UNIT I - Introduction to Chemistry

I. Laboratory Equipment

A. Things on a Ring Stand

OBJECT	PURPOSE	PICTURE	OBJECT	PURPOSE	PICTURE
Metal Ring	*To support wire gauze or clay triangle & hold object above burner*		Funnel Stand	*To support a funnel so a beaker or other container may be placed under it*	
Test Tube Clamp	*To hold a test tube securely on a ring stand*		Wire Gauze	*Placed on a metal ring. Supports beaker or other object over burner.*	
Ring Stand	*To serve as a base for holding rings, Bunsen burners, funnel stands, etc.*		Clay Triangle	*Placed on metal ring. Supports crucible over burner*	

B. Objects Used to Manipulate Things

OBJECT	PURPOSE	PICTURE	OBJECT	PURPOSE	PICTURE
Scoopul a	*To transfer granular solids from a container to another area. Also good for pulverizing solids.*		Crucible Tongs	*To grab and move a hot crucible from one area to another.*	
Micro-sp atula	*To transfer small amounts of granular solids.*		Beral (plastic) Pipet	*To transfer small amounts of liquid from one area to another.*	
Beaker Tongs	*To grab and move a hot beaker from one area to another.*		Forceps	*To grab and move solid objects.*	
Pipet Bulb	*To draw liquids into a pipet. NEVER USE YOUR MOUTH!!!*		Volumetri c Pipet	*To measusre out a specific volume of a liquid. NEVER USE YOUR MOUTH!!*	

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C. Containers - NOTE: *None of these are used for measurement*

OBJECT	PURPOSE	PICTURE	OBJECT	PURPOSE	PICTURE
Erlenmeyer Flask	*Glass container with narrow neck. Good for holding and heating chemicals*		Beaker	*Glass container with wide neck. Also good for holding and heating chemicals.. DO NOT USE TO MEASURE LIQUID VOLUMES!!*	
Test Tube	*Small glass tube with one open end. Commonly used for observing reactions.*		Crucible	*Porcelain container used for high temperature heating. VERY FRAGILE.*	
Squeeze Bottle	*Holds cleaning solution, reagent or distilled water. Used to rinse glassware.*		Evaporating Dish	*Lidless porcelain dish used for high temperature heating. VERY FRAGILE.*	
Reagent Bottle	*Glass container used to hold reagents. Comes in many shapes and sizes.*		Spot Plate	*Plastic plate with many wells. Used to perform many reactions next to each other for easy comparison.*	

D. Measuring Devices

OBJECT	PURPOSE	PICTURE	OBJECT	PURPOSE	PICTURE
Thermometer	*To measure temperatures of objects or substances. UNITS: °C*		Electronic Balance	*To measure the masses of substances. UNITS: g*	
Graduated Cylinder	*To measure volumes of liquids. UNITS: mL*		Volumetric Flask	*A flask designed to very precisely measure one particular volume of liquid*	

E. Miscellaneous other Items

OBJECT	PURPOSE	PICTURE	OBJECT	PURPOSE	PICTURE
Safety Goggles	*Protects eyes from damage. REQUIRED IN LAB AREA AT ALL TIMES UNLESS SPECIFICALLY TOLD BY INSTRUCTOR.*		Rubber Tubing	*Used to transfer a fluid (liquid or gas) safely from one container to another.*	
Plastic Apron	*Protects torso and legs from damage.*		Bunsen Burner	*Used for heating substances. Produces up to 950°C*	
Hot Plate	*To heat substances in glass or porcelain containers.*		Stopper	*Used to close flasks and test tubes. Varieties include rubber and cork.*	
Stir Rod/ Stir Bar	***Rod -*** *Glass rod used to stir solutions* ***Bar -*** Magnetic Bar used on hot/stir plate		Funnel	*Used to help transfer liquids from one container to another. Also used to make a filter with* ***filter paper***	

