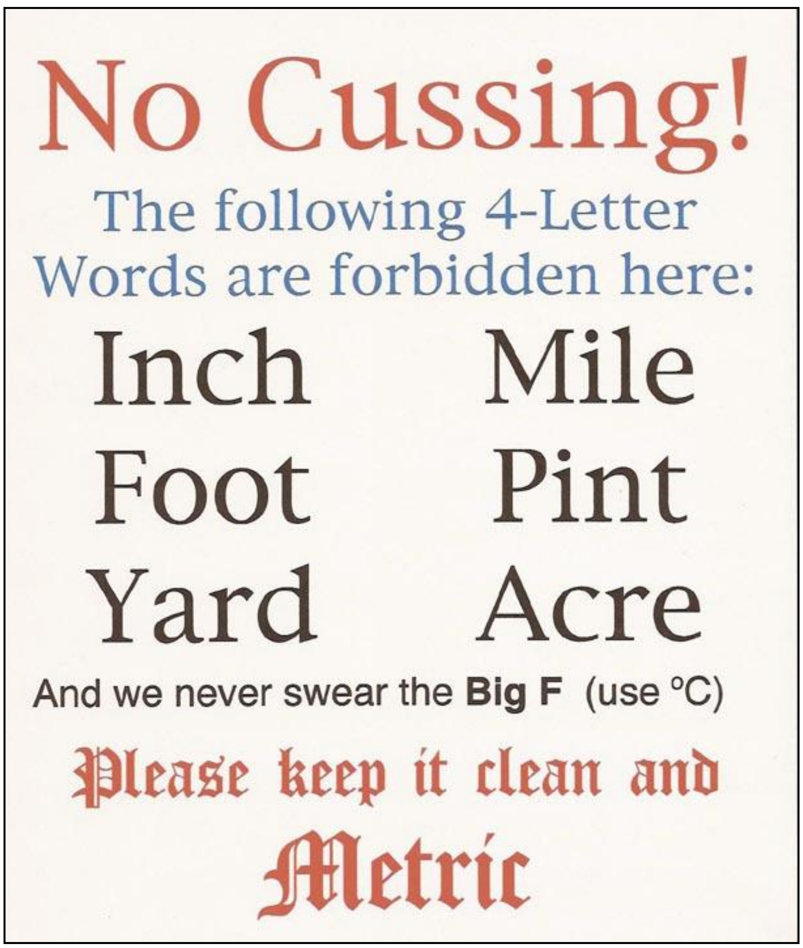
Name:

Regents Chemistry:

Notes: Unit 1: Math and Measurement



Key Ideas

- ***Major Understandings:***
  - ***Chemistry is the study of matter: Matter takes up space and has mass. (K-4, 3.1a)***
  - ***Objects have properties that can be observed, described, and/or measured. (K-4, 3.1c)***
  - ***Density can be described as the amount of matter that is in a given amount of space. If two objects have equal volume, but one had more mass, the one with more mass is denser. (5-8, 3.1h)***

- ***SKILLS:***
  - ***Use algebraic and geometric representations to describe and compare data. (M1.1)***
  - ***Determine the volume of a regular- and an irregular-shaped solid using water displacement.(5-8, skill PS 11)***
  - ***Describe the relationship between mass and volume and compute one variable given the other two.***
  - ***Convert temperatures in Celsius degrees (°C) to Kelvins (K) and Kelvins to Celsius degrees (3.4iii)***

Word	Definition
Absolute Zero	The theoretical temperature at which all molecular motion stops. This is equal to 0K or -273°C.
Accuracy	How close a measured value is to the accepted (or standard) value for that measurement.
Celsius	A temperature scale based on the freezing and normal boiling points of water (0 and 100°C, respectively).
Control	The conditions with remain constant during an experiment.
Conversion Factor	A number or ratio (in fraction form) that is used to convert from one unit type to another. The given units cancel out, leaving the desired target units.
Data	That which is measured or observed during an experiment.
Density	The relationship between mass and volume, i.e., how "tightly packed" a sample is. $D = m/V$.
Dependent Variable	The variable on the Y-axis that changes as a result of changing the independent variable.
Experiment	An activity designed to test the specifics of the hypothesis.
Exponent	A number that expresses a "power", is written as a superscript.
Extrapolation	Extending a graph beyond the data points to predict values beyond that which was plotted to get desired information.
Gram	The standard unit of measurement for mass.
Hypothesis	An "if-then-because" statement used to design an experiment to test an idea.
Independent Variable	The variable on the X-axis that the experimenter has control over.
Indirect (or Inverse) Relationship	A relationship where the increase of the independent variable results in the decrease of the dependent variable, or vice versa.
Interpolation	Reading between plotted data points on a graph to get desired information.
Kelvin	An absolute temperature scale proportional to Celsius but set at 0K = absolute zero.
Line of Best Fit	A straight line that best represents the slope of the data being analyzed. Can be approximated by hand or done with linear regression methods.
Liter	The standard unit of measurement of volume.
Mass	A measurement of the amount of matter in a sample.
Matter	Anything in nature which has mass and occupies space (has volume).
Meniscus	The curve in the surface of a liquid resulting from surface tension with the container. Measurements are made level with the midpoint.
Percent Error	A measure of how accurate a measurement is in relation to the actual or accepted value of that measurement.

