EXERCISE 1

Metric Measurement & Scientific Notation

LEARNING OBJECTIVES

- Writing numbers in scientific notation.
- Use of the metric system to measure length, mass, volume and temperature.
- Conversion of metric units.
- Use of basic lab apparatus used for measurement

INTRODUCTION

Science is the process of knowing and scientists are constantly making observation and making measures to gain knowledge and describe various features of the world around us. Measurements allow us to understand the relative size of structures. The metric system is the universal measurement system used in all fields of science and is used to measure length, mass, volume and temperature. Before we go on to the metric system let us first look at scientific notation.

SCIENTIFIC NOTATION

Scientific notation is a clear and concise way of writing very large or very small, cumbersome numbers that have many zeros. For example the distance from the earth to the sun is 149,600,000 kilometers and the size of a bacterial cell such as *E. coli* is 0.000000002 kilometers. Scientific notation allows us to write these numbers in a much neater form. It is made up of one non-zero number before the decimal point and multiplied by 10 (called the base), raised to a certain power (called the exponent). An example of a number written in scientific notation is 1.25×10^4.

To write 149,600,000 km in scientific notation, we must first move the decimal point 8 places to the left to obtain 1.496. (Note that where there is no decimal point, it is understood that it is after the last digit of the number). Every time the decimal point is moved one place to the left, we are dividing by 10, so moving it 8 places means we have divided by 100,000,000 or 10^8. Therefore in order to preserve the original value of the number it must be multiplied by 10^8 and will be written in scientific notation as 1.496×10^8. The exponent is the number of places moved. To write 0.000000002 the same principle applies but this time the decimal point has to be moved 9 places to the right. Moving the point to the right means we are multiplying by 10^9. Therefore in order to preserve the original value of the number it must be divided by 109, hence it will be written as 2.0×10^{-9} in scientific notation.

General Rule: Move the decimal point enough places so that **one non-zero number** is **in front of** the decimal point. The **exponent** is the **number of places moved**. The exponent is **positive** when moved to the **left** and **negative** when moved to the **right.**

Write the following numbers in scientific notation.

1) 800,000 ___________ 2) 123,000,000 ___________ 3) 0.00067 ___________

4) 0.00000000592___________ 5) 45,9000 ___________ 6) 0.0000732 ___________

Write the number represented by scientific notation.

7) 2.98×10^5 ___________ 8) 5.71×10^{-4} ___________ 9) 6.7×10^{-8} ___________

10) 3.9×10^3 ___________ 11) 2.56×10^2 ___________ 6) 8.24×10^4 ___________

METRIC SYSTEM CONVERSIONS

One of the greatest advantages of the metric system is the ease of conversion. It is a decimal system of measurements and so it is easy to convert from one unit to the next either by multiplying or diving by 10 or multiples of 10. This means that converting between units requires only the movement of decimal places. The metric units for length, mass, and volume are meters, grams, and liters, respectively. The same prefixes are used for all units. For example, the prefix kilo denotes 1,000; 1 kilometer = 1000 meters, 1 kilogram = 1000 grams, and 1 kiloliter = 1000 liters. Table 1 lists some common metric prefixes and their values.

Table 1 – Metric System Conversions.

Prefix	Symbol	Value	Exponential equivalent (scientific notation)
Giga	G	1,000,000,000	10^9
Mega	M	1,000,000	10^6
Kilo	K	1,000	10^3
Hepta	H	100	10^2
Deka	D	10	10^1
Meter, liter, gram	m, l, g	1	10^0
Deci	d	0.1	10^{-1}
Centi	c	0.01	10^{-2}
Milli	m	0.001	10^{-3}
Micro	µ	0.000001	10^{-6}
Nano	n	0.000000001	10^{-9}

To convert from one metric unit to another subtract the exponents, i.e.(the ***from*** exponent **minus** the ***to*** exponent) . For example to convert from Kg to mg:

Kg $=10^3$ mg = 10^{-3} $^{3-}$ $(^{-3}) = {}^6$

The difference between the exponents determines how many places the decimal will be moved. If you are converting from a larger metric unit to a smaller metric unit the difference between the exponents will be positive. Therefore the decimal point is moved to the right. So to convert from 65 kg to mg, the decimal point is moved six places to the right. The result will be 65, 000, 000 mg.

