Theoretical:</u>
8.25 mL

Review
Accuracy & Precision

SOL Question

10 **A student measures the mass of a piece of copper three times and records the results in the following table:**

Trial	Mass (grams)
1	26.5
2	26.4
3	26.5

The actual mass of the copper is 28.7 grams. Which of the following is demonstrated in the student's data?

F Accuracy

G Continuity

H Precision

J Reliability

SOL Question

34 The density of an unknown metal was determined to be 2.85 g/mL. The actual density was 2.70 g/mL. What is the percent error in this determination?

F 0.056%

G 0.15%

H 5.6%

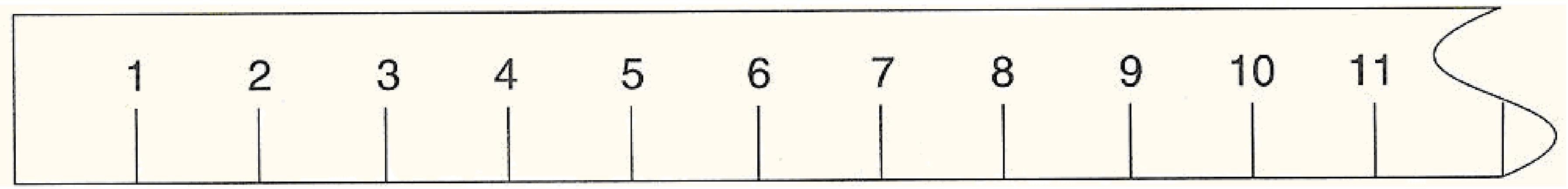
J 94.4%

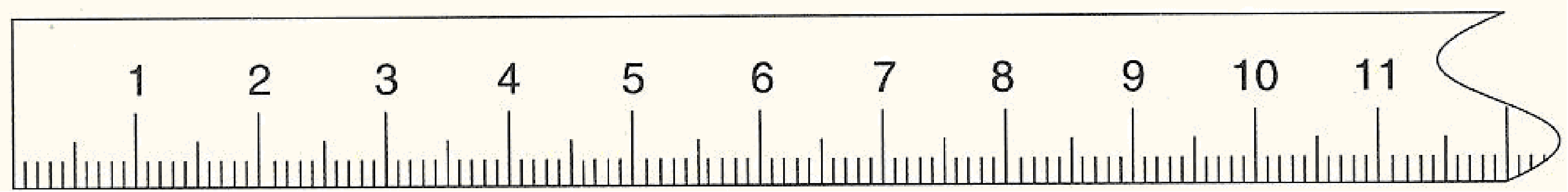
Uncertainty in Measurement

Practice reading volume using a graduated cylinder.

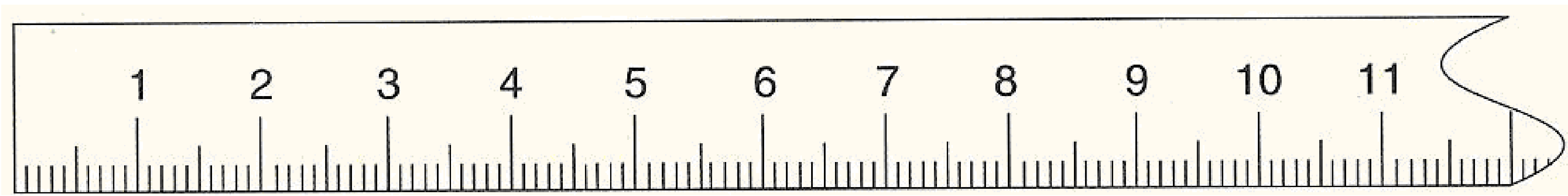
Why are measurements uncertain?

Which ruler is better?



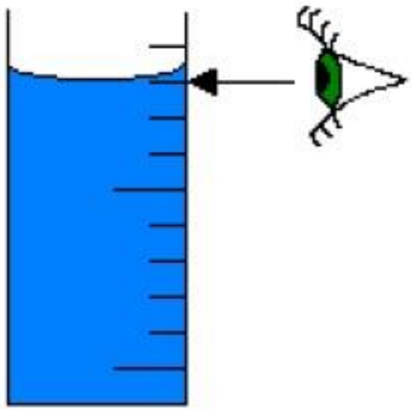


Estimate one decimal beyond what the tick mark represents.