Vocabulary

Precision	The place to which a measurement was made, e.g., ones, tens, tenths
Scientific Notation	A method of writing or displaying numbers in terms of a decimal number between 1 and 10, multiplied by a power of 10.
Significant Figures	The number of digits actually recorded by a measuring device during a measurement.
Tare	The mass of the receptacle containing the sample. This value is subtracted from the total mass to get the mass of the sample.
Temperature	A measurement of the Average Kinetic Energy of a sample.
Unit	A symbol which identifies the type of measurement that has been made. This needs to be placed after every measured number and every calculated answer.
Variable	The value that changes during an experiment.
Volume	A measurement of how much space a sample occupies.
Water Displacement	A method to measure the volume of an irregular solid object by determining the difference in volume between a liquid with and without the object submerged.

Objectives:

- ***Chemistry is the study of matter: Matter takes up space and has mass. (K-4, 3.1a)***
- ***Objects have properties that can be observed, described, and/or measured. (K-4, 3.1c)***
- ***Use algebraic and geometric representations to describe and compare data. (M1.1)***
  - ***recognize and convert various scales of measurement***

What is Chemistry? The study of matter and its changes.

What is **MATTER**?

Matter can be described through its properties, using terms which are:

QUALITATIVE (sounds like quality): descriptive, non-numerical observations

Examples:

QUANTITATIVE (sounds like quantity): are in the form of **NUMBERS** and **UNITS**.

Examples:

Example: Qualitative or Quantitative?

Some properties of a 5g sample of sodium are listed below:

- Is a soft, silver-colored metal
- Melts at a temperature of 371K
- Has a density of 0.97g/cm3
- Oxidizes easily in the presence of air
- Has a volume of 5.1mL

Qualitative	Quantitative

Quantitative Measurements:

The METRIC SYSTEM (SI): System of measurement used in science and in most countries

The BASE UNITS of measurement: (Found on Reference Table D)

Which units are new to you?

Example:
Name the quantity measured using Pa.

Table D
Selected Units

Symbol	Name	Quantity
m	meter	length
g	gram	mass
Pa	pascal	pressure
K	kelvin	temperature
mol	mole	amount of substance
J	joule	energy, work, quantity of heat
s	second	time
min	minute	time
h	hour	time
d	day	time
y	year	time
L	liter	volume
ppm	parts per million	concentration
M	molarity	solution concentration
u	atomic mass unit	atomic mass

PREFIXES: Used to modify base units of measurement. (Found on Reference Table C)

Table C
Selected Prefixes

Factor	Prefix	Symbol
10^{3}	kilo-	k
10^{-1}	deci-	d
10^{-2}	centi-	c
10^{-3}	milli-	m
10^{-6}	micro-	μ
10^{-9}	nano-	n
10^{-12}	pico-	p

Which prefixes are you already familiar with?

Example:
Which prefix would you use for one thousand meters?

Which would you use for one-thousandth of a meter?.

Example: gram (g) is a base unit for mass, while kg is a kilogram, or 10^3 (1000) grams. A unit symbol often consists of both the base unit and a prefix, e.g., cm, mL, kg.

Try these:

Symbol for kiloJoules:

Name unit represented by ms:

Name quantity represented by ms:

CONVERTING UNITS USING TABLE C

STEP 1: Find the number of places to move the decimal point by finding the difference between the exponents of the two prefixes on Table C.

STEP 2: Determine the direction of movement (left or right).

Move the decimal to the LEFT when going from: SMALLER to LARGER unit

Move the decimal to the RIGHT when going from: LARGER to SMALLER unit

Table C
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10^{-3}	milli-	m
10^{-6}	micro-	μ
10^{-9}	nano-	n
10^{-12}	pico-	p

Larger the unit, the smaller the value, e.g., 5km

Smaller the unit, the larger the value, e.g, 5,000,000mm

EXAMPLE 1: Convert 45mL to L.

• mL is _____________; L (base unit) is ______________

The difference between the two factors is ________.

