Units of Measurement and the Metric System

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Objective:

To use metric system units of measurement in laboratory procedures and in problem solving, at the level of 85% proficiency for each student.

In order to achieve this objective, you will need to be able to:

1. Name the major metric units and their abbreviations for length, volume, and mass.
2. Define and use: kilo-, deci-, centi-, milli-, micro-, and nano-.
3. Recall how many inches in a m, cm in an inch, mL in a fluid ounce, liters in a quart, pounds in a kg, and mm in a cm.
4. Convert between the following: m, cm, mm, µm, nm.
5. Convert between the following: L, dL, mL, µL, nL.
6. Convert between the following: kg, g, mg, µg, ng.

Materials

Group Supplies:

Meter stick
Millimeter ruler
50 mL beaker
10 mL graduated cylinder

Lab Supplies:

Balance
Water
Paper clips
Pencils

Methods and Results

Making conversions:

1. Fill in the basic unit of metric measurement and their standard abbreviations:

	Name of Unit	Abbreviation
length	meter	m
volume (liquid)	liter	L
mass	gram	g
temperature	Celsius	C
food energy	calorie	cal

2. Fill in the prefixes and their abbreviations:

	Prefix	Abbreviation
One Million	mega	M
One Thousand	kilo	k
One Hundred*	hecto*	h
Ten*	deka*	da
One-Tenth	deci	d
One-Hundredth	centi	c
One-Thousandth	milli	m
One-Millionth	micro	μ
One-Billionth	nano	n

*Not commonly used

3. Write these numbers in decimal form and in scientific notation:

	Decimal	Scientific Notation
One Million	1000000.	1×10^{6}
One Thousand	1000.	1×10^{3}
One Hundred	100.	1×10^{2}
Ten	10.	1×10^{1}
One-Tenth	0.1	1×10^{-1}
One-Hundredth	0.01	1×10^{-2}
One-Thousandth	0.001	1×10^{-3}
One-Millionth	0.000001	1×10^{-6}
One-Billionth	0.000000001	1×10^{-9}

Taking metric measurements:

1. Measure and record the dimensions of your textbook, in centimeters; then convert your units to millimeters; then convert the units to inches. Be sure to show what conversion factor you used each time

Textbook dimensions	centimeters	cm to mm convert by:	millimeters	cm to inches convert by:	inches
Length	25	$\times \frac{10\text{ mm}}{\text{cm}}$ OR by: $\times \frac{1\text{ mm}}{0.1\text{ cm}}$	250	$\times \frac{0.3937\text{ in}}{\text{cm}}$ OR by: $\times \frac{1\text{ in}}{2.54\text{ cm}}$	9.84
Width	15		150		5.91
Thickness	1.5		15		0.59

2. Each student should use the balance provided to weigh each of the objects listed. If the object is not out you need to find it in the room. Record the weights in grams; then convert the units to kilograms:

	Weight in grams	Convert by:	Weight in kilograms
paper clip	0.5	$\times \frac{0.001\text{ kg}}{\text{g}}$ OR by: $\times \frac{\text{kg}}{1000\text{ g}}$	0.0005
1 pc notebook paper	2		0.002
a 50 mL beaker	20		0.020
a pencil or pen	5		0.005
a 10 mL graduated cylinder	50		0.050
10 mL of water	10		0.010

3. Reorganize the following sets of units in descending (largest to smallest) order by placing the appropriate letter in order in the boxes provided:

   a. A =1 mL; B = 25 mL; C = 5 dL; D = 250 mL; E =1.2 L; F = 50 mL
   500 mL 1200 mL

E	C	D	F	B	A

b. A =1 mL; B = 2 fl oz; C = 3 L; D = 0.5 gallons; E = 0.75 pints; F = 2 tsp
60 mL 3000 mL 1893 ml 355 mL ~10 mL

C	D	E	B	F	A

c. A = 2.3 lbs; B = 5 oz; C = 30 kg; D = 310 grams; E = 0.025 tons
1.0433 kg 0.1417 kg 0.310 kg 22.68 kg

C	E	A	D	B

Additional Work with Metrics:

1. Convert these numbers as indicated. Show your work including conversion factors and units (the first one has been done for you):