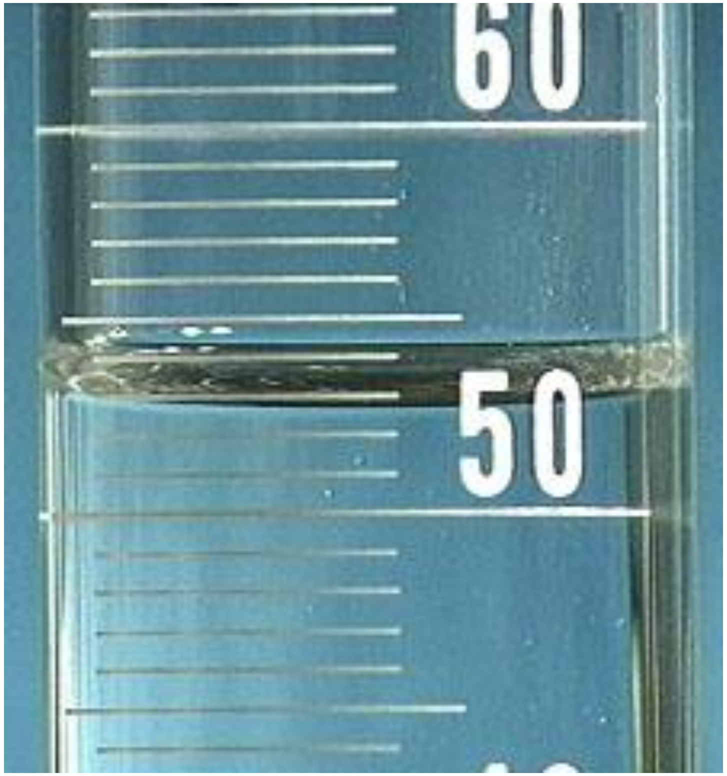


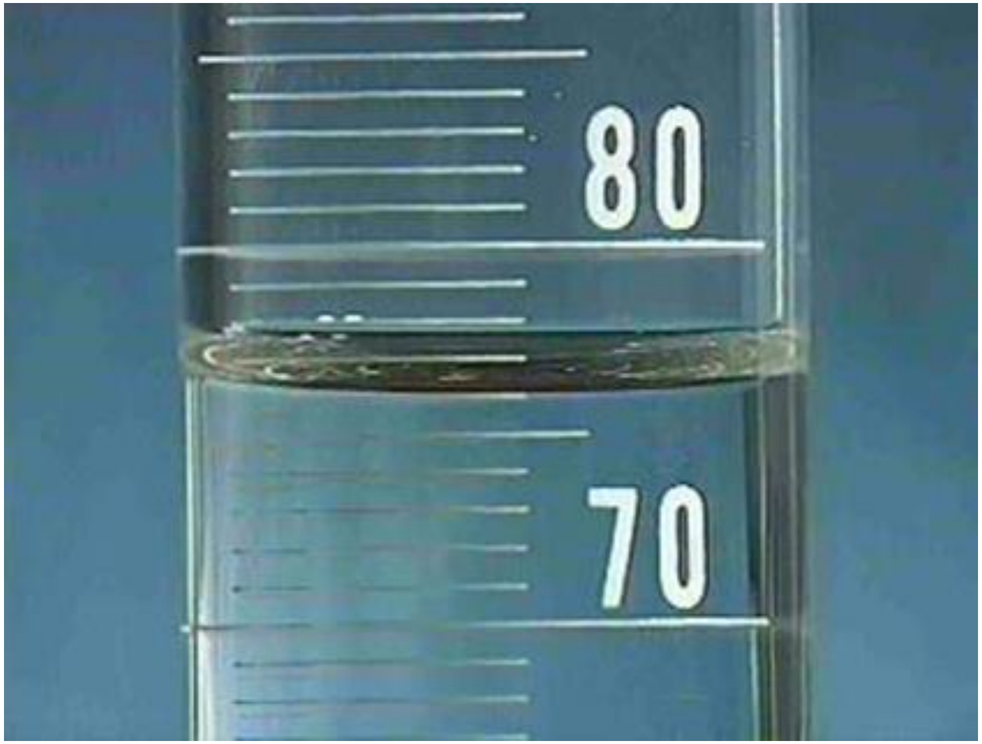
The last digit is the “uncertain” digit because it is estimated.