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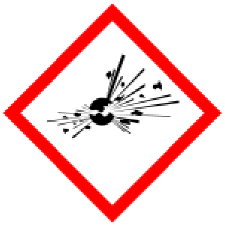
F. Laboratory Safety Highlights

Symbols you should know:

SYMBOL	MEANING	SYMBOL	MEANING	
	Explosive		Flammable	
	Toxic		Strong Oxidizer	Environmentally Damaging
	Health Hazard		Corrosive	
	Strong Irritant		Compressed Gas	

3. Other Safety Highlights from Past Experience
    a. Never directly smell or taste anything in the lab – learn to *waft* if smell is needed.
    b. Always listen to Teacher's tips before the lab.
    c. Always **READ THE DIRECTIONS FIRST!!!!!**
    d. Stick to the lab directions. Unauthorized experiments = trouble.

4. MSDS Labels – "Material Safety Data Sheets" – rank chemicals in certain danger areas on a scale from 1-4.

    A. Flammability – 0 is nonflammable, 4 is very flammable
        * remember, in order to burn, oxygen must also be present
    B. Reactivity – 0 means it is very ***inert*** (doesn't react with much), 4 is very reactive
    C. Health – 0 is safe (NaCl is a 1), 4 is very dangerous
        * remember, you should never eat things in the lab, even 0's

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I. Rules of Significant figures

- importance?

A. All digits 1-9 are significant

1) 45.1 　　2) 0.153

B. All zeros in a "sandwich" are significant

1) 105 　　2) 4053.01

C. All zeros that end a decimal fraction are significant

1) 5.430 　　2) 6.0100

D. All zeros in front of a fraction and not in a sandwich are not significant

1) 0.00501 　　2) 0.0005

E. All zeros at the end of a number greater than 10 not in a sandwich are not significant.

1) 100 　　2) 1010 　　3) 100.0

F. A "lined" zero (θ) is significant.

1) 1θ0 　　2) 10θ

- Try the "Atlantic-Pacific" rule to remember:

  - If the decimal point is **P**resent, count from the **P**acific side
  - If the decimal point is **A**bsent, count from the **A**tlantic side

S. How many significant figures are there in:

1) 45.6 　　2) 150 　　3) 0.055 　　4) 0.0306 　　5) 10,000.1

6) 5000 　　7) 30.1 　　8) 30.10 　　9) 400.00 　　10) 0.000051

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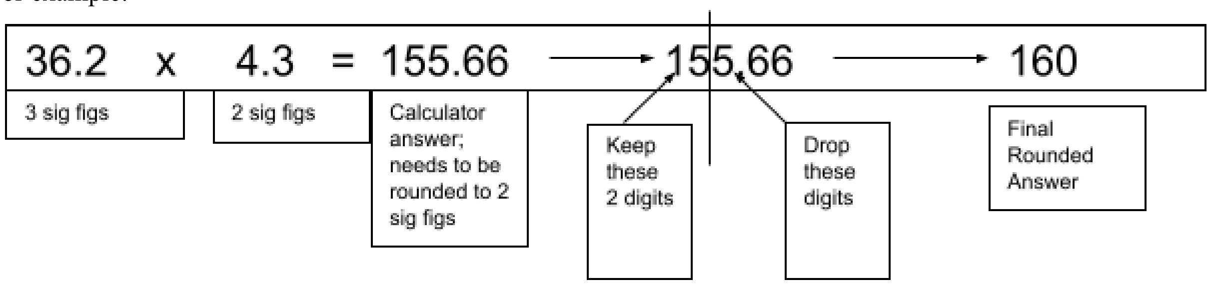
III. Multiplying and Dividing Significant Figures.