From:	Convert to:	show your work:	Answer
0.45 L	mL	0.45 L x (1000 mL / L) = $0.45\ \text{L} \times \frac{1000\ \text{mL}}{\text{L}} =$	450 mL
1250 mL	L	1250 mL x (L / 1000mL) =	1.25 L
0.065 mg	g	0.065 mg x (g / 1000 mg) =	0.000065 g
3.7 km	m	3.7 km x (1000 m / km) =	3700 m
120 cm	km	120 cm x (km / 100,000 cm) =	0.0012 km
3.6 kg	g	3.6 kg x (1000 g / kg) =	3600 g
670 cm	m	670 cm x (m / 100 cm) =	6.7 m
1250 g	kg	1250 g x (kg / 1000 g) =	1.25 kg
0.15 L	mL	0.15 L x (1000 mL/ L) =	150 mL
120 mm	cm	120 mm x (cm / 10 mm) =	12 cm
627 L	mL	627 L x (1000 mL / L) =	627,000 mL

2. You have to give your dog medicine at a dose rate of 1.5 mg of medicine per kg of the dog's weight. The dog weighs 50 lbs. How much medicine should you give him? (Show your work.) 50 lbs / 2.2046 lbs / kg = 22.68 kg x 1.5 mg / kg = 34.02 mg

Answer: 34.02 mg

3. You have a fever and your temperature is 102 degrees Fahrenheit.
   a. What is your temperature in degrees Celsius? 102 - 32 = 70 x 5/9 =38.89
   b. When your temperature returns to normal (98.6 degrees F) what is your temperature in Celsius? (Show your work.) 98.6 – 32 = 66.6 x 5/9 = 37

a. Answer: 38.89 C

b. Answer: 37 C

4. You have a friend who is 74 inches tall. How tall is your friend: (Show your work)

   a. in centimeters?

Answer: 187.96

74 in x 2.54 cm / in

   b. in millimeters?

Answer: 1879.6 mm

74 in x 25.4 mm / in

   c. in meters?

Answer: 1.8796 m

74 in x 0.0254 m / in

Table of Metric and English Equivalents and English Conversions for Common Measurements.

Quantity	Metric Unit	Symbol	Metric equivalent	English equivalent	English conversion
Length	kilometer	km	1000 m		
	meter	**m**	1 m	1.0936 yds	1 yd = 0.9144 m
	decimeter	dm	0.1 m		
	centimeter	cm	0.01 m	0.3937 in	1 in = 2.54 cm
	millimeter	mm	0.001 m		
	micrometer	µm	0.000001 m		
	nanometer	nm	0.000000001 m		
Area	**square meter**	**m^2**		10.7639 ft^2	1 ft^2 = 0.0929 m^2
	square centimeter	cm^2	0.0001 m^2		
Volume	cubic meter	m^3	1000 L		
	liter	**L**	1 L	1.0567 qt	1 qt = 0.94635 L
	deciliter	dL	0.1L		
	cubic centimeter	cm^3	0.001 L		
	milliliter	mL	0.001 L	0.0338 fl oz	1 fl oz = 29.5735 mL
					1 tsp = 4.9289 mL
	microliter	µL	0.000001 L		
	nanoliter	nL	0.000000001 L		
Mass	kilogram	kg	1000 g	2.2046 lb	1 lb = 0.4536 kg
	gram	**g**	1.g	0.0353 oz	1 oz = 28.3495 g
	gram	**g**	1 mL water @ 4 ºC		
	milligram	mg	0.001 g		
	microgram	µg	0.000001 g		
	nanogram	ng	0.000000001 g		
	picogram	pg	0.000000000001 g		
Energy	**celsius**	ºC		(5/9) x (F - 32)	F = ((9/5) x C) + 32
	calorie	cal*	4.186 joules		
	Calorie**	Cal	4.186 kilojoules		

*amount of heat energy required to raise 1 mL of water by 1 ºC
**Also known as a kilocalorie (kcal)

Discussion:

1. Explain the importance of the metric system in medicine.
2. Explain the meaning of the prefixes kilo(k)-, deci(d)-, centi(c)-, milli(m)-, micro(μ)-, and nano(n)-.
3. Explain how to convert a metric unit with one prefix into the same metric unit with another prefix. (For example, explain how to convert 1 dL to __mL.)