• Since you are moving from a smaller prefix to a larger prefix you move the decimal three places to the left.

45mL = ______________L (larger unit, smaller value)

EXAMPLE 2: 5.2 cm = ____________ mm

- Step 1: Find the difference between the two factors: ______________

- Step 2: Which direction do you move the decimal point? ____________________

Final answer: _________________

Workspace for Video Questions and additional notes:

Objective:

- ***Differentiate between Kelvin and Celsius scales***
- ***Convert temperatures in Celsius degrees (°C) to Kelvins (K) and Kelvins to Celsius degrees (3.4iii)***

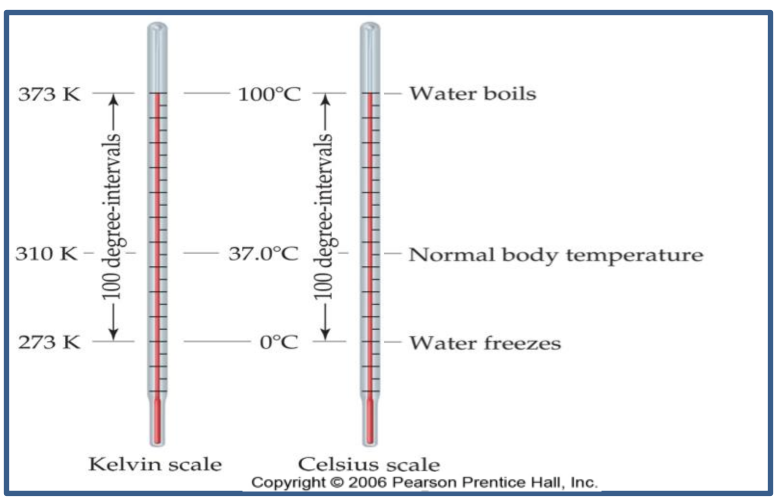
What is **Temperature?**

Celsius Scale:

- Freezing point of water at 0°C.
- Boiling for water at 100°C.
- Below 0 is NEGATIVE.

Kelvin Scale:

- Water freezes at 273K and boils at 373K
- Theoretical point of ABSOLUTE ZERO is when all molecular motion stops (0K = -273°C)
- NO NEGATIVE NUMBERS
- Divisions (degrees) are the same as in Celsius



CONVERTING BETWEEN TEMPERATURE SCALES

Temp Conversion Formula:

(TABLE T)

$$K = °C + 273$$

EXAMPLE 1: What is the temperature in Kelvin of an object that is 55°C ?

EXAMPLE 2: What is the temperature in Celsius of an object that is 150. K?

EXAMPLE 3: What is the CHANGE in Kelvin if the change in temperature in Celsius goes from 30.°C to 50.°C?

Objective:
- ***Differentiate between accuracy and precision***
- ***Compare the experimental result to the expected result; calculate the percent error (S3.3)***

ACCURACY - how close a measurement is to the accepted or true value

PRECISION - The place to which a measurement was made, e.g., ones, tens, tenths

EXAMPLE: These students were asked to determine the density of sucrose. Sucrose has a density of 1.59 g/cm^3. Which student is most *accurate?*

	Student A (g/cm^3)	Student B (g/cm^3)	Student C (g/cm^3)
Trial 1	1.54	1.40	1.70
Trial 2	1.60	1.68	1.69
Trial 3	1.57	1.45	1.71
Avg.	1.57	1.51	1.70

PERCENT ERROR

Measurement of **ACCURACY** (the % that the measured value is "off" from accepted value)

Measured value = value you "get"

Accepted value = value you "should get"

Formula located on: TABLE T

Percent Error	$\% \text{ error} = \frac{\text{measured value} - \text{accepted value}}{\text{accepted value}} \times 100$

*If answer is negative, your measured value is **LESS THAN** the accepted value*

*If answer is positive, your measured value is **GREATER THAN** the accepted value*

EXAMPLE: A student determines the density of a substance to be 1.40 g/mL. Find the % error if the accepted value of the density is 1.36 g/mL.

Percent error has no unit. Why?

Objective:

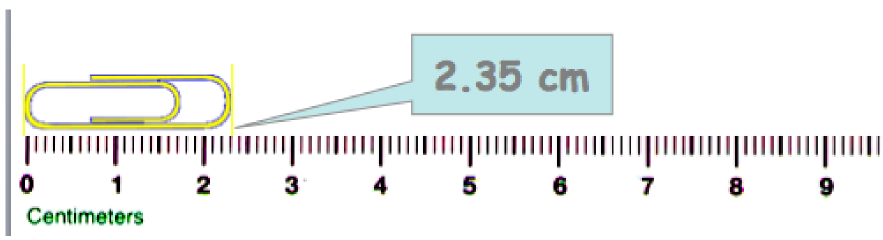
- ***Show uncertainty in measurement by the use of significant figures***
- ***Properly apply rules of significant figures (determining number of significant figures in a measurement).***

SIGNIFICANT FIGURES

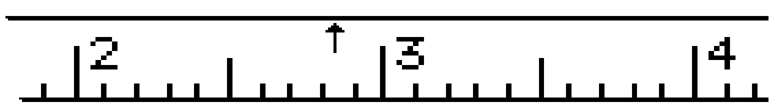
Sig Figs Indicate **PRECISION** of a measurement.

