Name ___________________

Human Physiology
Biological Measurements and Conversions Lab

Introduction: Science is quantitative in nature; therefore, the use of measurement and mathematical conversions is crucial for biological research and many biological methods and techniques.

Scientific Notation: Scientific notation is a concise way of expressing relatively large or small numbers. A number is expressed in scientific notation when it has the formula:

$$X \cdot 10^N, \text{ where } X \geq 1 \text{ and } X < 10; \text{ where } N = \text{integer}$$

The presence of a relatively large number of zeros at the beginning or ending of a number serves to indicate the position of the decimal point. For example, Avogadro's Number is written as 6023 + 20 additional zeros (602300000000000000000000): the decimal follows the last zero. This number is more efficiently presented as $6.023 \text{ X } 10^{23}$, that is, the decimal point has been moved 23 places to the left. A nanogram is equivalent to one billionth of a gram (g) or 0.000000001 g; however, it is more efficient to express this number as $1 \text{ X } 10^{-9}$ g. In this example, the decimal point is moved nine places to the right.

Answer the following questions:

1. Assume that the hydrogen ion concentration of a solution is 0.00000652 moles/liter. Express this concentration in scientific notation. _____________
2. The human body contains an average of 56,200 milliliters of fluid. Express this volume in scientific notation. _____________
3. The diameter of a molecule that measures 0.0000000039 centimeters is expressed in scientific notation as ______________.
4. The average distance to the sun is 97,333,000 miles. Express this in scientific notation. _____________

Prefixes: A prefix denotes a specific quantity of a unit. For example, the prefix micro-, symbolized by the Greek letter m, refers to one millionth or 1/1,000,000 or $1 \text{ X } 10^{-6}$ meter, and a mg (microgram) is 1/1,000,000 or $1 \text{ X } 10^{-6}$ gram. Other prefixes of interest are included in the following table:

Table 1. Metric prefixes

prefix	Abbreviation	Exponent
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
hecto	h	10^{2}
deka	da	10^{1}
Meter/Liter/Gram		**1**
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	µ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}

How to read this chart: 1 kilogram (kg) = 1,000 grams (g)
1 microliter (µL) = 1X 10^{-6} L or 0.000001 liters (L)
10 millimeters (mm) = 1.0 centimeter (cm)
1 micrometer (µm) = 1 X 10^{-6} m or 0.001 mm
1 nanometer (nm) = 1 X 10^{-9} m or 0.001 µm

Conversion Factors: The metric system is the system of measurement used in science and in most countries of the world. If you are unfamiliar this system, you must practice to become comfortable with its use. When converting between these systems of measurement, the following conversion factors can be used:

Table 2. Equivalents

Length	**1 in = 2.54 cm** 1 m = 39.37 in 1 yd = 91.44 cm 1 yd = 3 feet 1 yd = 36 in 1 ft = 30.48 cm 1 ft = 12 in 1 mi = 5,280 ft	Weight	**1 kg = 2.2 lb** 1 g = 0.035 oz 1 mg = 0.015 grain 1 ton = 2,000 lb 1 metric ton = 1,000 kg = 2,205 lb 1 lb = 0.454 kg 1 oz = 28.35 g 1 grain = 64.8 mg 1 kg = 1 L	Volume	1 gal = 3.785 L 1 quart = 0.946 L 1 pint = 473.2 mL 1 oz = 29.57 mL 1 teaspoon = 5 mL 1 tablespoon = 15 mL 1 L = 1 kg 1 mL = 1 cc

You are expected to know that 1 inch = 2.54 cm and 1 kg = 2.2 lbs. I will not give you these conversion factors.

In some instances you can create your own conversions - for example:

1 milliliter (mL) = 0.001 liter (L) or 1 X 10^{-3} L ------>1 L = 1000 mL

1 µm = 0.000001 meter (m) or 1 X 10^{-6} m ------------>1,000,000 µm = 1 m

1 nm = 0.001 µm or 1 X 10^{-3} µm ---------------------->1,000 nm = 1 µm

Table 3

Conversion	Formula
From °F to °C	(X°F – 32)/1.8
From °C to °F	(X°C X 1.8) + 32

When you do math problems you need to carry your answer 2 places past the decimal point or the answer will be counted wrong. For example: 17.02347g = 17.02 g and 8.137436L = 8.14L.

