Measurements, Significant Figures, and Unit Conversions

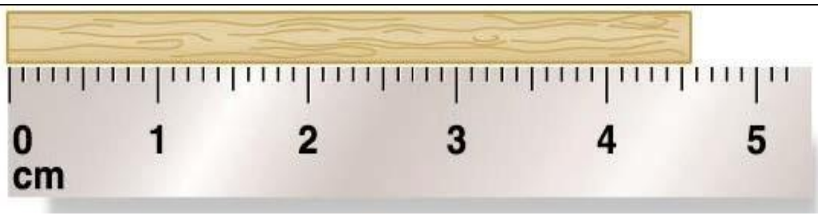
Name: ______________________________________ **Period:** _____

PART 1: MEASURING DEVICES and SIGNIFICANT FIGURES

An experiment that yields numerical data requires appropriate measuring devices – this lab is about you learning to read these devices correctly and to record the correct number of significant figures for each measurement. Most measuring devices will contain numbers with smaller subdivisions in between – first make sure you understand the range, major divisions, and subdivisions of the device before attempting to use it for a measurement.

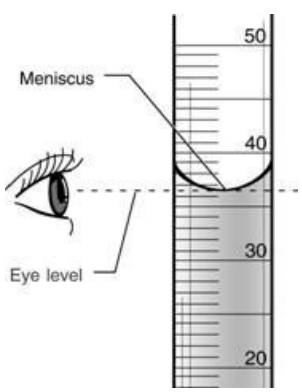
LENGTH:

Refer to the ruler below and see that there are *major divisions* labeled at intervals of 1 cm and *subdivisions* of a tenth of a cm (0.1cm or 1mm) indicated by smaller marks in between each number. When using a ruler that you can read to the tenth of a cm (0.1cm), you will record your answer to the hundredths (0.01cm) because any measurement contains an estimated digit too (that's why measurements are INEXACT numbers – there is always a degree of uncertainty since the last digit is an estimate!)

 Ruler indicates that the stick is somewhere between 4.5cm and 4.6cm. *YOU MUST ESTIMATE one more place and record*.	**The smallest subdivision is 0.1cm, the reading must be to 0.01cm.** 4.55 cm, 4.56cm, or 4.57cm could all be correct - remember YOU estimate the last digit, but the instrument tells you to which decimal place you will estimate.

VOLUME:

The volume of a liquid using cylindrical glassware such as a graduated cylinder (most common) is determined by reading the position of the "meniscus" relative to the calibration lines on the glass. To read the level of the liquid, position the eye on a horizontal line to the bottom of the meniscus as shown below. The same rules apply as described above – first determine what the range and major divisions of the device are. In this case, each line represents a milliliter (mL), so your answer will be recorded to the tenth of a mL (0.1mL).

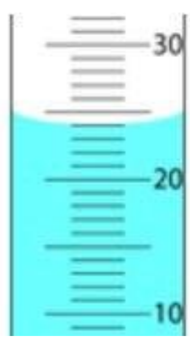


The volume level on the left is between 36mL and

37mL, so your recorded volume will include an estimated digit in the tenths place. **in this**

36.5mL, 36.6mL, or 36.7mL would be appropriate for this – depends on what YOU

volume? reasonably estimate the last digit to be



QUESTIONS: somewhere

What is the smallest subdivision cylinder?

How would you record this it

MASS:

In chemistry lab, you will have access to two different types of electronic balances. Which one you choose depends on how precise (how many decimal places) your measurement needs to be. We'll call the one with the glass box an "**analytical balance**" (reads to 0.0001g) and the one without the box a "**simple top loading balance**" (reads to 0.1g).

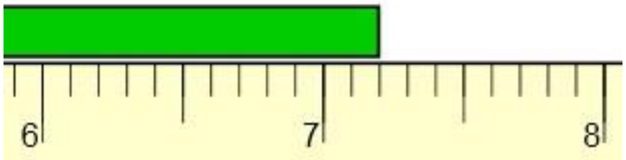
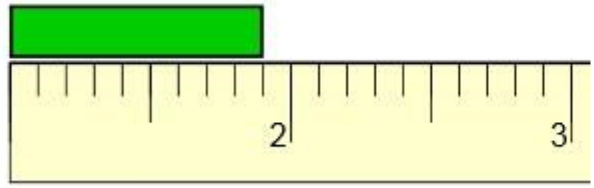
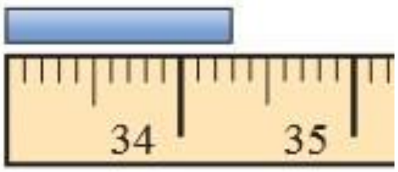
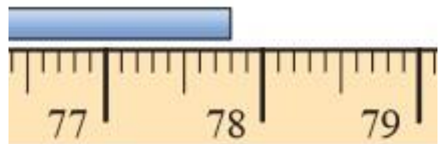
The "tare or rezero" button allows you to subtract the mass of a container if you place it on the balance first and use the tare/rezero button. ***Always make sure that the balance reads 0.0g before placing anything on the pan and place the object to be massed directly in the center***. Always close all of the doors when using an analytical balance and be careful not to lean on or touch the balance while it is equilibrating. ALWAYS RECORD ALL OF THE DIGITS ON WHICHEVER BALANCE YOU USE. ALWAYS.

