Bio 210A
Scientific Units of Measurement & Conversion Worksheet

Principle or Rationale:
Scientific measurements are made and reported using the metric system and conversion between different units is an integral part of scientific measurement and data analysis.

Reference table of common prefixes and scientific units of measurement:

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Decimal Equivalent</th>
<th>Exponent Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hecto- (h)</td>
<td>100</td>
<td>10^{-2}</td>
</tr>
<tr>
<td>Kilo – (k)</td>
<td>1000</td>
<td>10^{-3}</td>
</tr>
<tr>
<td>Deca - (d)</td>
<td>10</td>
<td>10^{-1}</td>
</tr>
<tr>
<td>Meter, Liter, or Gram</td>
<td>1</td>
<td>10^{0}</td>
</tr>
<tr>
<td>Centi – (c)</td>
<td>1/100 or 0.01</td>
<td>10^{-2}</td>
</tr>
<tr>
<td>Milli – (m)</td>
<td>1/1000 or 0.001</td>
<td>10^{-3}</td>
</tr>
<tr>
<td>Micro – (µ)</td>
<td>1/1000000 or 0.000001</td>
<td>10^{-6}</td>
</tr>
<tr>
<td>Nano – (n)</td>
<td>1/1000000000 or 0.000000001</td>
<td>10^{-9}</td>
</tr>
</tbody>
</table>

In science, and increasingly in other fields, the International System of units (metric system) is universally used. The scientific unit of measurement for length and distance is a meter (m), for volume a liter (l), and for mass or weight a gram (g). The prefixes are added to the unit to represent the size of measurement prefixes. The meter is used as an example below and the same applies to units of volume and weight. In descending order,

1 meter (m) = 100 centimeters (cm) = 1000 millimeter (mm) = 1000,000 micrometer (µm) = 1,000,000,000 nanometer (nm)

Note that 1 meter (m) = 100 centimeters (cm) can also be represented as the conversion factor which can be used for any conversion between the two units.

\[
\frac{1 \text{ meter (m)}}{100 \text{ centimeter (cm)}} = \frac{1 \text{ m}}{100 \text{ cm}}
\]

For example, to calculate how many meters are present in 20 cm, written as 20 cm = ? m, you multiply 20 by the conversion factor, in this way

\[
20 \text{ cm} \times \frac{1 \text{ m}}{100 \text{ cm}} = 2 \text{ m}
\]

Note that as 1 meter (m) = 100 centimeters (cm) when you convert a quantity less than 100 centimeters to meter the answer is <1 since a centimeter is a smaller unit than a meter.

The same conversion factor is used to calculate how many centimeters are present in 20 meters, written as 20 m = ? cm, in this way:

\[
20 \text{ m} \times \frac{100 \text{ cm}}{1 \text{ m}} = 2000 \text{ cm}
\]

and when you convert from meter to centimeter the answer is >1 since a meter is a larger unit than a centimeter.
Follow the example presented above and demonstrate your understanding of conversion of units by answering the questions in the Scientific Units of Measurement & Conversion sheets.

**Scientific Units of Measurement & Conversion sheet**

I. Conversion of Units

A. Fill in the spaces in the following table with the symbols, conversion factor, and calculation, as appropriate

<table>
<thead>
<tr>
<th></th>
<th>Symbols</th>
<th>Conversion</th>
<th>Solve (Showing your calculation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meter to centimeter</td>
<td>m to cm</td>
<td>multiply by 100 cm/1 m</td>
<td>0.5 m = cm</td>
</tr>
<tr>
<td>Centimeter to meter</td>
<td>cm to m</td>
<td>multiply by 1 m/100 cm</td>
<td>50 cm = m</td>
</tr>
<tr>
<td>Centimeter to millimeter</td>
<td>cm to mm</td>
<td>multiply by 10 mm/1 cm</td>
<td>0.2 cm = mm</td>
</tr>
<tr>
<td>Millimeter to centimeter</td>
<td>mm to cm</td>
<td>multiply by 1 cm/10 mm</td>
<td>20 mm = cm</td>
</tr>
<tr>
<td>Millimeter to micrometer</td>
<td>mm to μm</td>
<td>multiply by 1000 μm/1 mm</td>
<td>5 mm = μm</td>
</tr>
<tr>
<td>Micrometer to millimeter</td>
<td>μm to mm</td>
<td>multiply by 1 mm/1000 μm</td>
<td>50 μm = mm</td>
</tr>
<tr>
<td>Micrometer to nanometer</td>
<td>μm to nm</td>
<td>multiply by 1000 nm/1 μm</td>
<td>50 μm = nm</td>
</tr>
<tr>
<td>Nanometer to Micrometer</td>
<td>nm to μm</td>
<td>multiply by 1 μm/1000 nm</td>
<td>5 nm = μm</td>
</tr>
</tbody>
</table>

B. Figure out how many micrometers are present in 1 meter by solving the following 1 m = ??? μm equation. You can do so by systematically sequentially converting from one unit to the next until you learn it and no longer have to do it the long way.