•Recording Sig Figs:

–Sig figs in a measurement include the **known digits** plus a final **estimated digit** (precision of instrument)



EXAMPLE 1:



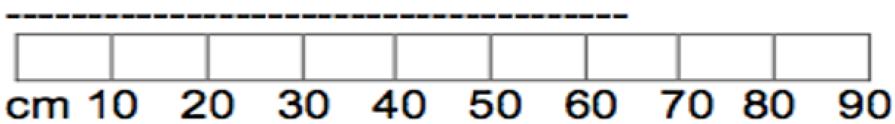
cm (not to scale)

•We know for sure that the object is more than _______cm, but less than ________cm

•We know for sure that the object is more than ________cm, but less than ________cm

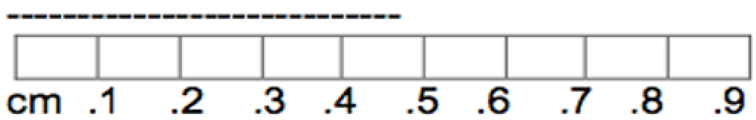
•This ruler allows us to **estimate** the length to _________cm

EXAMPLE 2:



Device is <u>marked</u> to the **TENS** place, so <u>read</u> to the **ONES** place

Measurement: 6<u>7</u> cm ← the 7 in the ones place is ESTIMATED

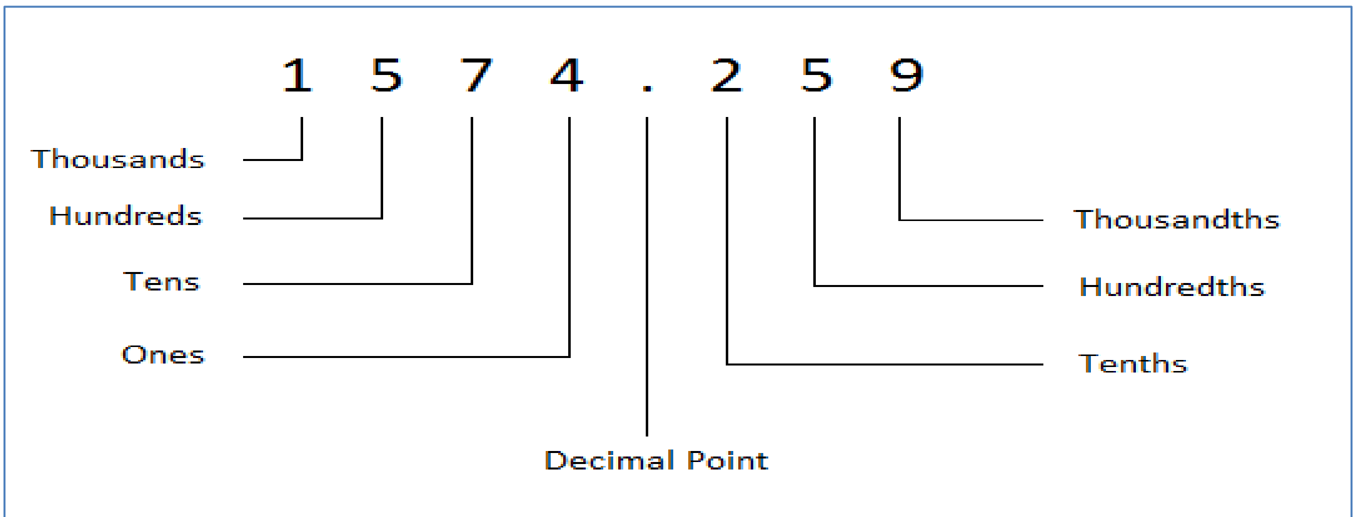


Device is <u>marked</u> to the **TENTHS** place, so <u>read</u> to the **HUNDREDTHS** place

Measurement: 0.4<u>8</u> cm ← the 8 in the hundredths place is ESTIMATED

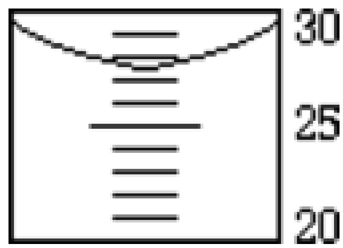
Which measuring tool above is more precise?

