

## CHEM 130

# Exp. 1: Metric Measurements

### Introduction:

There are numerous aspects to chemistry, but a common thread between them all is the process of collecting data and observations through field studies or in a laboratory. It is critical to understand how to make and read measurements, and we will focus on the basic types in this experiment: mass, length, volume and temperature.

All quantitative measurements (involving a numerical value) are meaningless without an associated unit. It is necessary to always include a unit with a number, and that unit is determined by the measuring device. Since there are many different units for mass, volume, length, etc., we will look at the relation between some common units from the English system and the metric system during lab.

The other major goal is to learn how to use, read and interpolate the basic measuring devices found in the laboratory, such as the Top Loader Balances, Graduated Cylinders, Meter Sticks and Celsius Thermometers. The concept of significant figures will be covered in depth to aid in understanding the limitations inherent in any measurement and later calculations involving that value.

### Discussion:

There are many basic concepts that will be carried throughout the entire semester in lab which are briefly covered below. More details will be given as the semester progresses.

- 1) **Safety:** Safety rules are covered the first day of lab, and a 20 question, multiple choice safety quiz is taken on the second day of lab. All safety rules must be followed at all times, with specific ones covered in the prelab lecture for each class. Make sure you are on time! Safety goggles are required by the second day of lab.
- 2) **Primary/Secondary Data:** Primary data should always be written in ink directly onto your data sheets. These involve both quantitative measurements and qualitative observations. Think of primary data as anything you must be in the lab in order to record. Secondary data is always in pencil and involves calculations or questions answered using the Primary data.
- 3) **Prelab Assignments:** These are due at the beginning of lab, no exceptions. You may not perform the lab if the prelab is not complete. You can download these from the instructor's website and have an entire week to ask questions if you are unsure of anything. Be familiar with the proper instructions and calculations for the lab before you try anything!
- 4) **Problem Solving and Calculations:** All work must be shown for mathematical calculations, and all unit conversions should be set up as unit line equations for clarity. Be neat! Always include units for any number.

For example, to calculate the density (D) of a liquid with a measured volume (V) of 9.83 mL and a mass (M) of 12.90 g, show the formula, insert the primary data with units, show the unrounded answer, and then box the rounded answer to the appropriate number of significant figures with the correct units.

$$D = \frac{M}{V} = \frac{12.90 \text{ g}}{9.83 \text{ mL}} = \frac{1.31123 \text{ g}}{\text{mL}} \text{ -----} \rightarrow \boxed{1.31 \text{ g/mL}}$$

If this value was to be converted into units of grams per Liter (L), use the unrounded answer in the Unit Line Equation with the conversion factor to change the units of mL to L:

$$\frac{1.31123 \text{ g}}{\text{mL}} \left( \frac{1000 \text{ mL}}{\text{L}} \right) = \frac{1311.23 \text{ g}}{\text{L}} \text{ -----} \rightarrow \boxed{1310 \text{ g/L}} \quad \text{or} \quad 1.31 \times 10^3 \text{ g/L}$$

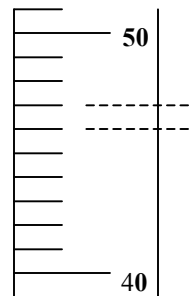
in scientific notation

## Making Measurements:

Each measuring device has its own limitations and techniques. For digital readings, there is no estimation involved and all digits shown are recorded except for any zero preceding a non – zero number (i.e.: 3.20 g instead of 03.20 g).

For non – digital instruments, the first step is to determine the value represented by the increment, or the space between the smallest divisions (lines) on the measuring device (represented by dashed lines in the figure to the right). This is most easily done by dividing the difference between two labeled lines by the number of lines between them.

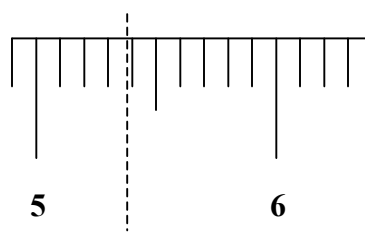
For the example shown to the right (assume it is a graduated cylinder), the difference between the labeled lines is: 50 mL – 40 mL = 10 mL. There are 10 divisions between these labeled lines, and so the value of the increment is  $10 \text{ mL} \div 10 = 1 \text{ mL}$ .



Interpolating the measurement, or estimating the uncertain digit between the lines, is based on the value of the increment. If the value is 0.1, 1, 10 or 100, mentally divide the increment into 10 equal divisions. If the increment is 0.2, 2, 20 or 200, mentally divide it into 2 equal divisions. If the increment is 0.5, 5, 50 or 500, mentally divide it into 5 equal divisions.