If you are converting from a smaller metric unit to a larger metric unit the difference between the exponents will be negative. Therefore the decimal point is moved to the left.

For example, to convert from 97 Kg to Mg: Kg = 10^3 Mg = 10^6 ^{3}-(^{6}) = $^{-3}$

The point is moved three places to the left. The result is 0.097Mg

Another example: To convert from 853 µg to cg: ug =10^{-6} cg = 10^{-2} $^{-6}$-($^{-2}$) = $^{-4}$

The point is moved four decimal places to the left. The result will be 0.0853 cg.

Complete the following metric conversions.

13) 28nm = ___________ mm 14) 462g = ___________ kg 15) 51ml = ___________ kl

16) 8dm = ___________ m 17) 9837 kg = ___________ mg 18) 36 mm = ___________ dm

19) 6Gm = ___________ m 20) 1763nm = ___________ cm

METRIC MEASUREMENTS (LENGTH)

The metric unit for measuring **length** is the **meter**. In this exercise, you will measure the length of various objects.

Procedure

1. Measure the length of the following objects in the units indicated:

Your index finger (cm)	
Diameter of a penny (mm)	
Height of your lab partner (m)	

2. Area is calculated by multiplying the length x width. Measure the length and width of your driver's license in centimeters and the lab table in meters and find their areas. **Always record the units when you make a measurement**.

	Length	Width	Area
Driver's license			
Lab table			

3. Select three small wooden blocks. Measure the length, width, and height of each block in cm and record those values below. Volume is calculated by multiplying length x width x height. Calculate the volumes of the 3 blocks.

Block #	Length		Width		Height		Volume
1	___________	x	___________	x	___________	=	___________
2	___________	x	___________	x	___________	=	___________
3	___________	x	___________	x	___________	=	___________

METRIC MEASUREMENTS (VOLUME)

Volume is typically measured in units termed **liters**. However it can be measured in cubic centimeters (cm^3 or cc). One cubic cm equals 1 milliliter. (1cm^3 or cc = 1ml.)

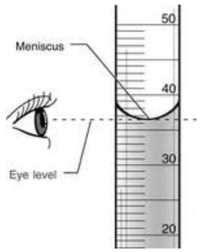
Procedure

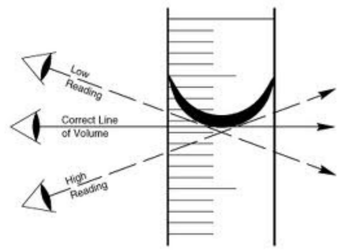
1. Using the data collected in the previous section, calculate the volume of each of the three blocks in ml and record the data below.

Volume of block 1___________ ml block 2 ___________ ml block 3 ___________ ml

Graduated cylinders are used in the laboratory to measure small amounts of liquid.
Obtain 3 graduated cylinders, a beaker, a test tube and a cuvette.

Note: When water is placed into a graduated cylinder or other container, it begins to climb the sides of the container by cohesion and adhesion. Cohesion is the tendency of water molecules to stick to each other and adhesion is the way they cling to the side of the glass container. The water level inside the container is uneven. This is termed the **meniscus**. The correct volume should be read at the lowest margin of the water level.





2. Fill the beaker up to the 200ml mark and pour the water into the graduated cylinder. What is the volume? ___________ . This discrepancy tells us that the beaker can be used to give **approximate** amounts of a liquid. For **accuracy** and precision in the measurement of liquid, the **graduated cylinder** must be used.

3. Use the graduated cylinders to find the volume of the test tube, the cuvette and the completely full beaker.

Test tube	
Cuvette	
Beaker	

Volume of cube-shaped object can be determined by measuring length, width, and height and multiplying these together. The volume of irregularly shaped objects, like a screw, can not be measured in this way. Another technique, known as water displacement, permits volumes of all objects to be calculated.

4. Measure the volume the three irregularly shaped objects using water displacement.

Place some water into the graduated cylinder. Note the amount. This is your initial volume. Gently place the object into the graduated cylinder so that there is no splashing or loss of water. The level of the water will rise. Note the new level. This is your final volume. Subtract the initial volume from the final to get the volume of your object in ml.

