# Chem. 101 Laboratory
# Fall 2005-06

## Lecture 1

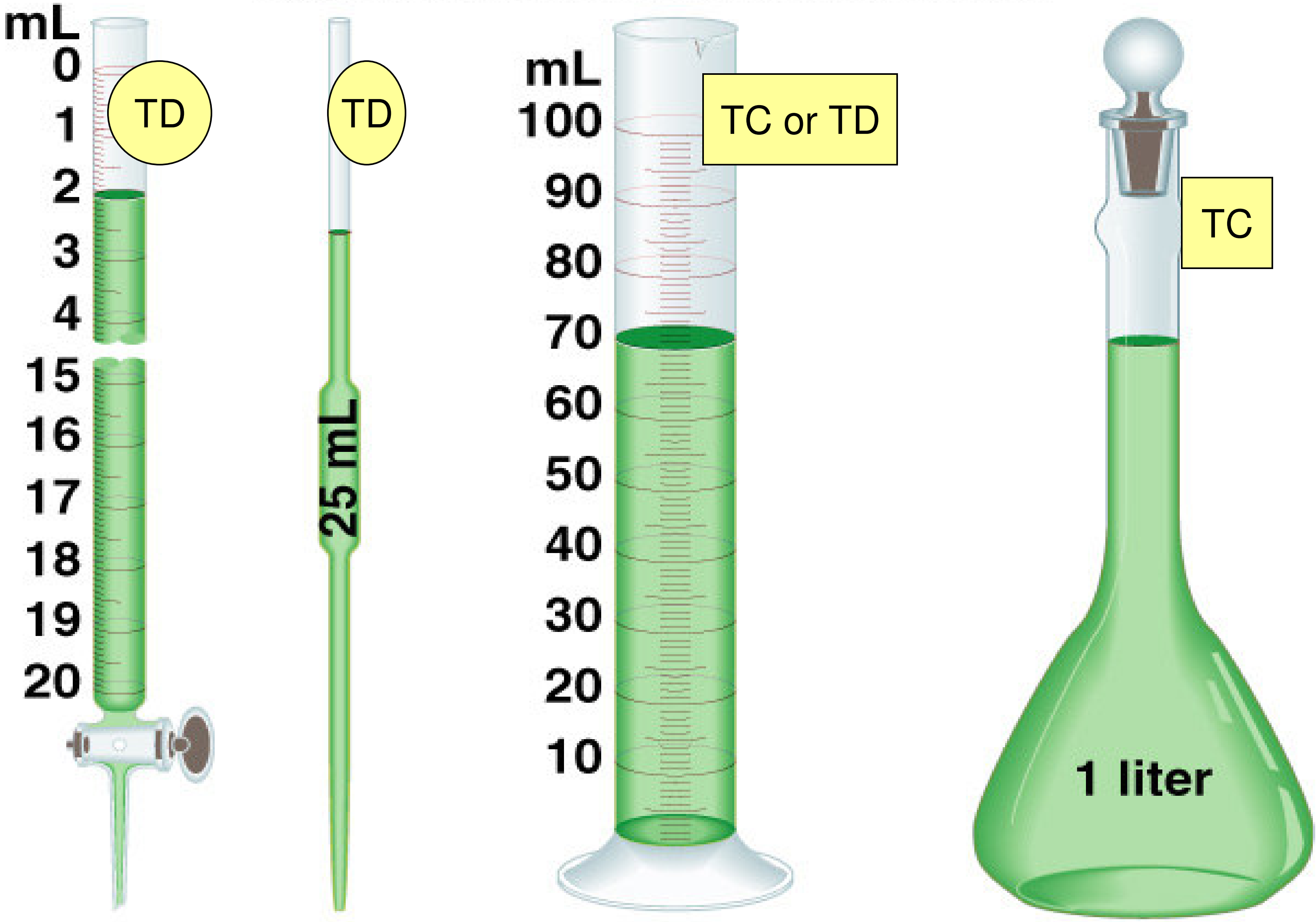
## Measurement

# Purpose

- To become acquainted with the various types of balances and volumetric glassware and to compare their use and precision.
- To develop the technique of using such glassware.
- To learn how to report a measurement to the right precision
- To determine the density of an unknown substance.

# Volumetric glassware






Buret Pipet Graduated cylinder Volumetric flask

# Volumetric glassware (cont'd)

- **Buret:** Calibrated TD (to deliver) at 20 ºC.
  Used to deliver any needed volume.

- **Pipet:** Calibrated TD (to deliver) at 20 ºC.
  Used to deliver accurately measured volume.

- **Graduated cylinder:** Calibrated TC (to contain) or TD (to deliver) depending on its intended use.

- **Volumetric flask:** Calibrated TC (to contain).
  Used to make up solutions to given volume.

# Uncertainty

- In every measurement there is a possibility of experimental error. The margin of error in a given measurement is called the uncertainty on that measurement.

- Uncertainty depends on the measuring tool or instrument.