**Meter Sticks:** A portion of a meter stick is shown to the right, showing the divisions. The smallest division (the increment) is a millimeter (mm), or a tenth of a centimeter (cm). You must estimate the reading between these lines to a tenth of a mm or a hundredth of a cm.

The position marked by the dashed line is read as 5.38 cm or 53.8 mm.

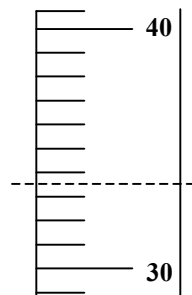


**Thermometers:** All temperature measurements are made in degrees Celsius (°C) for the thermometers used in this lab. You do not need to shake the thermometer before use, and do not hold the bulb in your hand when making any measurements.

If the red liquid is segmented or the thermometer broken, turn it in to your instructor to be fixed and get a new one.

A portion of a thermometer is shown to the right in units of °C. Note the (increment) is one degree, and the measurement is estimated to a tenth of a degree (10 mental divisions).

The position marked by the dashed line is read as 33.5 °C.



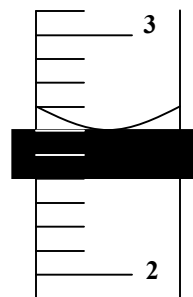
**Graduated Cylinders:** There are two main factors to watch out for when reading a graduated cylinder: reading from the meniscus and avoiding parallax error.

Since the liquid surface is not level (concave or convex), then a standard must be agreed upon for consistency. This point is at the bottom of the curve, called the meniscus. Line up a buret reading card behind the cylinder so that the upper edge of the black line almost touches the bottom of the meniscus. This is shown on the figure to the right.

Parallax error involves orienting your line of sight even with the meniscus. For very large cylinders, leave them on the counter and adjust your height to even your line of sight. For smaller cylinders, you can pick them up and hold them like a plumb bob between your fingers in line with your eyes.

There are some tricks involved with determining whether you are oriented properly which will be covered in lab as a demonstration.

For the example on the right, the increment is 0.1 mL ( $3 \text{ mL} - 2 \text{ mL} = 1 \text{ mL}$  divided by 10 divisions). This particular cylinder is estimated to the nearest hundredth of a mL ( $\pm 0.01 \text{ mL}$ ). Since the meniscus falls exactly on the line, the value would be 2.60 mL. (You must include the last zero since this cylinder is estimated to 2 decimal places).



**Balances:** We use top loader digital balances in this lab, and there are some important rules to follow so as to not damage them. They are all displayed to a hundredth of a gram ( $\pm 0.01 \text{ g}$ ).

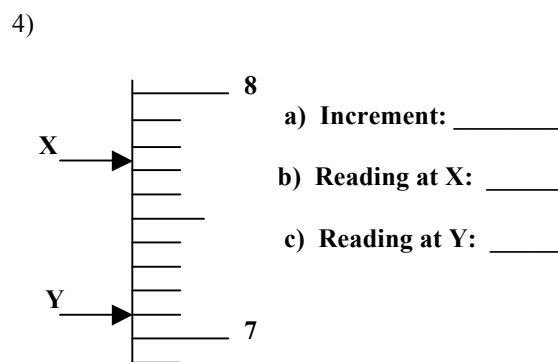
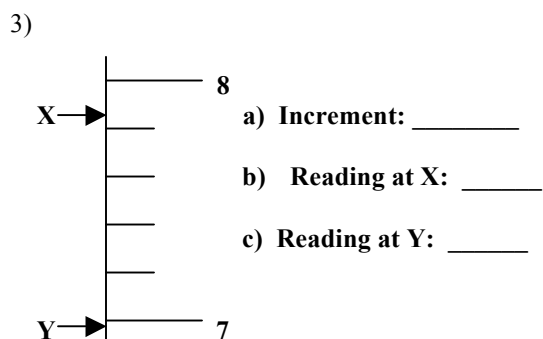
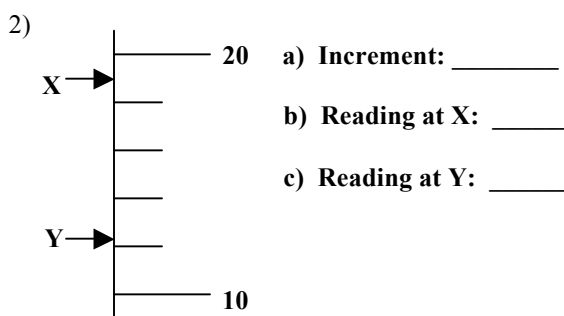
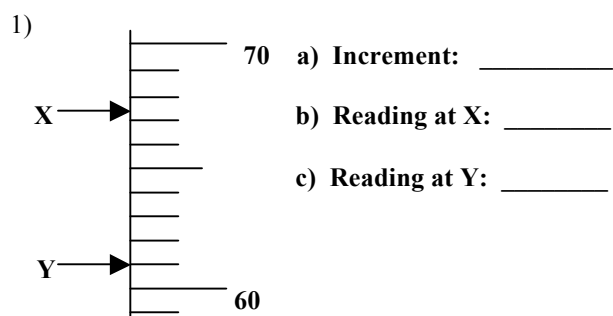
- Never move a balance or turn them off (by lifting up the horizontal bar).
- Never put chemicals directly on a balance (use weighing paper or a container).
- Clean up any spilled chemicals immediately!