♦ When multiplying and dividing measurements, the answer should have a number of significant figures equal to the multiplicant with the least number of sig figs

For example:



T. Calculate the following. Make sure the answer has the correct number of sig figs.

1) 4.11 x 5 =

2) 5.00 x 5.00 =

3) 4.7152 x 3.446 =

4) 6 x 6 =

5) 38.1 / 655 =

6) 9.475 / 12.05 =

S. Calculate the following.

1) 3.65 x 5.01 =

2) 0.0522 x 0.827 =

3) 26.0 x 2.00 =

4) 5.2 x 20.0 =

5) 4.0 / 381.3 =

6) 4.08 / 0.061 =

IV. Adding and Subracting Significant Figures.

- When adding and subtracting measurements, round your answer to the decimal place represented by the least precise number – round it to the "worst" decimal place

For example:

Nearest 1's digit	123
Nearest 0.01	40.55
Nearest 10's digit	+ 270
	433.55

123
40.55
\+ 270

433.55 → 430

Keep this drop this

T. 1) 0.03694 + 0.0770 ----------- 2) 38.5 0.051 + 100 ------------ 3) 6.0098 - 2.51 ------------

S. 1) 0.450 + 0.0347 ---------- 2) 4.3 14.62 + 327.9 ------------ 3) 761.8 - 100 ----------

V. Dealing with units in calculations - ** the units are treated just like variables in algebra*

A. Multiplying and Dividing

In algebra: $2y \times 4y = 8y^2$

Similarly: $4.5\ \text{cm} \times 10.2\ \text{cm} = 45.9\ \text{cm}^2$ □ $46\ \text{cm}^2$

Also: $\frac{35.44\ g}{5.4\ mL} = 6.5692\ g/mL = 6.6\ g/mL$

B. Adding and Subtracting - **ALL UNITS MUST BE EXACTLY THE SAME!!!!**

For example: 3.5 cm + 4.2 cm + 7.1 cm = 14.8 cm

However: 3.6 cm + 0.21 km + 450 mm = Not Possible

VI. Measurement Activity –

1) Measure the length and width of 4 tile squares on the lab floor **to the nearest 0.001 m**
2) Calculate the area of each square. Make sure to round the answer to the correct number of sig figs.
3) Add your four results to determine the total area of the big square made up by your 4 squares.

Square	Length (m)	Width (m)	Area (m^2)
1			
2			
3			
4			
		Total Area	

4) Measure the length and width of the big square formed by the 4 squares you selected.

Length (m)	Width (m)	Area (m^2)

Questions:

1) How do the area values for the big square compare between question #3 and #4?

2) Why do you think a difference occurs?

3) Describe how the number of sig figs in a measurement relates to its precision.

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VII. Scientific Notation

- a method used to express extremely large numbers or extremely small numbers

base - must be greater than or equal to 1 and less than 10

$$4.56 \times 10^5$$

power

- the number of sig figs in a number expressed in scientific notation corresponds to the number of sig figs in the base number
- **Contest**: How many molecules are there in 36.0 mL of water? ________________________________

S. How many sig figs in the following numbers?

1) 3.123×10^3
2) 5×10^{11}
3) 4.010×10^{-11}

T. Convert the following to scientific notation:

1) 47,000,000,000
2) 2,600,000,000,000
3) 0.0000000005
4) 0.0000001020

S. Convert the following to scientific notation:

1) 863,030,000,000,000
2) 953,000,000,000,000,000,000
3) 0.000000040101
4) 0.00000000000000021

T. Convert the following to decimal notation:

1) 4×10^{-4}
2) 9.24×10^7
3) 7.030×10^6

S. Convert the following to decimal notation:

1) 5.0×10^{-5}
2) 6.73×10^8
3) 8.923×10^{-10}

When using your calculator, the "EE" or "EXP" button is equivalent to "10 to the....."