Volume Measurements



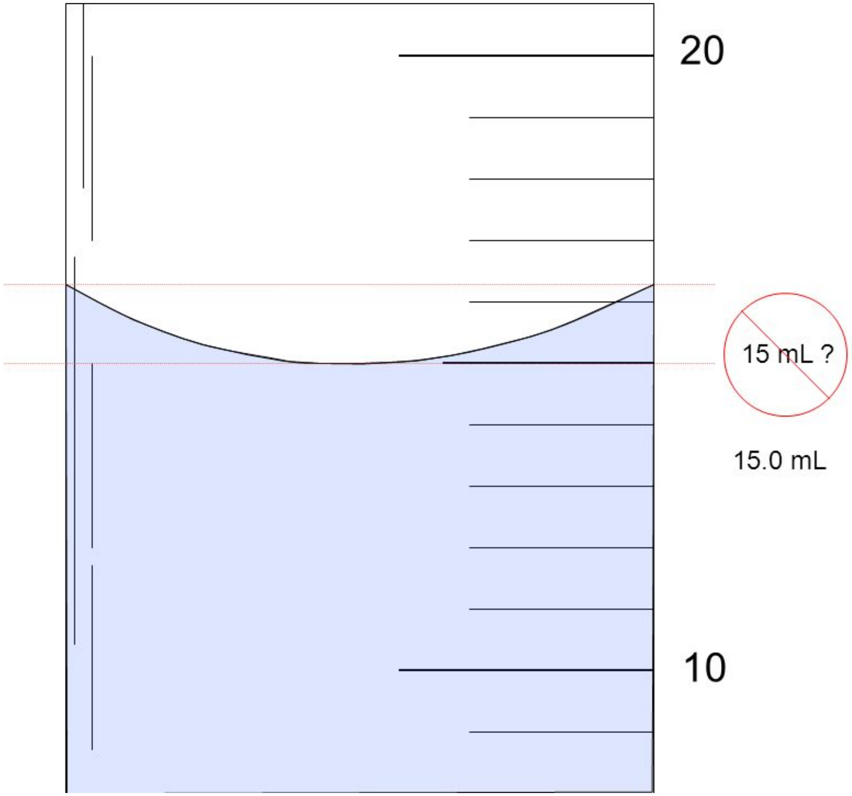
Volume Measurements

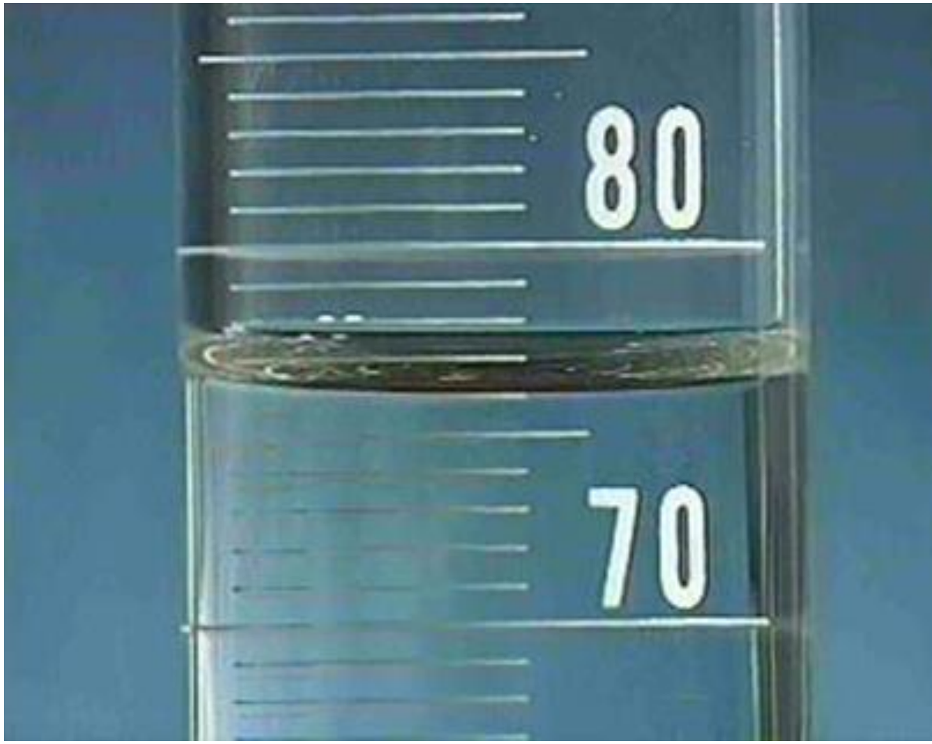




Volume Measurements