Important Metric System Prefixes (these should be memorized):

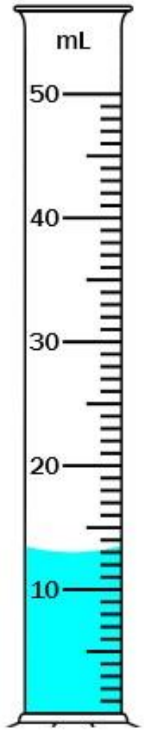
These are the most common metric prefixes used in chemistry. You will need to have an understanding of how they are related, their relative sizes, and be able to use these equalities in unit conversions.

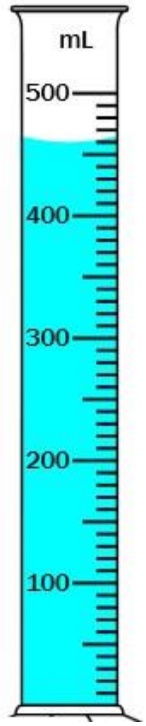
Metric Prefixes and symbol:	**Means:** **EQUALITIES (to be used in conversions are in red)**	**Scientific notation:**	
kilo- (k)	**x 1,000 (times 1000) (so 1 km = 1000 m)**	**1,000 = 10^3**	thousand
deci- (d)	**÷ 10 (divided by 10) (so 1 m = 10 dm)**	**0.1 = 10^{-1}**	tenth
centi- (c)	**÷ 100 (divided by 100) (so 1 m = 100 cm)**	**0.01 = 10^{-2}**	hundredth
milli- (m)	**÷ 1000 (divided by 1000) (so 1 m = 1000 mm)**	**0.001 = 10^{-3}**	thousandth
micro- (□)	**÷ 1 000 000 (divided by million) (so 1 m = 1000000 □m)**	**0.000001 = 10^{-6}**	millionth

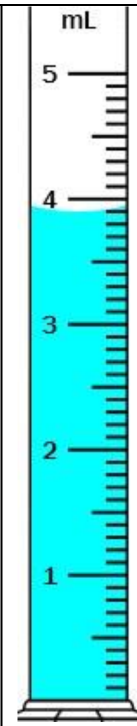
1. **MEASURING LENGTH:** Record the length for each of the bars below. The unit for each ruler below is centimeters (cm). If an object being measured is directly on the line of the subdivision, remember that a zero must be used to indicate your estimated digit.

 Smallest subdivision in cm: 0.1 cm (tenths) LENGTH in cm:	 Smallest subdivision in cm: LENGTH in cm:
 Smallest subdivision in cm: LENGTH in cm:	 Smallest subdivision in cm: LENGTH in cm:

2. MEASURING VOLUME of a LIQUID: Record the volume of liquid in each of the graduated cylinders below. Remember to first DETERMINE what each subdivision represents (for example, 0.1 mL, 1mL, 10mL,…):







What is the value of each subdivision? What is the volume?	What is the value of each subdivision? What is the volume?	What is the value of each subdivision? What is the volume?	What is the value of each subdivision? What is the volume?

3. Read and record the volumes of the two liquids in the graduated cylinders on display: Graduated cylinder 1:

Size of cylinder:	Volume represented each subdivision? *Circle one:* 1 mL, 0.1mL, 0.01mL, other	Volume of liquid:

Graduate cylinder 2:

Size of cylinder:	Volume represented by the smallest marked lines? *Circle one:* 1 mL, 0.1mL, 0.01mL, other	Volume of liquid:

PART 2: Determining the number of Significant Figures in a measured number

PROCEDURES FOR PART 2: Use the rules to determine the number of significant figures in each of the measured numbers.

How many sig figs are in the following numbers?

TABLE 1.6 Significant Figures in Measured Numbers

Rule	Measured Number	Number of Significant Figures
1. A number is a *significant figure* if it is		
a. not a zero	4.5 g 122.35 m	2 5
b. one or more zeros between nonzero digits	205 m 5.008 kg	3 4
c. one or more zeros at the end of a decimal number	50. L 25.0 °C 16.00 g	2 3 4
d. in the coefficient of a number written in scientific notation	4.8×10^5 m 5.70×10^{-3} g	2 3
2. A zero is *not significant* if it is		
a. at the beginning of a decimal number	0.0004 s 0.075 m	1 2
b. used as a placeholder in a large number without a decimal point	850 000 m 1 250 000 g	2 3

a. 55.552 g

b. 90031 g

c. 24.00 mL

d. 106.0000 g

e. 0.00432 mg

f. 1.00 mL

g. 10.023 m

h. 0.00032 mg

i. 5.2×10^3 mL

j. 3.440×10^{-4} g

PART 3: Using Significant Figures in Mathematical Calculations

PROCEDURES FOR PART 3: Use the rules to determine the number of significant figures in each of the following mathematical calculations. Record the calculator answer, then give your rounded answer.