  **Example:** measurement of the length of a certain rod using two different rulers.

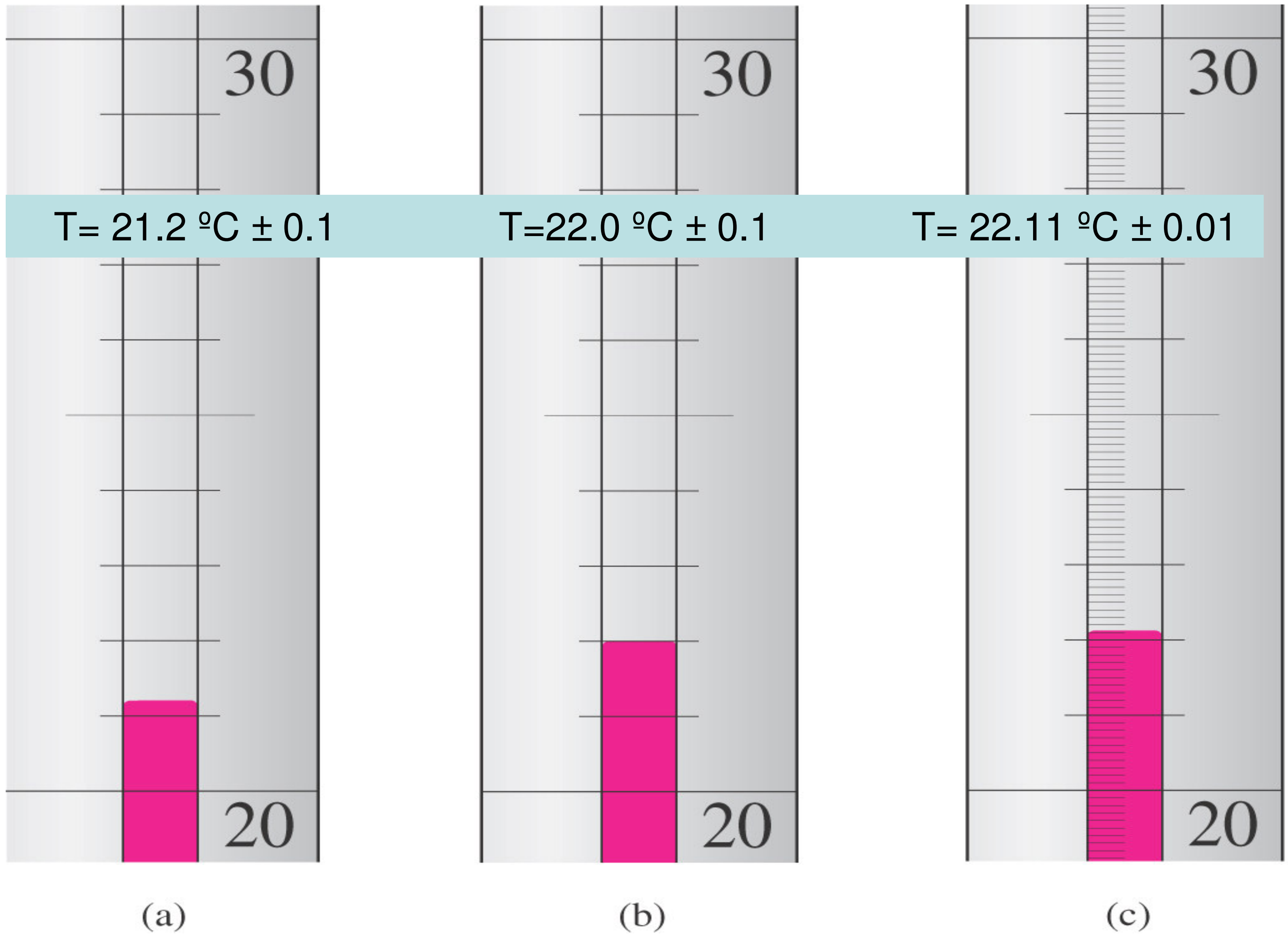
  Ruler 1: $3.7 \pm 0.1$ cm

  Ruler 2: $3.69 \pm 0.01$ cm

  Ruler 2 is more precise.

- The uncertainty is usually given with the instrument, if not, consider it 1/10 of the smallest division.

# Uncertainty (cont'd)



# Examples

| Instrument or Tool | Uncertainty | Correct Expression of Measurement |
|---|---|---|
| Top loading balance | $\pm$ 0.01 g | 4.01 g |
| Analytical balance | $\pm$ 0.0001 g | 2.1049 g |
| 10 mL graduated cylinder | $\pm$ 0.1 mL | 6.3 mL |
| 50 mL buret | $\pm$ 0.02 mL | 28.04 mL |
| 25 mL volumetric pipet | $\pm$ 0.02 mL | 25.00 mL |
| 250 mL volumetric flask | $\pm$ 0.12 mL | 250.0 mL |

# Significant Figures

## Definition

All digits required to express a measurement or a calculated result to the proper uncertainty. (A measurement contains significant figures that are all certain digits + one uncertain digit).