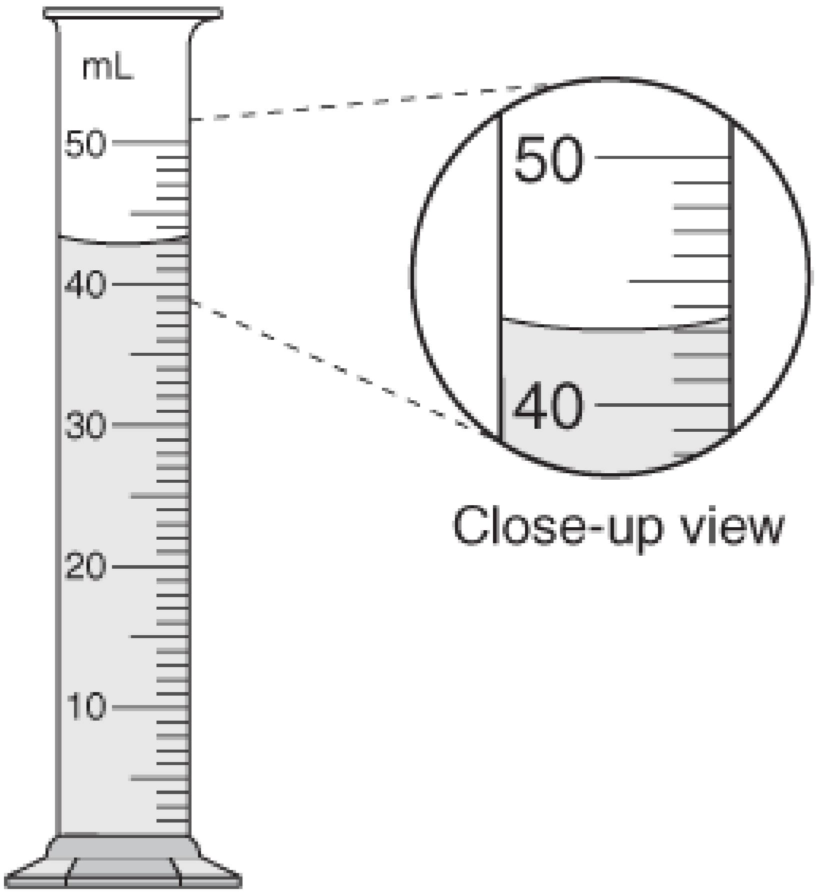
If it is EXACTLY on the line…



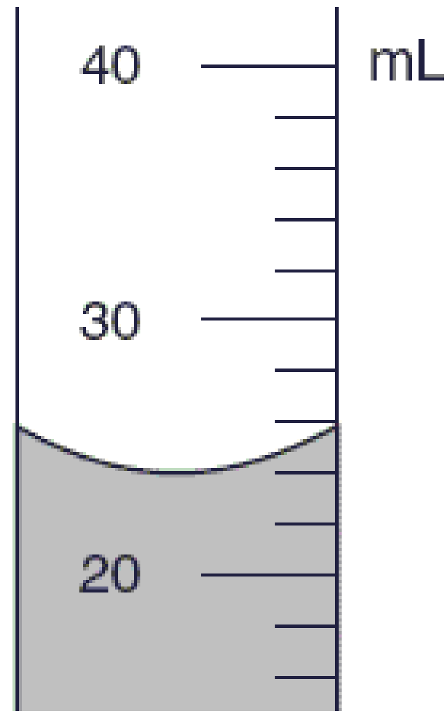


Volume Measurements

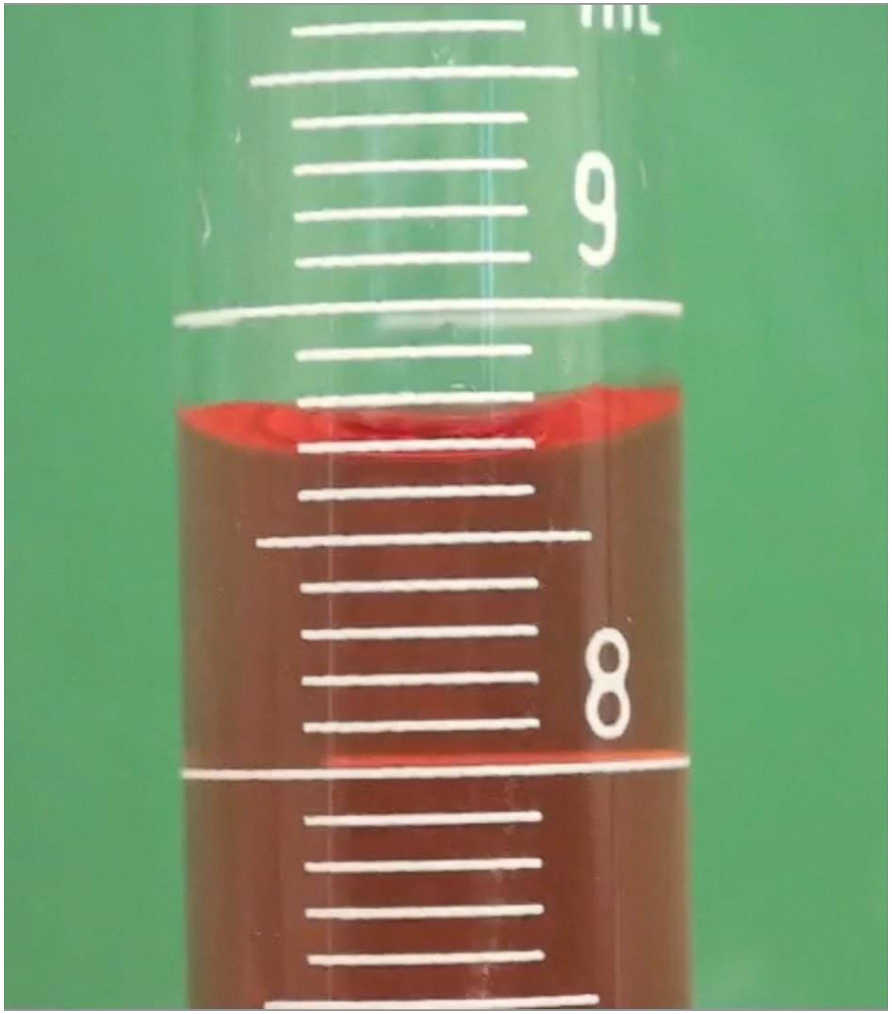