When you do math and/or conversions problems you need to carry your units throughout the problem. I will take off if you do not carry your units through the entire calculation.

Logarithms: The logarithm of a number is the power or exponent to which a base number must be raised to obtain that number. The base number used in many calculations is ten. Logarithmic tables or calculators can be used to find the logarithm of a number.

The logarithm of 100 is 2 because the base number, 10, must be raised to the second power to obtain 100, that is, $10^2 = 100$.

The logarithm of 1000 is 3 because the base number, 10, must be raised to the third power to obtain 1000, that is $10^3 = 1000$.

Half Life: Half-life is defined as the time required for the nuclei of the atoms in a radioactive element to decay (i.e. change proton number) into another element. For example, the radioactive isotope ^{13}N has a half-life of 10 minutes. The most common isotope of uranium, ^{238}U, has a half-life of 4.5 billion years. ^{14}C is a radioactive form of carbon that decays into ^{14}N. When an organism is alive, it uses carbon to build organic molecules. Some of the carbon will be ^{12}C and some will be ^{14}C. The ratio of ^{12}C to ^{14}C is fairly constant in all organisms. When organisms die, the ^{14}C begins to decay. It takes 5,730 years for 50% of the ^{14}C to decay into its non-radioactive form. For each remaining unit of 5,730 years, 50% of the remaining ^{14}C decays. By comparing the ratio of ^{14}C to ^{12}C within organic fossil remains, the age of the object can be determined (up to a limit of about 50,000 years for this isotope). For example, if the ratio of ^{14}C to ^{12}C is 50% of that contained in present day living organisms, the age of the fossil organism is determined to be 5,730 years.

Estimate the age of organic remains that contain 12.5% of the ^{14}C contained in present day organisms.

The answer is 17,190 years. Solution=

X= 100% of ^{14}C

↓ } 5,730 years

50% of X

↓ } 5,730 years

25% of X (50% of 50%)

↓ } 5,730 years

12.5% of X (50% of 25%)

Measuring: The quantitative nature of science requires measurements of length, volume, and mass.

- **Length** - The meter is the standard unit of length in the metric system. A meter = 39.37 inches. A meter also equals 1000 millimeters (mm).

The SI unit for length is the **meter (m)**. A meter is a little longer than a yard.

1. Using a tape measure, measure your height in inches and record in Table 3.
2. Convert your height into centimeters (cm) (1 inch = 2.54 cm).
3. Fill in the remainder of the chart using information on prefixes from Tables 1 and 2.

Station 1.

Table 4. Length conversions of height. Please show work for your calculations.

Unit	Your height measurement
inches (in)	
centimeters (cm)	
meters (m)	
Kilometers (km)	
millimeters (mm)	
micrometers (µm)	

- **Volume** - several types of glassware are used to measure volumes of liquids. Described below are some common pieces of glassware used in biological science.
  - **Graduated cylinders, Erlenmeyer flasks, and beakers** - Graduated cylinders and Erlenmeyer flasks are calibrated, such that a known volume of liquid can be delivered. A one liter cylinder or flask is often marked in 10 or 100 ml increments, respectively. Beakers are also graduated in appropriate increments. Due to the cohesive and polar characteristics of water molecules, water tends to "climb" up the walls of the containing vessel. As this happens, the liquid surface takes on a "∪" shape. The extent of this "∪" depends on the diameter of the containing vessel. The "∪" is steeper in containers with a narrow diameter and less steep in containers with a large diameter. The liquid level is read at the **meniscus** or the bottom of the "∪".
  - **Volumetric flasks** - These vessels have only one graduation mark: fluid is added until the meniscus is exactly even with this mark. This determination should be done when your eyes are directly in line with the meniscus, that is, do not orient your eyes such that they are above or below the meniscus. Volumetric flasks are designed to hold an exacting amount of fluid; thus, they are more accurate than graduated cylinders, flasks, or beakers. Volumetric flasks have the disadvantage of delivering only a specific quantity of fluid, whereas, a graduated cylinder or flask can deliver many different volumes of fluid.