Some useful techniques that are used throughout the semester are listed below.

- Zeroing a balance:** If the display is not at 0.00 g ( $\pm 0.01$  g) before you begin, gently depress the horizontal bar and it will zero the display.
- The tare function:** This is done by placing an object (i.e.: a container or weighing paper) on the balance pan and depressing the horizontal bar. This zeroes the display (it essentially subtracts the mass of the item on the balance pan). Any chemicals added will have the mass shown on the display. When the item tared is removed from the balance, the negative mass of that item will be displayed. (Be considerate of the next person and zero the balance when you are finished).
- Recording a mass:** Since these are digital instruments, there is no estimation involved in the reading. All digits shown are recorded except for any zero preceding a non – zero number (i.e.: 3.20 g instead of 03.20 g). There may be some minor fluctuation of the last (uncertain) digit. Be sure any hot objects have been cooled to room temperature since they may cause the reading to fluctuate too much.

### Practice Problems:

For the following scales (no units), determine the size of the increment, and then estimate the readings at the lines given to the appropriate number of digits. The answers are given below.....don't cheat!



### Answers to the Practice problems:

If you had trouble with these, check with your instructor prior to lab to make sure you understand the concepts.

- |                           |                         |                          |                           |
|---------------------------|-------------------------|--------------------------|---------------------------|
| 1) Increment: <u>1</u>    | 2) Increment: <u>2</u>  | 3) Increment: <u>0.2</u> | 4) Increment: <u>0.1</u>  |
| Reading at X: <u>67.4</u> | Reading at X: <u>19</u> | Reading at X: <u>7.9</u> | Reading at X: <u>7.74</u> |
| Reading at Y: <u>61.0</u> | Reading at Y: <u>12</u> | Reading at Y: <u>7.0</u> | Reading at Y: <u>7.10</u> |

Date: \_\_\_\_\_

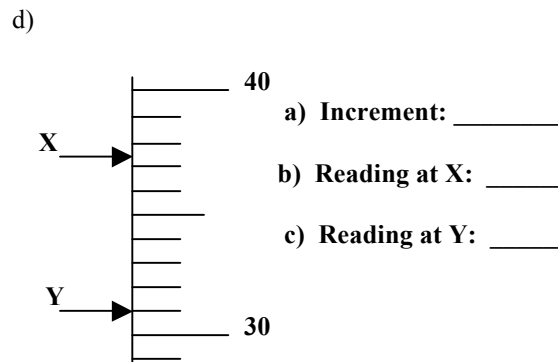
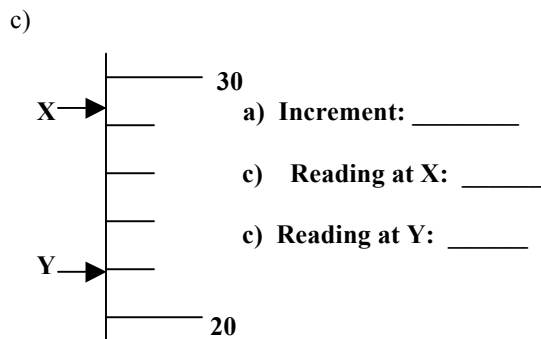
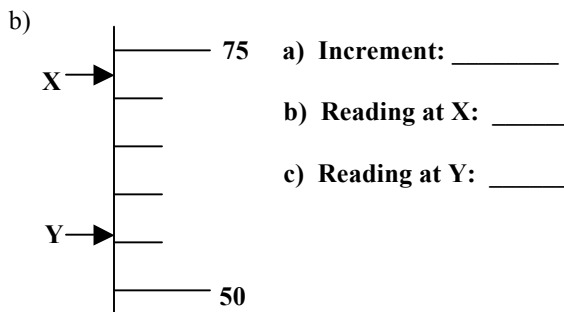
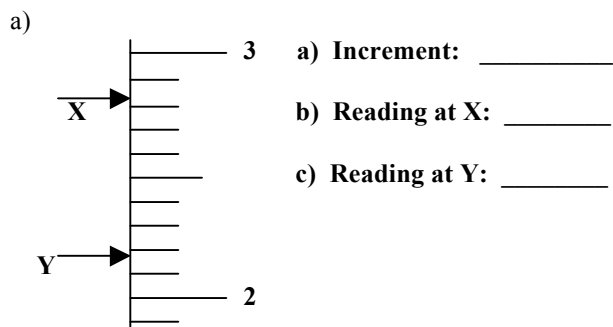
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NAME: \_\_\_\_\_