Volume Measurements



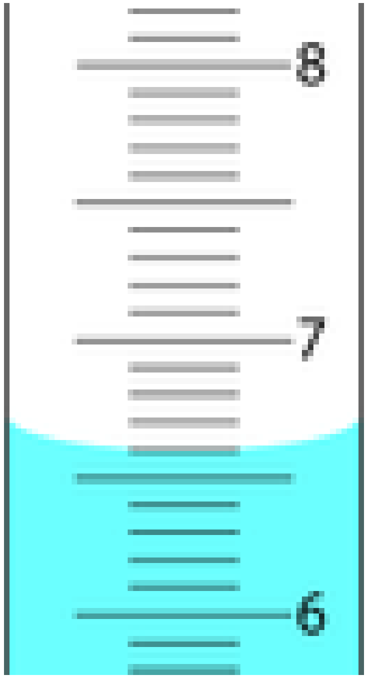
Graduated cylinder



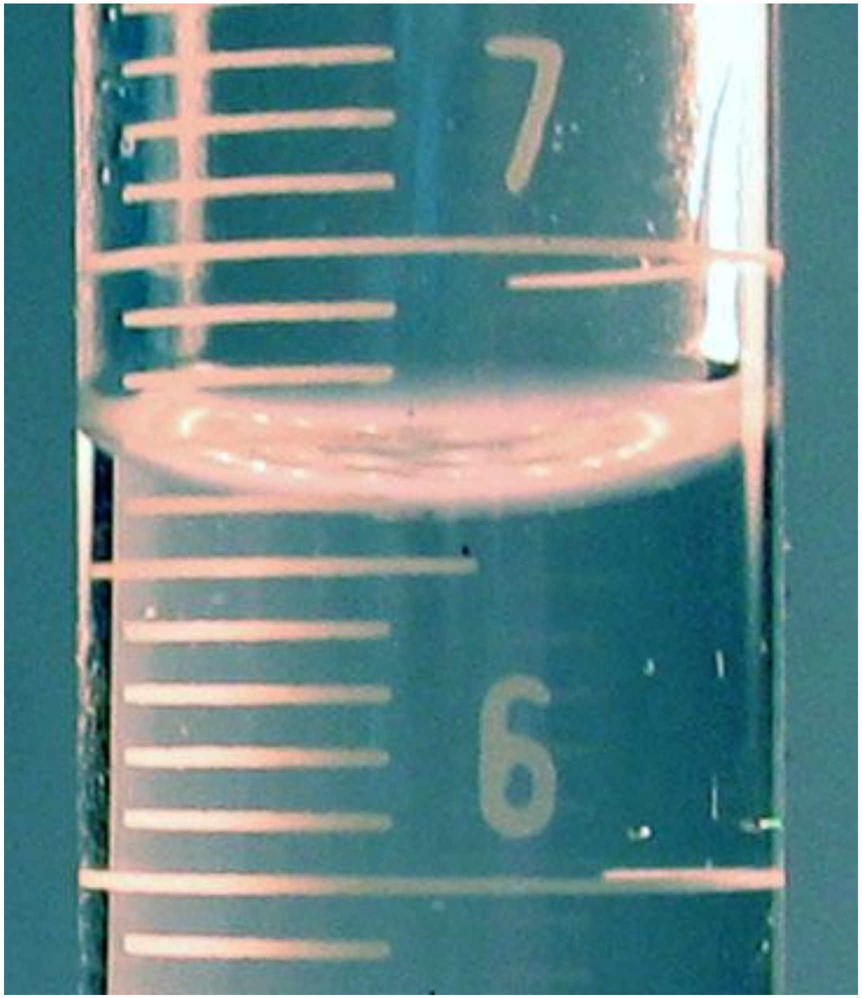
Volume Measurements