Example: $4 \times 10^{5} \times 3.2 \times 10^{-2}$ is entered:

4	EE	5	*	3	.	2	EE	(-)	2	=

What do you get? **1.28** ^{04} **1.28 04** **1.28 E 04** **or** **12800**

Either way, you must round the **base** to the correct number of sig figs: **Answer**: 1×10^{4}

S. Calculate the following. Make sure the answer has the correct number of sig figs.

1) $(2.3 \times 10^{6})(4.2 \times 10^{-11}) =$

2) $(4.00 \times 10^{-15})(3.0040 \times 10^{4}) =$

3) $\dfrac{8.5x10^{8}}{3x10^{-4}}$

4) $\dfrac{4.00x10^{-15}}{6.22x10^{5}}$

5) $\dfrac{(8.05x10^{-11})(5.9x10^{7})}{3.1x10^{14}}$

7) $\dfrac{(43{,}000{,}000)(0.00071)}{(10.24)(0.000000234)}$

6) $\dfrac{(5.444x10^{8})(1.0001x10^{-23})}{(2.43x10^{-10})(5.3063x10^{30})}$

8) $\dfrac{(5.0404x10^{-22})(3.2x10^{5})}{(7.020x10^{-10})(6x10^{40})}$

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VIII. Graphing - an important tool in scientific experiments

* <u>independent variable</u> - x-axis; variable whose values are determined before the experiment

* <u>dependent variable</u> - y-axis; variable whose values are measured during the experiment

<u>S.</u> In each of the following statements, declare what is the independent variable and the dependent variable.

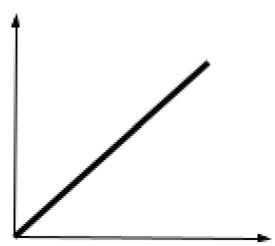
1. In my experiment, I checked the temperature of my heating water every 5 minutes.

    * independent variable -   * dependent variable -

2. I wanted to see the relationship between the pressure and volume of a trapped gas, so I increased the pressure on the gas 0.500 atm at a time and measured the volume at that pressure.

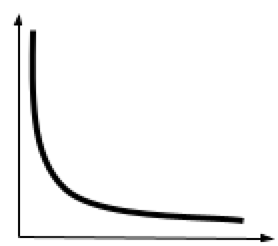
    * independent variable -   * dependent variable -

<u>directly proportional</u> – as "x" increases, "y" increases



$y = kx$ OR $k = \dfrac{y}{x}$

<u>inversely proportional</u> – as "x" increases, "y" decreases



$xy = k$ OR $y = \dfrac{k}{x}$

<u>S</u>. Graph each of the following sets of data. Make sure you correctly label the independent variable and dependent variable. When the data points are plotted, draw a best-fit line and answer the question.

* <u>best-fit line</u>

1. Volume of an Enclosed Gas vs. Temperature

Temp (ºC)	Volume (mL)
25	10.0
30	11.7
35	13.4
40	15.0
45	16.7
50	18.4
55	20.1
60	21.7
65	23.4
70	25.1

a. Is the relationship linear? If so, draw a best-fit line.

2. Data From a Bike Trip

Time (hrs)	Distance (km)
0	0
1	12
2	22
3	34
4	42
5	50
6	56
7	60
8	63

a. Is the relationship linear? If so, draw a best-fit line.

b. Is the relationship directly proportional, inversely proportional, or neither?

c. Calculate the slope of the line.

d. Use the slope-intercept formula to find the equation for the line.

e. Using the equation, what will the volume be at 95ºC?

b. Is the relationship directly proportional, inversely proportional, or neither?

c. Approximate when the biker will reach 100 km.

f. Using the equation, at what temperature would the volume be 93.4 mL?

3. Water Temperature Fluctuations - 1991

Month	**Temperature (ºC)**
Jan	3.8
Feb	0.9
Mar	1.1
Apr	2.5
May	5.2
Jun	10.1
Jul	15.5
Aug	19.0
Sep	18.5
Oct	15.5
Nov	9.2
Dec	5.8

a. When is the peak month for swimming?

b. Does this lake freeze over? Explain.

c. Is this a linear relationship? If not, is there still a predictable pattern?

