Name: ____ Date: ______________ Period: ________

Unit 1: Nature of Science and Scientific Measurement - Chapter 1

Lesson 2: Measurement Notes

Why metric?

Base Units

Let's discuss →

TABLE 2 **SI Base Units**

Quantity	Base Unit
Time	second (s)
Length	meter (m)
Mass	kilogram (kg)
Temperature	kelvin (K)
Amount of a substance	mole (mol)
Electric current	ampere (A)
Luminous intensity	candela (cd)

Prefixes

TABLE 3 **SI Prefixes**

Prefix	Symbol	Numerical Value in Base Units	Power of 10 Equivalent
Giga	G	1,000,000,000	10^{9}
Mega	M	1,000,000	10^{6}
Kilo	k	1000	10^{3}
–	–	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}
Pico	p	0.000000000001	10^{-12}

Converting from one prefix to another

How can we go from kilograms to grams?

What's larger a kilogram or a gram? What's the exponent for kilogram? What's the exponent for gram? What's the difference in exponents? So how many places are we going to move the decimal? Are going to move it to the right or the left? Why?	<u>Example</u> How many grams are in 456 kilograms?

More examples

Convert 360 m to km

Convert 4800 g to kg

Temperature

Convert the following temperatures

25ºC = __________ºF

198 K = _________ ºC

Which is warmer, 25ºF or 25ºC?

ºC ↔ ºF

$°C = (.56)(°F - 32)$

$°F = (1.8)(°C) + 32$

ºC ↔ K

$K = °C + 273$

$°C = K - 273$

K ↔ ºF

$K = (.56)(°F - 32) + 273$

$°F = (1.8)(K) - 459.67$

Density

Density Equation

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

The density of an object or a sample of matter is equal to its mass divided by its volume.

Examples

<table>
<tr><td>Sean, a high school student, measures the mass of a solid metal object. It has a mass of 350.0 grams. The student also measures the volume of that object and the object has a volume of 129.6 mL. What is the density of the metal object?</td><td>What is the mass of ethyl alcohol that exactly fills a 200.0 mL container? The density of ethyl alcohol is 0.789 g/mL.</td></tr>
<tr><td>Bart finds a shiny object! It has a mass of 124 g and a volume of 6.42 mL. What is the density of the metal object?</td><td>What volume of silver metal will weigh exactly 2500.0 g. The density of silver is 10.5 g/cm^3.</td></tr>
<tr><td colspan="2">A block of lead has dimensions of 4.50 cm by 5.20 cm by 6.00 cm. The block weighs 1587 g. From this information, calculate the density of lead.</td></tr>
</table>

Scientific Notation Notes

General Information

- Scientific notation is used to simplify writing very large or very small numbers.
- Scientific notation can also be used to add zero's that are significant figures to values.
- Scientific notation is expressed by multiplying a decimal by a power of ten (10).
- Numbers expressed in scientific notation with positive exponents are large numbers.
- Numbers expressed in scientific notation with negative exponents are small numbers.

Converting to Scientific Notation

1. Rewrite the original value with the decimal point to the right of the first non-zero number and leave out all of the place holder zero's that were at the front, or back, of the original value.
2. To the right of the number write "x 10", you will write the exponent later. (Do not use "E" notation).
3. Count how many places the decimal point was moved for it to be between the two non-zero numbers furthest to the left.
4. Write the number of places the decimal point was moved as the exponent.
    a. If the decimal point was moved to the left, the exponent should be positive.
    b. If the decimal point was moved to the right, the exponent should be negative.
5. Check the answer: The final value of the value in standard form should be a number between 1 and 9 multiplied by an exponent of ten.