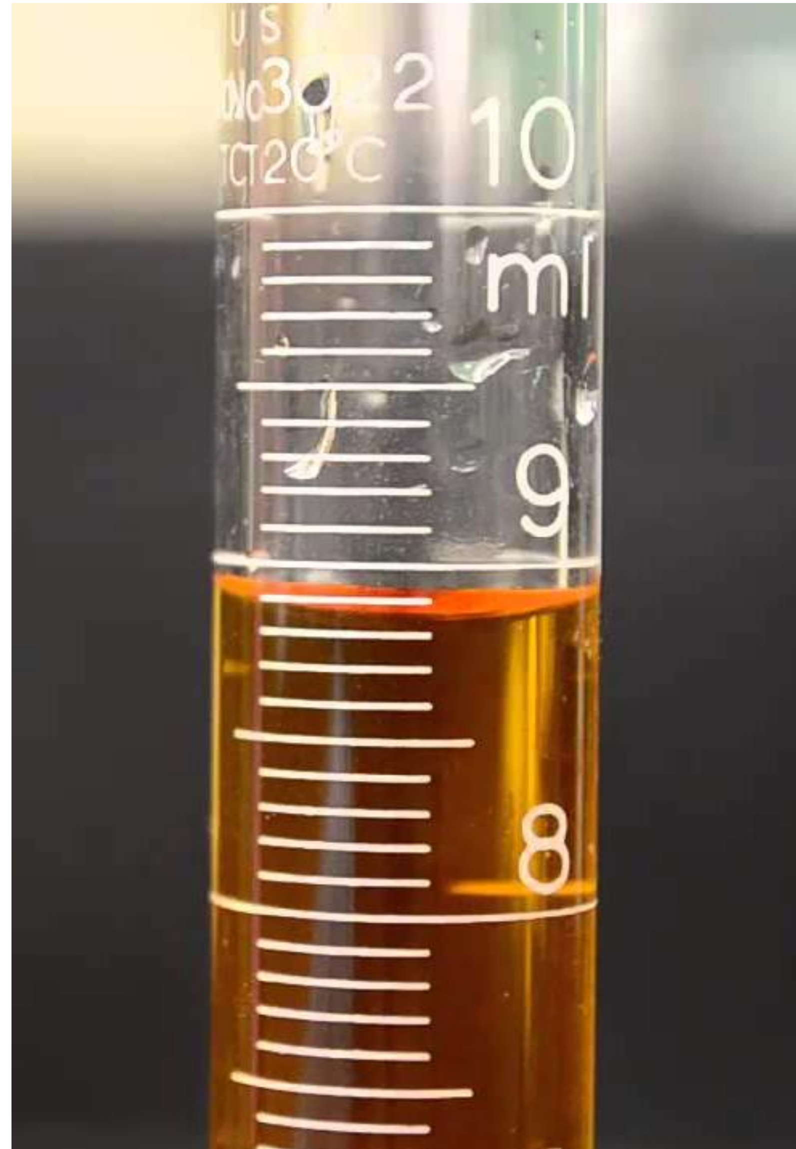


Volume Measurements



Volume Measurements

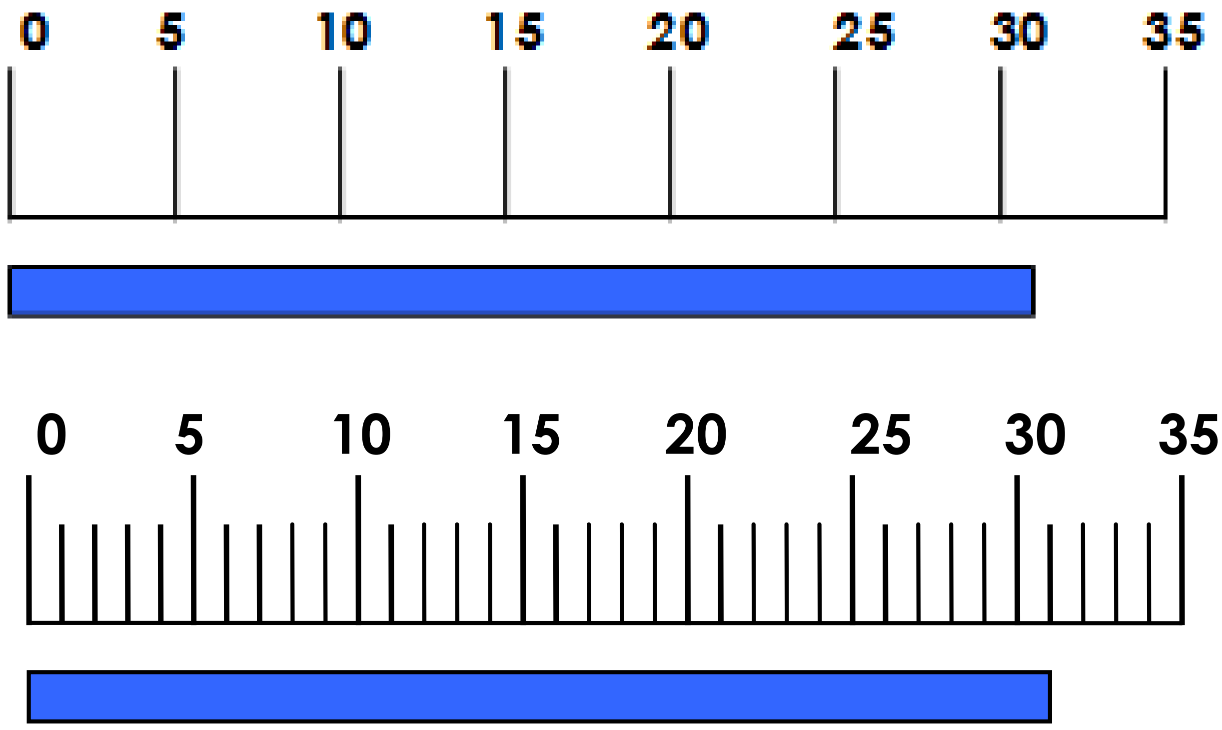




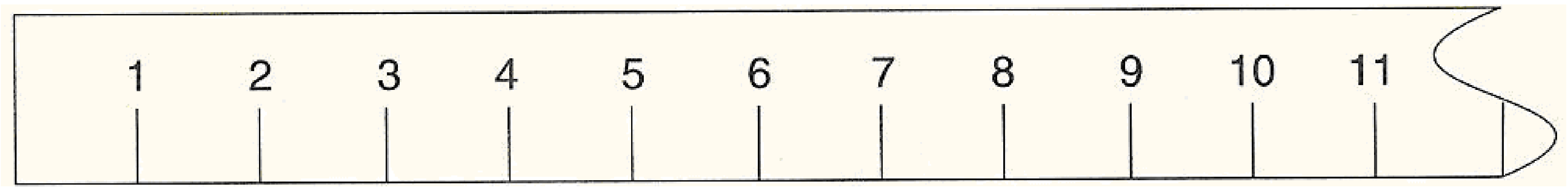
Significant Figures

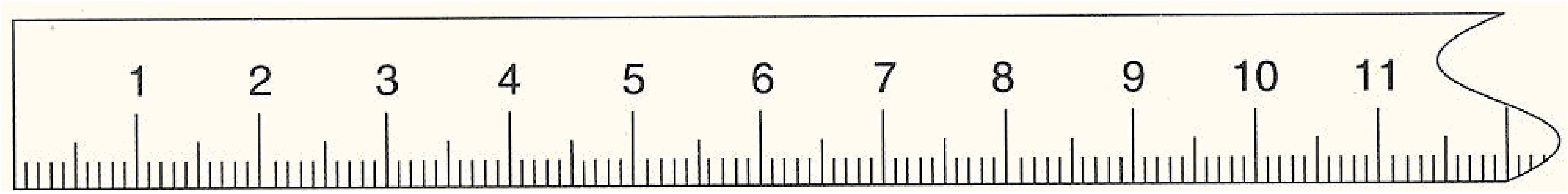
- The measurement 100.0 mL is fundamentally different than the measurement 100.00 mL in terms of its precision.