4. Rate of Decay for ^{238}U at certain temperatures

Time (min)	Number of Atoms
1	256
2	128
3	85
4	64
5	51
6	43
7	37
8	32
9	28

a. Is this a linear relationship?

b. Is it directly or inversely proportional (or neither)?

c. Write an equation that fits this relationship, including a proportionality constant (k)

d. How many atoms will be remaining after 2.5 minutes?

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IX. The Scientific Method – i.e. "What is it that makes an experiment reliable?"

A. **Question** – What is the purpose of this experiment?

1. It is important here to define your **variables** (things that will change)
2. **independent variable** – the variable whose values you set ahead of time
3. **dependent variable** – the variable whose values you measure in the experiment

* You are conducting an experiment in which you are measuring the effect of temperature on the dissolving rate of a sucrose cube in water. What is the *independent variable*? *Dependent*?

B. **Prediction** – What do you believe will happen in this experiment?

* One default way to phrase: "We believe that as the (iv) *increases/decreases,etc.*, the (dv) …"

* State a prediction that matches the experiment above. What background knowledge contributed to this?

C. **Observation** – What does this experiment show you?

1. It is important here to have a clear **investigation plan** (step-by-step procedure)
2. The investigation plan should exhibit proper **variable control**

* Design an investigation plan that will test your prediction. Make sure to include any necessary and appropriate equipment. Are there any safety concerns that should be noted?

3. Your **data** should be observations only, not inferences.
4. It is best to organize your observations in a table if appropriate:

Trial	**Temperature (ºC)**	**Dissolving Time (s)**
1	10.1	234
2	20.0	187
3	29.9	140
4	40.2	88
5	49.8	32

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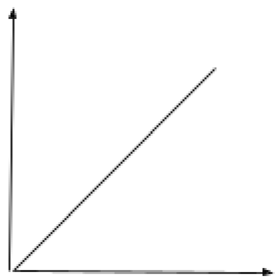
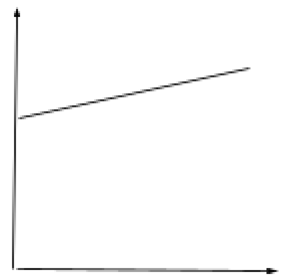
D. **Explanation** – What is the data showing you?

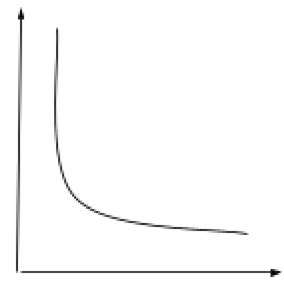
1. If possible, it is best to do **data analysis** - graphs do this well
2. Are there any mathematical patterns in the graphs?



Directly Proportional
$y = kx$ OR $y/x = k$



Linear
$y = kx + b$



Inversely Proportional
$y = k/x$ OR $xy = k$

* Make a graph of the data for the experiment on p. 1. Are there any mathematical patterns? Find any appropriate proportionality constants (slope, etc.) and express your pattern as an equation. What is "R"? What does it tell you?

3. The explanation should include:
   a. **Claim** – What does the data show you? It should be phrased like the prediction
   b. **Evidence** – refer specifically to what data clearly fits that claim
   c. **Reasoning** – Why do you think the data showed this? Use any background knowledge to explain, at a microscopic level, what the data showed

* Provide an explanation for the data in this experiment. Make sure to note your claim, evidence, and reasoning.

E. **Evaluation** – How good was your experiment?

1. Evaluate the strength of your claim? Was the **sample size** sufficient?
2. What sources of error contributed? What effect would they have?
3. How could this experiment have been improved?

* Evaluate the results of the experiment. Note any important sources of error and their effect.