Examples

157,892,200,000 Decimal point is placed behind the 1 and the place holder zero's are dropped. The decimal point was moved 11 times to the left so the exponent is a positive 11. $1.578922 \text{x} 10^{11}$	0.000005407 Decimal point is placed behind the 5 and the place holder zero's are dropped. The decimal point was moved 6 times to the right so the exponent is a negative 6. $5.407 \text{x} 10^{-6}$

Your turn

Write the following in scientific notation:

7,250 0.0025

Converting to Standard From

1. Look at the original value, if the exponent in the scientific notation expression is positive, leave space to the right of the number to add zero's; if the exponent in the scientific notation expression is negative leave space to the left of the number to add zero's.
2. Rewrite your original value with the decimal point and move the decimal point the number of spaces indicated by the exponent.
    a. If the exponent is negative, move the decimal point to the left.
    b. If the exponent is positive, move the decimal point to the right.
3. Add place holder zero's to the front, or end, of the value as necessary.
4. If writing a number smaller than one, you should <u>always</u> write a place holder zero to the left of the decimal point.

Examples

$7.14x10^{8}$	$6.31x10^{-4}$
The exponent is positive, so this is a large number. The decimal point is moved 8 places to the right and 6 place holder zero's are added. 714,000,000	The exponent is negative, so this is a small number. The decimal point is moved 4 places to the right and 3 place holder zero's are added (Plus one in front of the decimal). 0.000631

Your turn
Write the following in standard form

$8.0541x10^{3}$

$1.09x10^{-2}$

Significant Figures

General Information

- The certainty of a measurement is expressed by significant figures.
- Significant Figures are used when you work with measured quantities.
- Significant Figures in a measurement consist of all the digits known with certainty, plus one final digit that is called the estimated digit.

Identification Rules

1. Any digit that is not a zero (0) is significant
2. Zero's between non-zero digits are significant.
    a. Zero's (0's) between non-zero digits are significant.
    b. Zero's (0's) between a non-zero digit and a significant zero are significant.
3. Zero's appearing in front of the first non-zero digit are not significant.
4. If there is no decimal point, zero's that follow the last non-zero digit are not significant.
5. If there is a decimal point, zero's that follow the last non-zero digit are significant.
6. Any zero's that "appear" or "disappear" when converting a number to or from scientific notation are NOT significant.

3.1415	1,004,000
• 5 significant figures. • All numbers are non-zero digits, therefore all are significant figures.	• 4 significant figures. • The 1, the 4, and the two 0's between them are significant. • The three 0's at the end of the number are not significant.

Your turn, underline the significant figures

0.00859 0.00070

0.012500 6.02×10^{23}

General Rounding Rules –

- When counting significant figures start at the left and count to the right.
- If the number immediately to the right of the final Significant Figure is greater than or equal to 5, round UP.
- If the number immediately to the right of the final Significant Figure is less than 5, leave the number as it is.
- Sometimes you will have to use scientific notation to express your answer with the correct number of significant figures.

Round 23,587 to 4 significant figures. The 4th significant figure from the left is the 8, the 7 makes it round up to a 9: 23,590	Round 0.01240978 to 3 significant figures. The 3rd significant figure from the left is the 4, the 0 makes it round down to a 4: 0.0124
Round 102.968.543 to 4 significant figures. The 4th significant figure from the left is the 9, the 6 makes it round up. 103,000,000 only has 3 significant figures, so the answer must be expressed in scientific notation: 1.03×10^8	Round 0.00027043 to 3 significant figures. The 3rd significant figure from the left is the 0 between the 7 and the 4. The 4 makes it round down. 0.000270 has 3 significant figures, but can also be written in scientific notation as 2.70×10^{-4}

Your turn

Round 78.48 to 3 significant figures

Round 40872 to 4 significant figures

Round 40026 to 3 significant figures

Significant Figure Rounding Rules –

- When multiplying or dividing, the answer can have no more significant figures that are in the measurement with the fewest number of significant figures.
- When adding or subtracting, the answer must have the same number of digits to the right of the decimal as the measurement having the fewest digits to the right of the decimal.
- If in doubt, give your answer so that it has the same number of significant figures (or decimal points) as the values with which you start.

0.01956 x 120,765 = ? The first number has 4 significant figures and the second number has 6. The answer should have 4 significant figures: 2362	0.450 ÷ 73.5 = ? The first number has 2 significant figures and the second number has 3. The answer should have 2 significant figures: 6.1
9.853 + 0.001204 = ? The first number has 3decimal points and the second number has 6. The answer should have 3decimal points: 9.854	$1.7 \times 10^{-3} - 9.5 \times 10^{-4}$ = ? The first number has 4 decimal points and the second number has 5. The answer should have 4 decimal points: 8×10^{-4}

Dimensional Analysis

What's dimensional analysis and why is it important to learn?