## Exp 1: Metric Measurements Prelab

These are due at the beginning of lab and must be completed to start the lab.

1) For the following scales (no units), determine the size of the increment, and then estimate the readings at the lines given to the appropriate number of digits.



2) What are the two main things to remember when reading a graduated cylinder?

3) What does it mean to “tare” and what would be a reason to do this?

Some more reading to do before lab...bring this handout with you to lab.

## Reading Graduated Cylinders and Burets

When measuring the volume of water or aqueous solution in a narrow glass container, such as a graduated cylinder or buret, the surface of the water will be curved. This curvature is due to the attraction water has for glass and is referred to as a meniscus.

Graduated cylinders and burets are calibrated such that the volume is determined at the very bottom of the meniscus when the meniscus is held at eye level. There are specific steps that must be done to assure that proper volume measurements are made.

### 1) Eye level

Graduated cylinders and burets have labels lines that go completely around the cylinders, and have a stated value. In the example given below, the labeled lines are 3 and 4 mL. These lines will assist you in knowing when you are holding the cylinder such that the meniscus is at eye level.

**Eye Level at Labeled Line:** If the meniscus is at or very near a labeled line, you can determine that you are holding the cylinder properly if the labeled line appears as a straight line. That is to say, the front of the labeled line, which is closest to you will completely overlap the line that wraps around the back side of the cylinder, as in the 4 mL line in Figure 1.

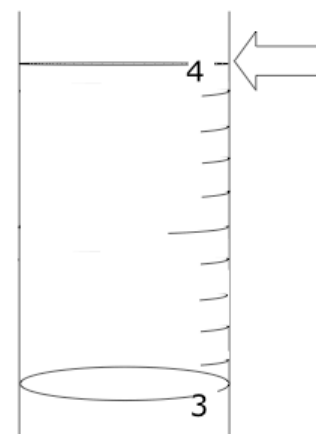


Figure 1

**Eye Level in the Middle of Two Labeled Lines:** If cylinder is held such that a labeled line is not at eye level, it will appear as an ellipsis (Figure 2a.) If the meniscus is in the middle of two labeled lines, it can be determined that the cylinder is being held at the proper eye level when the ellipses above and below the meniscus are of even thickness (Figure 2a.)

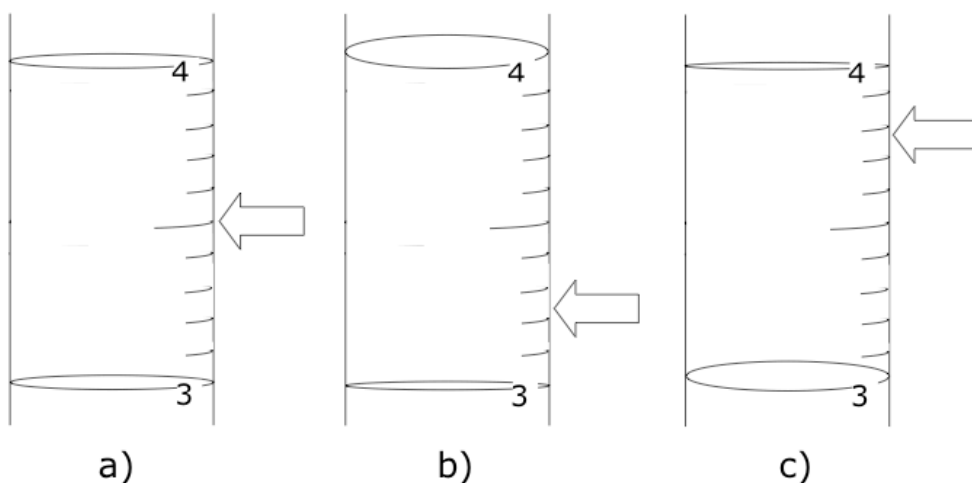


Figure 2

If the cylinder is being held too high, so that the meniscus is above eye level, the upper ellipses will appear thicker than the lower one. If the cylinder is being held too low, so that the meniscus is below eye level, then the upper ellipsis will be thinner than the lower one.