This section allows you to practice applying the two different rules you will be using all semester when performing calculations on measured numbers. There are only TWO rules for rounding your calculator answer - the rule you choose depend on the mathematical operation you are asked to perform (multiplication/division rule OR addition/subtraction rule). Enter the numbers into your calculator and round at the end using the appropriate rule.

- **Rule for multiplication or division**: the rounded answer should have the same number of SF as the measurement with the fewest significant figures.

- **Rule for addition and subtraction**: the rounded answer should have the same number of decimal places as the measurement having the fewest decimal places (the least precise measurement).

	Calculator answer:	**answer rounded to the appropriate number of Sig Figs (follow rounding rules):**
EXAMPLE: 1. 6.45m + 2.333m + 8.1m =	16.883 m	8.1 has the fewest number (tenths), so the answer needs to be rounded to the tenths place: **16.9 m**
EXAMPLE: 2. 6.450m x 3.400m x 2.1m =	46.053 m^3	2.1 has the fewest SF (the other two number each have 4 SF), so the answer should be rounded to 2 SF: **46 m^3**
3. 0.003mL + 1.022mL + 2.11mL =		
4. 0.003mL x 1.022mL x 2.11mL =		
5. 29.00g + 11.000g =		
6. 29.00g x 11.000g =		
7. 16,340 g ÷ 23.42 g		
8. 17.6 mL – 12.73 mL		

PART 4: Unit conversions

PROCEDURES FOR PART 4: Follow the examples below to develop an understanding about how to use mathematical equalities as conversion factors. See example for how to correctly set-up and carry out a unit conversion. Complete the practice problems.

This section allows you to practice unit conversions. The two main types of unit conversions you will do this semester are unit conversions between the English and metric systems (for example, lbs to kilograms) and conversions between two units in the metric system (for example, millimeters to meters or grams to kilograms). First, it is important to understand that you cannot do any unit conversion without using AN EQUALITY. Every equality will give you TWO CONVERSION FACTORS:

Metric Equality	Conversion Factors
1 m = 100 cm	$\frac{100\text{ cm}}{1\text{ m}}$ and $\frac{1\text{ m}}{100\text{ cm}}$

Equality	Conversion Factors
2.20 lb = 1 kg	$\frac{2.20\text{ lb}}{1\text{ kg}}$ and $\frac{1\text{ kg}}{2.20\text{ lb}}$
1 qt = 946 mL	$\frac{1\text{ qt}}{946\text{ mL}}$ and $\frac{946\text{ mL}}{1\text{ qt}}$

Equality	Conversion Factors
1. 1 L = 1000 mL	$\frac{1\text{ L}}{1000\text{ mL}}$ and $\frac{1000\text{ mL}}{1\text{ L}}$
2. 1 h = 60 min	$\frac{1\text{ h}}{60\text{ min}}$ and $\frac{60\text{ min}}{1\text{ h}}$

Which version of the conversion factor you choose depends on what unit you are given in the problem. The conversion factors are set up so that the units cancel – eventually (either in one step or several), you end up with your target unit.

EXAMPLE:

If a person weighs 164 lbs, what is the body mass in kilograms (kg)? *Given the equality: 1 kg = 2.20 lbs*

Step 1. Write down the measurement you are given: 164 lbs (this is how you will ALWAYS start)

Step 2: Write down the conversion factor of an equality that allows you to cancel the given unit getting you to (or closer to) your target unit (kg in this case): ***EQUALITY:***

1 kg = 2.20 lb $\frac{2.20\text{ lb}}{1\text{kg}}$ and $\frac{1\text{kg}}{2.20\text{ lb}}$ ***so use like this:*** $164\ \cancel{\text{lb}} \times \frac{1\text{ kg}}{2.20\ \cancel{\text{lb}}} = 74.5\text{ kg}$

Step 3: Round your calculator answer using the multiplication/division rule (the calculator answer for the above division = 74.545454 kg, but the rounded answer to 3 SF is 74.5 kg – why 3 SF? Because your original measured number (164 lbs) has 3 SF!

UNIT CONVERSION PROBLEMS (show all work and be sure to ALWAYS USE UNITS). The equalities/conversion factors needed are given above or in the metric system prefixes in Part 1.

1. 333 mL is how many quarts (1 qt = 946 mL) ?

2. 0.2450 meters is how many centimeters?

Hint: Answer should be rounded to 4 sig figs because 0.2450 m has 4 sig figs

3. If a person weighs 68.2 kg, how many pounds (lbs) is that?

Hint: Don't forget to round to the correct number of significant figures.

4. If 1 inch = 2.54 cm, how many cm (centimeters) are there in 239 inches?

5. Convert 15.0 inches to meters.

Hint: Requires 2 conversion factors (inches to centimeters and centimeters to meters).

6. If an object has a mass of 3500. mg, what is its mass in kg?

Hint: This is a metric to metric conversion. Since there is not one equality that relates mg to kg, you should use the base unit of grams as a bridge: convert mg →g, then g→ kg.