What's a conversion factor?

<u>Examples</u>

- Ms. McDilda got up early Saturday morning to make sure she got to the Halo Donuts food truck before they sold out. She bought 16 donuts (don't judge, they're really good), how many dozen donuts did she eat, I mean buy, to share, yeah share?

12 donuts = 1 dozen $\frac{12\ donuts}{1\ dozen} = \frac{1 dozen}{12\ donuts}$

- Mr. Testa is going to order pizza for all of Ms. McDilda's chemistry students. If she has 113 students, each student is going to get 2 slices of pizza, and each pizza has 8 slices, how many pizzas should Mr. Testa order?

What are the conversion units?

- ➔ If you think it's easier to do these calculations in your head, just wait.
- ➔ In chemistry, we'll use conversion factors you've never heard of before, like grams/mol and atoms/mole.
- ➔ Keys to successful dimensional analysis:
    - ◆ Start with what you're given
    - ◆ Remember, units cancel top to bottom
    - ◆ Write down your units, so you can keep track of them

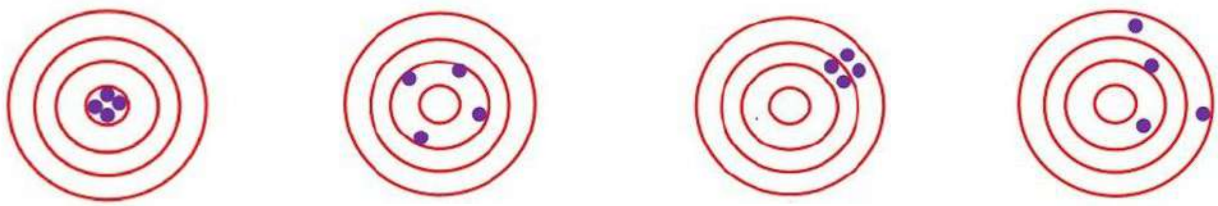
Uncertainty in Data

Important terms

- Accuracy

- Precision

And here we have the typical target to demonstrate accuracy and precision.



Example

- Studentswere asked to find the density of an unknown crystalline powder. Each student measured the volume and mass of three separate samples. Student data is shown in the table below. The unknown sample was sugar and has a density of 1.59 g/cm^3.

	Student A		Student B		Student C	
	Density	Error (g/cm^3)	Density	Error (g/cm^3)	Density	Error (g/cm^3)
Trial 1	1.54 g/cm^3	−0.05	1.40 g/cm^3	−0.19	[a] 1.70 g/cm^3	+0.11
Trial 2	1.60 g/cm^3	+0.01	1.68 g/cm^3	+0.09	1.69 g/cm^3	+0.10
Trial 3	1.57 g/cm^3	−0.02	1.45 g/cm^3	−0.14	1.71 g/cm^3	+0.12
Average	[b] 1.57 g/cm^3		1.51 g/cm^3		1.70 g/cm^3	

Which data is the most precise?

Which data is the most accurate?

Error and Percent Error

1. To evaluate the accuracy of experimental data, you can compare how close the experimental value is to the accepted value. The difference between the two is called error.
2. When we say 'accepted' value, we mean it's been proven, it's been reviewed and published in scientific literate. Experimental value is also called the measured value.

Error is calculated using the equation: error = experimental value - accepted value

More often we calculate the percent error using the equation:

$$\% \text{ error} = \left|\frac{\text{experimental value} - \text{accepted value}}{\text{exact value}}\right| \times 100$$

Step 1: Calculate the error (subtract one value from the other) ignore any minus sign.
Step 2: Divide the error by the exact value (we get a decimal number)
Step 3: Convert that to a percentage (by multiplying by 100 and adding a "%" sign)

Looking back at the data table, calculate the %error for the average density determined by each student.

Student A:

Student B:

Student C:

Which student had the lowest percent error?
Which student had the greatest percent error?