**Eye Level Closer to One of Two Labeled Lines:** It can be determined that a meniscus that is not centered between two labeled lines is being held at eye level by deliberately holding the cylinder such that ellipsis that is closer to the meniscus is thinner than the one that is farther away from it. Example 2b) is held appropriately for a meniscus at about 3.25 mL and 2c) for a meniscus at about 3.75 mL.

## 2) Buret Reading Card

A meniscus can be challenging to read because it has some thickness to it, and it is clear & transparent, making it difficult to see the very bottom of it (Figure 3a.) A buret reading card is used to help clarify the meniscus.

**Highlight the Meniscus:** Hold a buret reading card behind the cylinder such that the black bar is parallel to the meniscus. Slowly bring the card up, closer to the meniscus until the meniscus begins to reflect the black from the bar on the card (Figure 3b.) It looks as if someone took a black marker and outlined the meniscus. The bottom of this black line is where you want to record the volume contained in the cylinder.

**Determining the Volume:** Continue to raise the card until the black bar *just* touches the bottom of the meniscus. If the bar is raised too high, the bottom of the meniscus will look flat. If it is not raised far enough, there will be a white gap between the meniscus and the black bar.

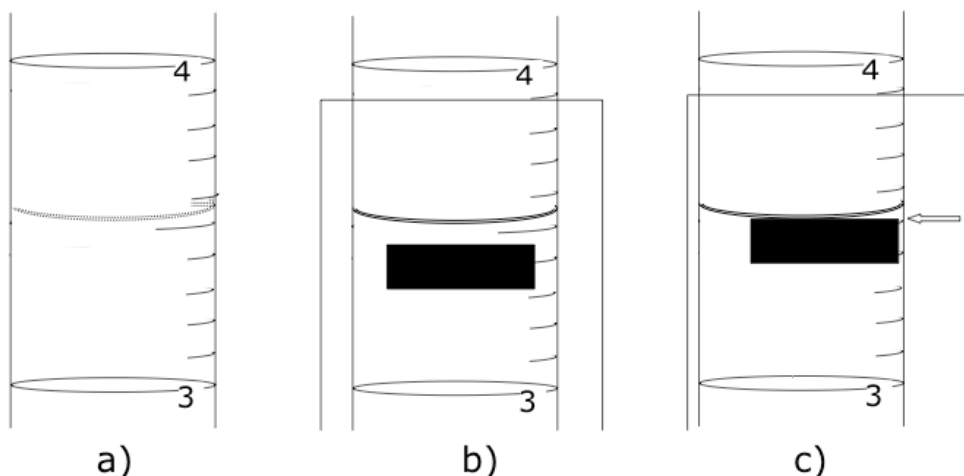


Figure 3

Slide the buret reading card over, so as to extrapolate the line from the bottom of the meniscus to the scale on the cylinder (Figure 3c.) This is the volume that should be recorded.

## 3) Increments and Uncertainty

Refer to the Linear Scale handout on how to determine increments and uncertainty. In Figure 4 the increment is 0.1 mL and the absolute uncertainty is 0.01 mL. The volume should thus be recorded as 3.61 mL.

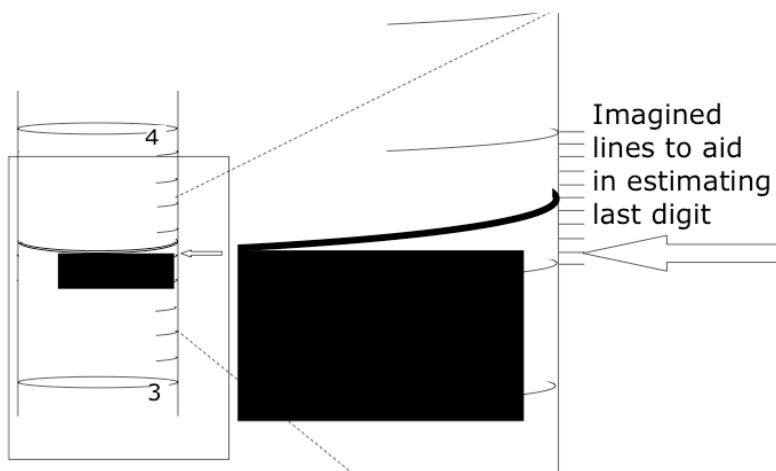


Figure 4