    Examples of 100 ml, 500 ml, and 1000 ml volumetric flasks will be available for your inspection.

You will observe six demonstration vessels to determine the liquid level in each.

Station 2.

Table 5. Volumes and Vessels

	Volume	Type of Vessel
#1		
#2		
#3		
#4		
#5		
#6		

Station 3.

- **Mass.** Mass is how much matter an object contains. The unit for mass is the kilogram **(kg)**. There are about 2.2 pounds in a kilogram. A common method for measuring mass in a laboratory is to use a balance.

To use the electronic balance, follow these steps:

- Turn the balance on by pressing the "On" button to your left.
- Place your sample on the round metal tray on the top of the balance.
- Wait until the digital read-out stabilizes and record the value.
- To turn the balance off, press and HOLD the "On" button.

Table 6. You will weigh 5 different objects with each scale and then convert this mass to mg, kg, and µg.

Object	Mass	Rubber stopper	Scissor	Mallet	Metal ring	Test tube holder
Weight with Electronic Scale	in grams					
	in mg					
	in kg					
	in µg					
	in oz					

<u>Problems and Measurements:</u> Answer the following questions. Show work.

1. The half life of drug A is 36 hours. If you take 736 mg of the drug, how long will it take (in hours) to reach 92 mg?

2. The half life of drug B is 7 hours. How much of a 35 mg sample of this drug remains after 21 hours?

3. The half-life of drug C is 4 days. What was the original weight of a sample of this drug if 0.0500 g remains after 16 days?

4. The half-life of drug D is 8 days. If you start with a 1.7 g sample of drug D how many half lives will it take to get a 0.2125 g of the sample?

5. If you consume 0.00506 lb of a medication in one month, how many milligrams of this medication are you consuming daily? Assume 30 d/mo.

6. Diabetes insipidus, an abnormal condition in humans, can result in a urine output of 3.87 gallons per day. What is this volume expressed in liters?

7. During summer, oxygen concentration in lakes is influenced by both water depth and water temperature. You monitor oxygen concentration at a depth of 1.25 yards where the water temperature is 62 ^{o}F. What are these values in cm and ^{o}C?

8. When cruising at 37,400 feet in a jet airplane, what is your altitude in km?

9. While fishing, you land a striped bass that weighs 5.2 lbs. What is this weight in grams?

10. Draw a 100 ml graduated cylinder such that each major graduation represents 20 ml. Draw a meniscus at 63 ml.

Abbreviation	Meaning
ad lib	freely; as much as is wanted
BID	twice a day
caps	capsules
h	hour
SID	once a day
QID	four times a day
tab	tablet
TID	three times a day
Per Os or PO	by mouth

11. A 30-year old, 195 pound man presented with swelling of his left lower leg. He had recently returned from Indonesia. Lab results showed he had elephantiasis caused by the parasite *Brugia malayi*. The treatment of choice is doxycycline at 7 mg/kg BID. How much doxycycline will the patient need per dose?

But doxycycline has a maximum dosage of 100 mg/dose and a maximum of 2 100 mg doses a day. Now back to our patient.
If the treatment is 100 mg/dose, BID for 8 weeks what's the total amount of the drug (in grams) that the patient needs?

If the medication comes as 100 mg tablets, how many tablets will he need for the entire treatment?

If each tablet costs $0.16, how much will it cost to treat this condition for the entire course of the medication?

If the half life of this drug is 12 hours, how long (in hours) after the last dose will it take for him to reach 6.25 mg in his body?

Fig 14.10 in your text shows a patient with severe elephantiasis.