Are all measurements created equal?



Which ruler is better?





Are all measurements created equal?

- Which instrument is better?
- A graduated cylinder measures 100.0 mL
- A volumetric flask measures 100.00 mL

Why must we talk about this?

- *Does it really matter??*
- *YES! Here's an example of why:*

- I want to find the average mass of a penny. I use three different balances: 2.48 g, 2.499 g, 2.5010 g

- Do I report the average mass as 2.49333333 g?
- NO! It would be 2.49 g
- Why? I will explain in this lesson☺

Significant Figures: Definition

- **Significant figures**, also known as significant digits, are all of the digits that can be known with certainty in a measurement plus an estimated last digit.

- Significant figures provide a system to keep track of the limits of the original measurement.

Today we will learn about…

1) How do I determine the number of significant figures?

2) How do they affect <u>multiplication</u> & <u>division</u> of measurements?

3) How do they affect <u>addition</u> & <u>subtraction</u> of measurements?

Determine the Number of Sig Figs

1) All digits are significant.
   - Any number 1 through 9
   - 45 kg = ___ sig figs

Determine the Number of Sig Figs

2) Any zero that is between significant figures is significant.
   - 303 cm = ___ sig figs
   - 9009 m = ___ sig figs

Determine the Number of Sig Figs

3) Any zero that comes *after* a digit AND a decimal is significant.
   - 93.0 g = ____ sig figs
   - 4.00 mg = ____ sig figs
   - 0.0090 cm = ____ sig figs
   - 700 km = ____ sig fig
   - 200.0 kg = ____ sig figs

Determine the Number of Sig Figs

1) All digits are significant.
   - Any number 1 through 9
   - 45 kg = two sig figs

Determine the Number of Sig Figs

2) Any zero that is between significant figures is significant.
   - 303 cm = three sig figs
   - 9009 m = four sig figs

Determine the Number of Sig Figs

3) Any zero that comes *after* a digit AND a decimal is significant.
   - 93.0 g = three sig figs
   - 4.00 mg = three sig figs
   - 0.0090 cm = two sig figs
   - 700 km = one sig fig
   - 200.0 kg = four sig figs

Practice Determining Sig Figs

- 1) 5.40 ____
- 2) 210 ____
- 3) 801.5 ____
- 4) 1,000 ____
- 5) 101.0100 ____

6) 1.2×10^{3}____

7) 0.00120 ____

8) 0.0102 ____

9) 9.010×10^{-6} ____

10) 2,370.0 ____

Practice Determining Sig Figs

- 11) 300.0 ____
- 12) 105.060 ____
- 13) 0.0034 ____
- 14) 4.50×10^{-4} ____
- 15) 200 ____
- 16) 1050 ____
- 17) 3400.0 ____
- 18) 190 ____
- 19) 2.30 ____
- 20) 104.0 ____

21) 15.0 g + 1.230 g + 0.05 g =

22) What is the density of an object that has a mass of 201.0 g and a volume of 11.050 mL?

Sig Figs & Orders of Operation

Addition & Subtraction

Least number of decimal places

Multiplication & Division

Least number of sig digits

Sig Figs & Orders of Operation

a) $35.72 \times 0.00590 =$

b) $201.0 + 3.57 + 98.493 =$

Sig Figs & Orders of Operation

a) 56.0 mL ÷ 2.304 mL = 24.3

b) 20.5 g – 5.483 g – 3.40 g = 11.6

Review
Scientific Notation

Practice Scientific Notation

Put the following into scientific notation

1) 540,000,000
2) 70,900
3) 500,300
4) 0.000405
5) 0.09204
6) 0.00000302

Practice Scientific Notation

Take the following out of scientific notation

1) 9.80×10^{4}
2) 3.04×10^{-3}
3) 9.006×10^{-4}
4) 8.07×10^{-1}
5) 3.2×10^{2}

Practice Scientific Notation

Put the following into scientific notation

1) 420,000
2) 0.00256
3) 0.0000305
4) 7,901,000
5) 0.00094
6) 82,000

Practice Scientific Notation

Take the following out of scientific notation

1) 7.81×10^{-4}
2) 1.5×10^{3}
3) 4×10^{-2}
4) 8.02×10^{-5}
5) 9.305×10^{6}