Review of the decimal positions -- memorize if you don't know these!!!

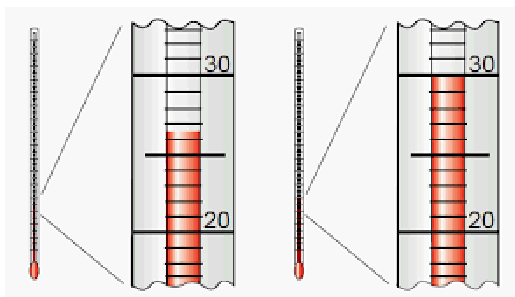


EXAMPLE 3:
If the graduated cylinder is marked to the ONES, read to the ___________.

Volume = ________ mL



EXAMPLE 4: Reading a thermometer marked to the _________ place, so read to the ________.



RULES FOR COUNTING SIG FIGS

1. All non-zero digits ***are*** significant.

2. Leading zeros are ***never*** significant. ex. 0.421 (3 sig figs)

3. All captive zeros are ***always*** significant.

(Captive is a zero between 2 other non-zero digits.) ex. 4012 (4 sig figs)

4. For Trailing zeros: (zeros after last non-zero digit) ***sometimes*** significant…

- Decimal point → significant ex. 114.20 (5 sig figs)
- **No** decimal point → **not** significant ex. 11,420 (4 sig figs)

HOW TO COUNT SIG FIGS

1. Start counting from LEFT to RIGHT at first **nonzero number**.
2. If decimal point **is present** then count any trailing zeros
3. If decimal is **not present** don't count trailing zeros

EXAMPLES:

1) 2545.300 g ___________ sig figs (Rule applied: ____)

2) 4530 km ___________ sig figs (Rule applied: ____)

3) 0.00453 m ___________ sig figs (Rule applied: ____)

Objective:

- ***Properly apply rules of significant figures (determine number of significant figures to be rounded to when doing calculations).***

Every measurement has some error in it. When performing calculations **AN ANSWER CAN NEVER BE MORE PRECISE THAN THE LEAST PRECISE MEASUREMENT**

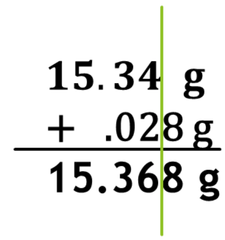
RULES FOR ADDITION/SUBTRACTION

Answer can only be as precise as least precise number.

Example: 15.34g + .028g -- which is less precise?

Round your answer to which place?__________________

Final answer: _________________g



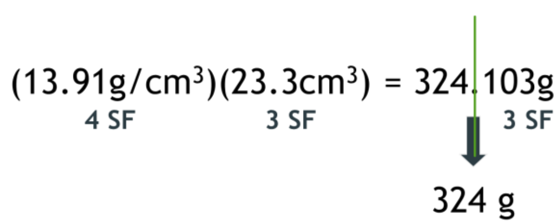
EXAMPLE: 224g + 130g =

EXAMPLE: 24.533 mL + 34.1mL =

RULES FOR MULTIPLICATION/DIVISION

Multiply/Divide – Round answer to the least number of significant figures.

EXAMPLE:



Example:

d = 56.0 g / 12.45mL

Quantitative Calculations:

Mass: the amount of matter an object contains. (This is different than weight, which is mass times gravity)

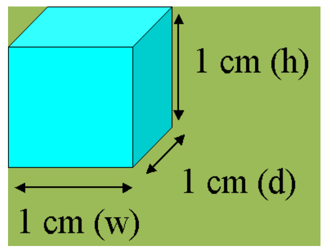
Volume: The amount of space a substance occupies

How do we measure mass in the lab? The electronic balance.

How can we measure volume?

1.) l x w x h (regular solid)

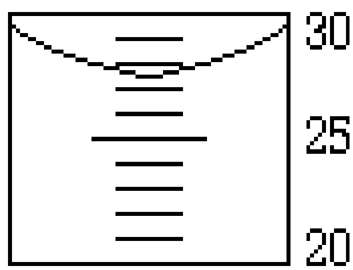
ex. V = 1cm^3



2.) Graduated cylinder (liquids)