## Counting Significant Figures:

- In a given number, each digit that appears to the right of the first nonzero digit, including that latter digit, is a significant digit.

| | | |
|---|---|---|
| **Examples:** | 1.3520 | *5 sig. fig.* |
| | 0.0452 | *3 sig. fig.* |
| | 9.020 | *4 sig. fig.* |
| | 56 | *2 sig. fig.* |

# Counting Significant Figures (Cont'd)

- Zeroes to the left of the first nonzero digit and exponents are not significant.

  **Examples:** 0.0050 *2 sig. fig.*

  $5.00 \times 10^2$ *3 sig. fig.*

  $0.01 \times 10^{-4}$ *1 sig. fig.*

- **Exact numbers**: Numbers obtained from definitions or by simple counting are considered to have an infinite number of significant figures.

  ***Examples:*** 25 dollars

  60 minutes in one hour

**The average of three measured lengths: 6.64, 6.68 and 6.70?**

$$\frac{6.64 + 6.68 + 6.70}{3} = 6.67333 = 6.67 = \cancel{7}$$

(3 is an exact number)

# Significant figures in mathematical operations

***1- Addition and subtraction:***

The number of decimal places in the answer is the same as that in the component having the lowest number of decimal places

**Examples:**

i- 114.65 + 1.961 + **12.3** = 128.911

= 128.9 (one decimal place)

ii- **66.59** – 3.113 = 63.477

= 63.48 (two decimal places)

## *2- Multiplication and division*

The number of significant figures in the answer is the same as that in the component having the least number of significant figures.

**Examples:**

i- **8.16** x 5.1355 = 41.90568

= 41.9 **(3 sig. fig.)**

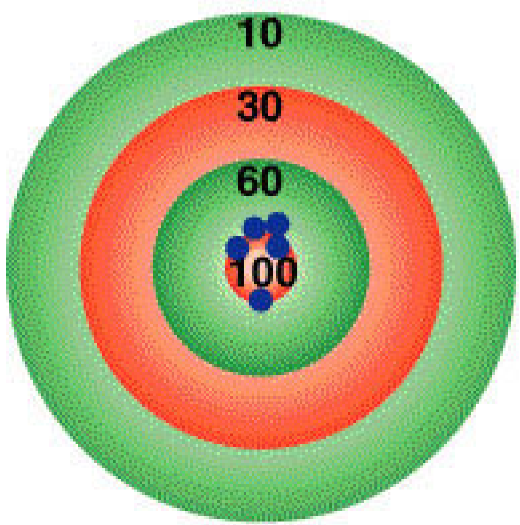
ii- 0.01540 / **883** = 0.0000174405

= $1.74 \times 10^{-5}$ **(3 sig. fig.)**

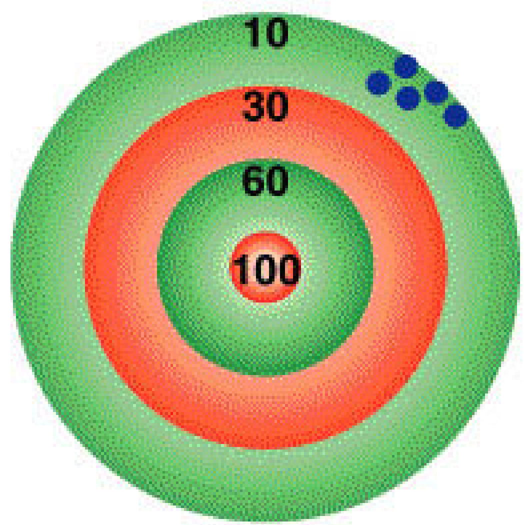
# Accuracy and precision

***Accuracy*** – how close a measurement is to the *true* value

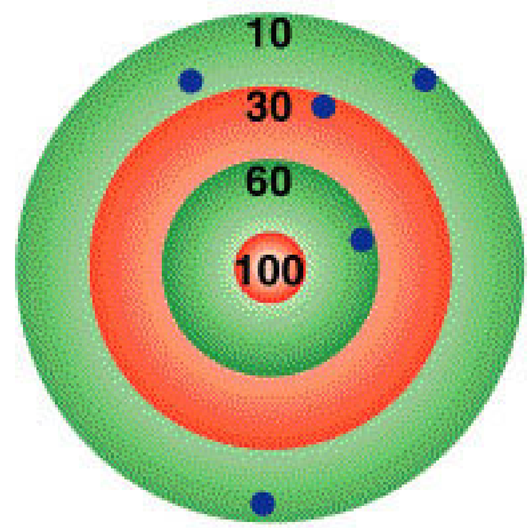
***Precision*** – how close a set of measurements are to each other




accurate
&
precise




precise
but
not accurate




not accurate
&
not precise

# Expression of Error

- **Absolute Error** = | Exp. Value – True Value |

  $$= |\mathbf{X} - \mathbf{X_T}|$$

- **Relative Percent Error** = $\dfrac{|\mathbf{X} - \mathbf{X_T}|}{\mathbf{X_T}} \times 100$

Higher Percent Error indicates lower accuracy