If you know that

\[
\begin{align*}
1 \text{ m} & = 100 \text{ cm} \\
1 \text{ cm} & = 10 \text{ mm} \\
1 \text{ mm} & = 1000 \text{ μm}
\end{align*}
\]

then

\[
1 \text{ m} \times 100 \text{ cm} \times 10 \text{ mm} \times 1000 \text{ μm} = 1,000,000 \text{ μm or } 10^6 \text{ μm}
\]

C. Calculate how many nanometers are present in 1 meter. (Show your calculations)
II. Scientific Conversions Practice & Applications
A. Use the reference table of common prefixes and scientific units of measurement to make the appropriate volume conversions in this table (show your calculations in the space provided in each box)

| 500 µL = | mL | 20 µL = | mL |
| 0.6 mL = | µL | 100 µL = | mL |
| 240 mL = | L  | 0.1 L = | mL |

B. Everyday applications
1. Your doctor prescribed eye drops for you to treat a certain condition. You obtain the eye drop liquid medication in a small bottle containing a total volume 20 ml. Your instructions were to apply 2 drops in each eye at night. Given that the volume of 1 drop is 0.05 ml. Calculate many days will the eye drop liquid medication last?
   Key: start by calculating how many drops are present in 1 ml

2. Your friend needs your help! He or she were prescribed a medication, in pill form at 20 milligram (mg), to be taken once per day. The pharmacy carried the medication only in solution form at 40 milligrams per milliliter (mg/ml). Answer the following questions showing your calculations:
   a. How many milliliters does he/she need to take every day?
   b. Based on your calculation of the number of drops per milliliter (in the previous question) how many drops would that be?
      ________________.

III. Conversions between the American/English and the Metric units of measurement
A. Measurement of Weight or Mass
In contrast to the American/English unit of the **pound** (lb) consisting of 16 **ounces** (oz), the **gram** with its 10-fold subdivisions and multiples the unit of measurement in the metric system, as shown in the reference table above.

It is very useful to remember that **one kilogram (kg) = 2.21 pounds (lb)**

1. Use this relationship to calculate your weight from the American to the Metric system. Or from the Metric to the American system, as applicable.
   a. Enter your weight in the units that you know: _________ (lb or kg)
   b. Calculate your weight in the opposite units, showing your calculations:

2. Apply your understanding of the difference between the American and Metric units of weight measurement using the following scenario:
   **Your normally weigh 160 lbs and you have been traveling abroad on a one month trip to Europe experiencing the variety of attractions and enjoying the local food, and drinks using public transport systems and walking around. At the end of the trip you weigh yourself in Europe using a scale that shows your weight to be 72.3kg. Have you added or lost weight over that month? (Show you calculation and reasoning!)**

B. **Measurement of Height or Length**

In contrast to the American/English unit of the **foot** (ft) consisting of 12 **inches** (in), the **meter** with its 10-fold subdivisions and multiples the unit of measurement in the metric system, as shown in the reference table above.

It is very useful to remember that **1 inch (in) = 2.54 centimeter (cm)**

1. Use this relationship to calculate your weight from the American to the Metric system. Or from the Metric to the American system, as applicable.
   a. Record your height in the units that you know: ___’ ___” i.e. ___ ft ___ ins or _______ m
   b. Calculate your height in the opposite units, showing your calculations:
      *Remember that you need to convert your height in feet into inches first (1 ft = 12 inches) and to calculate your total height in inches first.*

C. **Measurement of Liquid Volume**

In contrast to the American/English units of the **gallon** (gal), **quart** (qt), **pint** (pt), and **cup** (cp), the **liter** (L) with its 10-fold subdivisions and multiples the unit of measurement in the metric system, as shown in the reference table above.
It is very useful to remember that 1 gallon (gal) = 4 quarts (qts), 1 quart (qt) = 2 pints (pts), 1 pint (pt) = 2 cups (cp), and 1 cup (1 cp) = 8 fluid ounces (fl oz) and that 1 gallon (gal) = 3.79 Liters (L) or that 1 pint (pt) = 0.474 Liters (L).

Use the above relations to determine the following, showing your calculations:

1. the number of pints within a gallon

2. the number of cups within a gallon

3. the volume of liquid coffee in 1 cup

D. Measurement of Temperature
In contrast to the customary use in the US of the Fahrenheit scale to measure temperature in degrees Fahrenheit (°F) by non-scientists, the Celsius scale is used instead by biological scientists to measure temperature in degrees Celsius (°C). The two scales are linearly correlated with the freezing temperature of water at 0 °C corresponding to 32 °F and the boil temperature at 100 °C corresponding to at 212 °F.

To convert temperature from Fahrenheit to Celsius the following conversion formula is used

\[ °C = \frac{5}{9} (°F - 32) \quad \text{or} \quad °C = 0.55 (°F - 32) \quad \text{or} \quad °C = \frac{1}{1.8} (°F - 32) \]

For example, if you want to know a temperature of 55 °F is equivalent to how many °C, you start by subtracting 32 from 55 °F as in 55-32 = 23, then multiply the answer by 5/9 or 0.55 as in 23 x 0.55 = 12.78 °C

On the other hand, to convert temperature from Celsius to Fahrenheit the following conversion formula is used

\[ °F = \frac{9}{5} °C + 32 \quad \text{or} \quad °F = 1.8 °C + 32 \]

For example if you wanted to know a temperature of 40 °C is equivalent to how many °F, you start by multiplying 40 °C by 9/5 or 1.8 as in 40 X 1.8 = 72, then add 32 to the answer, as in 72 + 32 = 104 °F

1. Calculate your body temperature in Celsius, given that the normal human body temperature is 98.6 °F.

2. On your one month long trip to Europe, the temperature was 24 °C. What was that temperature in °F? (Show your calculations!)