Read bottom of **MENISCUS**

ex. V = 27.5 mL

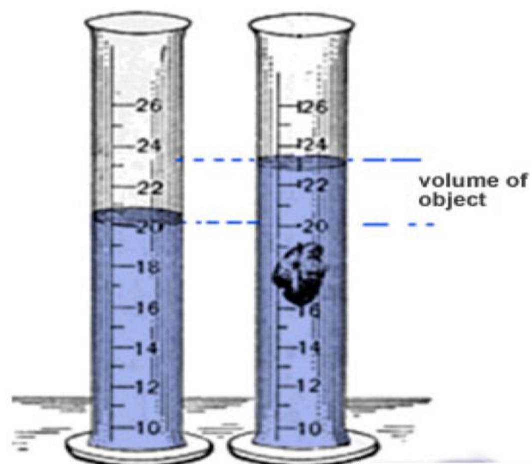


3.) Water Displacement: measures volume of an irregular solid

STEPS TO MESASURE VOLUME BY DISPLACEMENT:

1. Measure initial volume
2. Measure final volume with object
3. The Difference is the volume of the object

EXAMPLE: What is the volume of the solid object?



CALCULATING DENSITY

DENSITY: The Ratio of mass of an object to its volume

The density formula is: $d = \frac{m}{V}$ and is located on **TABLE T**

NOTE: IN WORKING EXAMPLES, BE SURE TO INCLUDE THE FORMULA, VARIABLES, NUMERICAL SET-UP, AND ANSWER <u>WITH UNITS</u>!

EXAMPLE 1:

What is the density of an object with a mass of 60 g and a volume of 2 cm^3?

EXAMPLE 2:

An object has a volume of 825 cm^3 and a density of 13.6 g/cm^3. Find its mass.

<u>How to solve for mass or volume if density is not given:</u>

Use TABLE S to find the density of the element. Then solve for the unknown variable.

EXAMPLE 3:

The volume of an aluminum sample is 251 cm^3. What is the mass of the sample?

The density of aluminum on table S is 2.70g/cm³

EXAMPLE 4:

What is the volume of a 25g sample of copper?

WORKSPACE FOR ADDITIONAL NOTES/QUESTIONS:

Objective:

- ***Properly use and interpret scientific notation:***
  - ***Convert numbers into scientific notation and standard notation***
  - ***Compute operations using scientific notation***

Scientific notation: A way to represent large or small numbers

For example:

- the mass of a hydrogen atom is 0.00000000000000000000000167g.
- 2 g of H_2 contains 602,000,000,000,000,000,000,000 molecules.

Scientific Notation is written as the product of two numbers: a coefficient and a 10 raised to a power.

The coefficient (number written first) is always a number from 1 to 9

Example (from above):

Mass of a Hydrogen atom is 1.67×10^{-24} g.

2 g of H_2 contains 6.02×10^{23} molecules.

NOTE: When done correctly, EVERY digit in the coefficient in scientific notation is significant!

CONVERTING FROM STANDARD NOTATION INTO SCIENTIFIC NOTATION

1. For large numbers (greater than 1) move decimal to the LEFT until there is only 1 digit to its left. The number of places moved = exponent number

EXAMPLE: 454,500 g =

2. For small numbers (less than 1) move decimal to RIGHT stopping after the first non-zero number. The number of places moved = negative exponent number

EXAMPLE: 0.00453 ml =

CONVERTING FROM SCIENTIFIC NOTATION INTO STANDARD NOTATION

Move the decimal place the number of times indicated by the exponent:

If exponent is positive, move to the right (number gets larger).

If the exponent is negative, move to the left (number gets smaller).

EXAMPLE:

4.5×10^{-2} =

EXAMPLES Convert the following in standard notation:

6.5678×10^{7} =

8.79×10^{-4} =

CALCLUATING WITH SCIENTIFIC NOTATION USING A CALCULATOR

$3 \times (7.04 \times 10^{8}$ y)

Scientific:

Type on your calculator:

3 [x] 7.04 [EE] 8 [ENTER]

= **2.112 E9**

= 2.112×10^{9} y

= 2112000000 y

Four-Function:

Use the Calculator for the Coefficients

$(3 \times 7.04) \times 10^{8}$y

= 21.12×10^{8} y

= 2.112×10^{9} y

Objective:

- ***Construct and interpret a graph from experimentally obtained data (M2.1)***
    - ***identify independent and dependent variables***
    - ***create appropriate axes with labels and scale***
    - ***identify graph points clearly***
- ***Identify relationships within variables from graphs (direct, inverse)***
- ***Make predictions using graphs***

Graphs are used to visually make sense of experimental data and can also be used to make predictions.

Data Set: An experimenter recorded the temperature of a sample as she added heat over time:

Time (min)	Temperature (˚C)
0	15
1.0	19
2.0	26
3.0	30
4.0	36
5.0	39

Variables:

Changing one thing in an experiment (**independent variable**) will often cause something else to change (**dependent variable**).