	Initial volume	Final volume	Volume of object
Object 1			
Object 2			
Object 3			

METRIC MEASUREMENTS (MASS)

Mass is a measure of the amount of matter that an object has. Mass differs from weight in that weight is the force gravity exerts on an object. Therefore, the mass of an object stays constant, but weight can change if gravity changes. For example, the moon's gravity is roughly 1/6 that of the earth's. A person weight 180 lbs. on earth would weigh 30 lbs. on the moon. Since mass is constant, a person with a mass of 82 kg would have that mass on earth or on the moon.

The **Density** of a material is calculated by the dividing the mass by the volume. **(D=M/V)**

The **mass** is always measured in **grams** and the **volume** in **ml (cc)**.

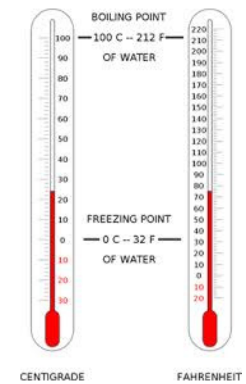
Procedure

1. Using a triple-beam balance, calculate the mass of the three objects indicated.

	Mass (g)	Volume (ml)	Density (g/ml)

METRIC MEASUREMENTS (TEMPERATURE)

Scientists measure temperature using the Celsius or centigrade scale, which is based upon the freezing and boiling points of water. The Fahrenheit scale is not used in science. Water freezes at 0°C (32°F) and boils at 100°C (212°F).



Converting from Fahrenheit to Celsius requires using the following equation:

°C = 5/9 x (°F – 32) or **°C = 0.56 x (°F – 32)**

Converting from Celsius to Fahrenheit requires using the following equation:

°F = (9/5 x °C) + 32 or **°F = (1.8 x °C) + 32**

Procedure

Using the Celsius thermometer provided, measure the temperature of the following and then use the equation above to convert each into Fahrenheit.

	Temp. in Celsius	Temp. in Fahrenheit
Room temperature	______________	______________
Surface of skin	______________	______________
Ice water in beaker	______________	______________
Boiling water	______________	______________
Tap water	______________	______________
Today's temperature	_______________	______________

PRACTICE PROBLEMS

Complete the following problems.

Write the following numbers in scientific notation.

1) 7000 ___________ 2) 51,800___________ 3) 465,000,000 ___________

4) 8,000,000 ___________ 5) 234,000 ___________ 6) 0.000003 ___________

7) 0.0089 ___________ 8) 0.00000239 ___________ 9) 0.0045 ___________

10) 567,000,000 ___________

Write out the numbers represented by scientific notation.

11) 8.0×10^{3} ___________ 12) 4.23×10^{8} ___________

13) 9.21×10^{-4} ___________ 14) 9.27×10^{-9} ___________

15) 1.5×10^{4}___________

Complete the following metric conversions.

16) 4.5 cm ___________ mm 17) 63 kg ___________g 18) 28.6 l ___________ml

19) 1.45 mm ___________ cm 20) 98.2 nm ___________mm 21) 7.8 g ___________ mg

22) 89.2 ml ___________ l 23) 34.8 nm ___________ cm 24) 28.5 cm ___________km

25) 78.9 km ___________ m 26) 30.6 cm ___________ mm 27) 45.0 nm ___________mm

28) 23.8 kg ___________mg 29) 76 ml ___________ l 30) 58.5 g ___________mg

Metric Conversions

Metric to American Standard	**American Standard to Metric**
Length	
1 mm = 0.039 inches	1 inch = 2.54 cm
1 cm = 0.394 inches	1 foot = 0.305 m
1 m = 3.28 feet	1 yard = 0.914 m
1 m = 1.09 yards	1 mile = 1.61 km
Volume	
1 ml = 0.0338 fluid ounces	1 fluid ounce = 29.6 ml
1 L = 4.23 cups	1 cup = 237 ml
1L = 2.11 pints	l pint = 0.474 L
1L = 1.06 quarts	1 quart = 0.947 L
1L = 0.264 gallons	1 gallon = 3.79 L
Mass	
1 mg = 0.0000353 ounces	1 ounce = 28.3 g
1 g = 0.0353 ounces	1 pound = 0.454 kg

1 kg = 2.21 pounds

Temperature

To convert temperature:

$°C = \frac{5}{9}(F - 32)$

$°F = \frac{9}{5}C + 32$