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X. **Systeme' Internationale (SI system)** – developed and adopted in 1960; has seven base units; five are shown on table below (Ampere and Candela aren't used in Chemistry)

A. Metric System
- Metric System devised in 1798 in Paris, FRA
- Metric System Treaty (1875) – adopted by all industrialized nations (inc. USA)
  * by 1900, only British Commonwealth and USA didn't use metric
  * late 1960's, early 1970's, Commonwealth adopts
- Metric Conversion Act (1975) – USA will be under complete metric system by 1985
- Other non-metric countries (only 2)?

B. Units used - SI Base Units; adding a prefix modifies the unit

* How long is a meter (m)? centimeter (cm)? kilometer (km)?

Unit	Abbreviation	Quantity
meter	m	length
gram	g	mass
second	s	time
mole	mol	number of items
Kelvin	K	temperature

C. **Dimensional Analysis** - a system used to solve any problem requiring proportional reasoning

* requires a known value and an equivalency

* example: I know 1m = 1000mm. How many meters are equivalent to 2430mm?

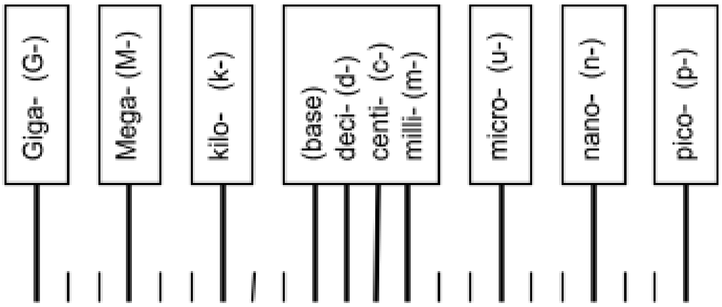
1. Write down the known value. 2430mm
2. Set up your conversion factor. 2430mm x ______
3. Match units on the bottom of the conversion factor with the known value. $2430\text{mm} \times \frac{}{\text{mm}}$
4. Put the units desired on the top. $2430\text{mm} \times \frac{\text{m}}{\text{mm}}$
5. Place the known equivalency into the conversion factor. $2430\text{mm} \times \frac{1 \text{ m}}{1000 \text{ mm}}$
6. Simplify. $2430 \text{ mm} \times \frac{1 \text{ m}}{1000 \text{ mm}}$ = **2.43 m**

T. 1) 3,540,000 nm = ? m

2) 4500 kg = ? mg

3) Given: 1km = 0.6214mi
How many kilometers is it from Holland to Detroit? (186 miles)

4) Given: $1.00 = 4.87 tuttles and 1 tuttle = 15 crowns
If you travel to Tuttleland with $150 in your pocket, how many crowns can you get?



DEFINITIONS	APPROXIMATIONS
1 ton = 2000 lbs	1 inch = 2.54 cm
16 oz = 1 lb	1 liter = 1.06 qts
1 gal = 4 qts	1 km = 0.6214 mi
1 foot = 12 in	1 kg = 2.2046 lbs

<u>**S**</u>. Complete the following conversions.

1) 78.0cm = ? um

2) 3.71×10^{-11} km = ? nm

3) 450g = ? kg

4) 65.1 ms = ? s

5) 3.00g = ? mg

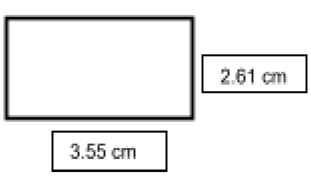
6) 3.45×10^{7} um = ? km

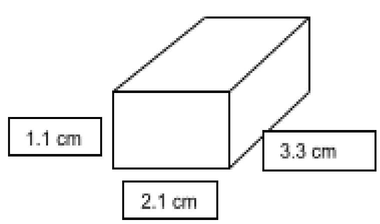
7) 5.66 inches = ? cm

8) 355 mL = ? qts

D. Combined Units - treated in many ways like variables in algebra

* we'll use rectangular stuff for simplicity





NOTE: 1 L = 1 dm^3 1 mL = 1 cm^3