When graphing, the independent variable is on the X axis (with units) and the dependent variable is on the Y axis (with units).

In this example,

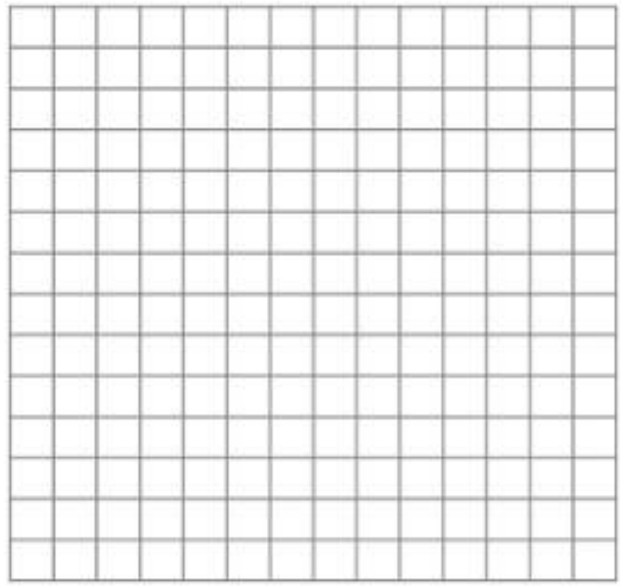
______________ is independent variable, X-axis

______________ is dependent variable, Y-axis

Time (min)	Temperature (˚C)
0	15
1.0	19
2.0	26
3.0	30
4.0	36
5.0	39

SAMPLE GRAPH ***(USE A PENCIL AND RULER!):***

Time (min)	Temperature (˚C)
0	15
1.0	19
2.0	26
3.0	30
4.0	36
5.0	39



1) Label the X- and Y-axes. Don't forget units!!

2) A numerical scale representing **uniform** increases in each variable.

3) A title: (Dependent Variable) vs. (Independent Variable) or "y" vs. "x"

4) Data points, circled with "point protectors". These circles serve two purposes: to make the point more visible and to represent the margin of error associated with estimated digits.

5) A line either connecting the data points or in a curve of best fit between the points.

NOTE: A computer can draw a very precise, "best fit" – your eyeball is approximate and may differ slightly from your classmates while both are correct!!

Best Fit Line (Average Line): Notice how the line of best fit gives approximately the same number of data points above and below it, while maintaining a good idea of the slope of the data? Use a ruler and a pencil to create this line of best fit. GRAPHS SHOULD ALWAYS BE DONE WITH A PENCIL AND A RULER.

What if you were graphing the temperature change of two different substances – you'd have **two data sets** using the same independent variable – You can use colors or symbols to distinguish, but include a **KEY.**

USING YOUR GRAPH:

Interpolation and Extrapolation: When data is graphed and a line drawn, one can make estimations about information that is either between data points or outside the range of the data points.

INTERPOLATION: Reading between the data points to get information.

Examples ***(Use your sample graph, page 25!)***:

What will the temperature of the sample be after 2.5min? ____________________

How long would it take the sample to reach 25°C? ______________________

EXTRAPOLATION: Extending your graph line and reading outside your data range.

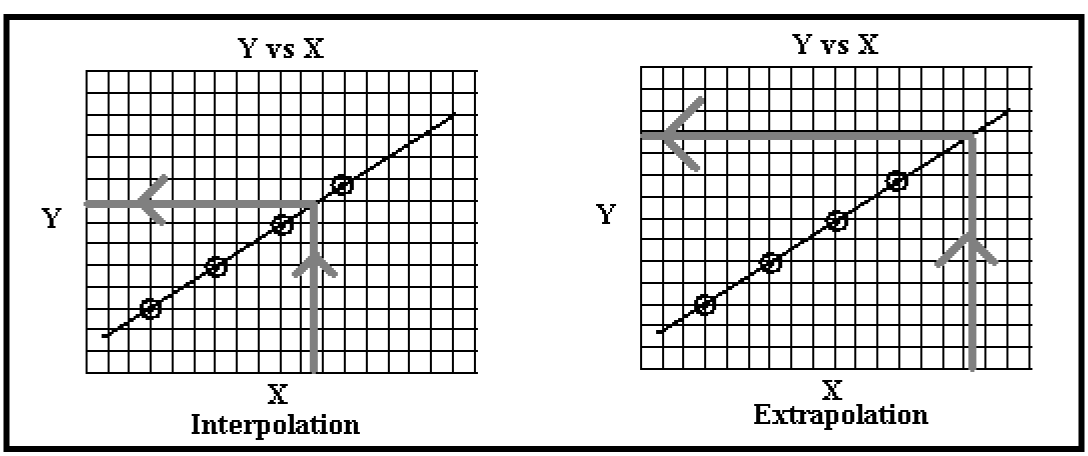
NOTE: This is a bit more dicey than interpolation as the situation can change, for example, if we're heating water, it will boil at 100. °C, so the trend probably won't continue!!

Examples ***(Use your sample graph, page 25!)***:

What will the temperature of the sample be after 6.0 min? _________________________

How long would it take the sample to reach 47.°C? _____________________________

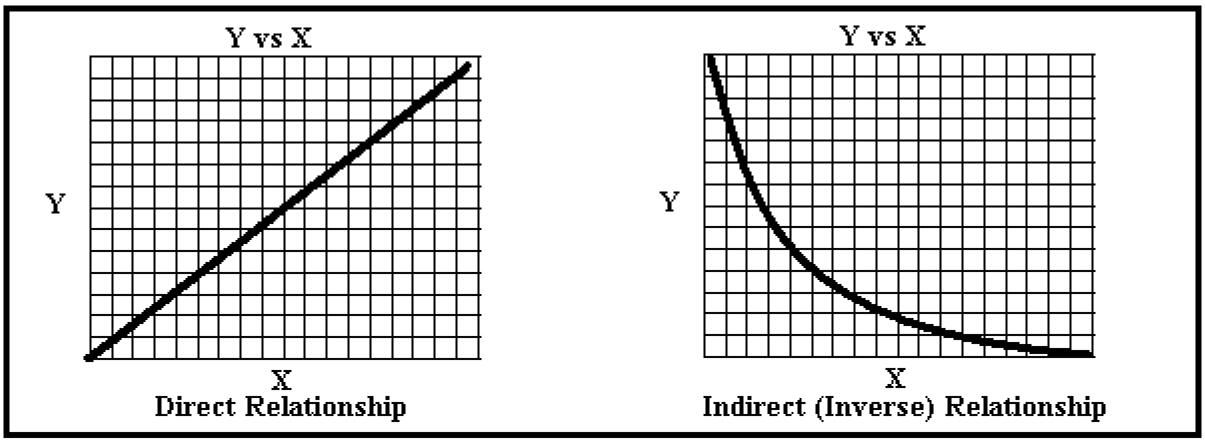
When you do either, you must keep the rules of precision in mind. If your graph reads to the nearest tenths, the estimated interpolation or extrapolation must be read to the nearest hundredth.



Relationships: Graphs show relationships between the dependent and the independent variable. This can be used to make predictions about behavior of physical and chemical phenomena.

Direct Relationship: As the independent variable is increased, the dependent variable also increases.

Indirect (Inverse) Relationship: As the independent variable is increased, the dependent variable decreases.



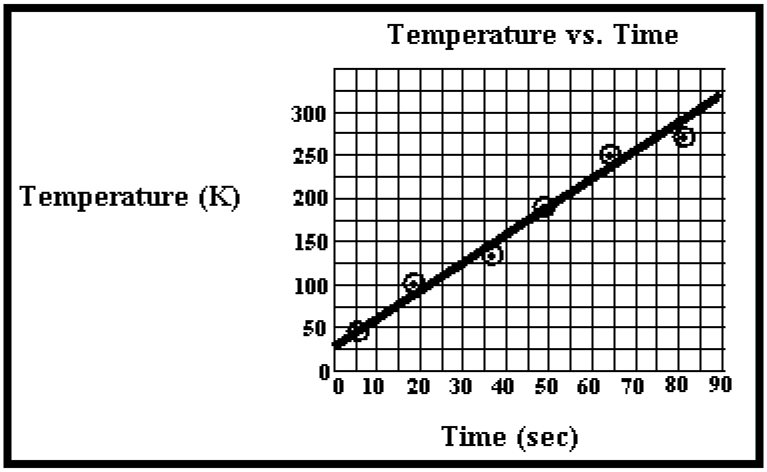
As the heat is added over time (**increased)** the temperature **increases**. This is a

________________ **relationship**.

As the pressure on a sample of confined gas is **increased**, its volume will **decrease**. This is an

________________ **relationship.**

A Good Graph



1) **Labeled Axes:** dependent on the Y axis, independent on the X axis, both with appropriate units

2) **Title:** Dependent Variable vs. Independent Variable

3) **Data Points:** with point protectors around them

4) **Best Fit Line:** showing the average slope of the linear data

5) **Scaled:** regular interval spacing for the scales on both axes

6) **Size:** The data should take up more than a quarter of the graph paper itself. The larger the graph, the
easier it is to interpolate and extrapolate from

If you are not told to draw a best fit line, then connecting the data points individually is the way to go.