Unit 1 Measurement

Scientific Methods

The scientific method refers to a ____________________ approach to scientific investigation. There is ________________________ one process known as the scientific method.

A. ____________________

1. Use existing __________________ and __________________
2. Qualitative data relates to the ______ ____________; describes _________________________
   - Examples:
3. Quantitative data involves _________________________ – numbers with ____________
   - Examples:

B. ____________________

1. Tentative ____________________ or ____________________ based upon observations
2. Includes ____________________ of results and _________________________
3. Two possible formats:
   - If/then statement
     - If: ____
       ____
     - Then: ____
       ____
     - May also include a ____________ to support prediction (____________)
   - Conditional statement
     - Suggests ____
       ____
     - Reason ____

C. ____________________

1. An experiment is a set of controlled ____________________ to test the hypothesis.

2. Only ______________________ variable can be changed or manipulated at a time.
3. __________________________ or manipulated variable is changed by the researcher. It may be the treatment applied or the ____________ and is graphed on the ____________.
4. __________________________ or responding variable changes in response. The value depends on the __________________________ variable. It represents the ____________ and is graphed on the ____________.
5. A _______________ is a factor that is not changed and that provides a basis or standard for __________________. An experiment may have control ____________ or _________________ _________________.
   - Control groups ____.
   - Controlled variables ____.
   - If an experiment is testing the effectiveness of a new fertilizer, what would be held constant?

Example

Melissa believes that turtles eating Tasty Turtle Tidbits food will become smarter and will be able to navigate a maze faster than turtles eating regular Turtle Chow. She decides to perform an experiment to test her hypothesis. She has ten turtles navigate a maze and records the time it takes for each one to make it to the end. She feeds Tasty Turtle Tidbits to five turtles and Turtle Chow to five other turtles. After one week, she puts the turtles through the maze again and records the times for each.

1) What was Melissa's hypothesis?
2) Which fish are in the control group?
3) What is the independent variable?
4) What is the dependent variable?

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Writing Activity: *A medical research team is investigating how taking aspirin will affect the number of heart attacks in men over 50 years of age.*

The control group takes a _____________________ instead of aspirin. Why? _______________________

____

What are the manipulated and responding variables? ____

____

____

What other factors would need to be controlled? ____

____

____

Write a possible hypothesis for this investigation. ____

____

____

In a line graph for this investigation, how would the x- and y-axes be labeled? _____________________

____

____

****

D. ____________________

1. ________ ____________ must be placed into meaningful context.
2. Involves performing ____ and summarizing data from multiple __________________.
3. Review, __________________, and make sense of collected data.
4. Allows comparison of experimental results to the ____________________.

E. ____________________

1. A ____________________ based on information obtained through experimentation
2. Data/results will ________________ or _________________________ the hypothesis.
3. A written conclusion _________________________ the results of the scientific process.

Hypotheses, Theories, and Laws

A. Hypothesis: supported by many ____________________

B. Theory: states a broad ____________________ of ____________ supported by many experiments over time. A theory is considered successful if it can be used to make predictions that are ____________. Example:

C. Scientific Law: describes a relationship in nature that is supported by multiple experiments with no _________________________. Example:

Measurement

Mars Climate Orbiter: What would happen if measurements were expressed one way but interpreted in another?

Reliability of Measurements

A. Every measurement consists of two parts: 1) a ____________ followed by 2) a __________ from the measuring tool.

- A measurement can only be as ____________ as the measuring tool used.
- The more _______________ in a measurement, the more _______________ it is.
    - Example: ____

B. All _________________________ possess a certain degree of ______________________________.

C. Types of Error

1. ____________________ error (_______________) are due to mistakes in procedure by experimenter or instrument and can be _______________.
2. _______________ error is expected, has an ____________ chance of being high or being low, and is addressed by _________________________________.
3. _______________ error or ________ occurs in the same direction (always high or always low) and is usually to ____.

D. Propagation of error: ____

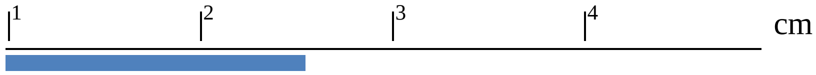
____

____

- Process begins with the experimenter making the measurement with a _____________________.
    - __________________________ are indicated by markings on measuring tool.
    - Space between markings gives one __________________________.
- Error is inherent in making measurements due to __________________ digits, and these errors subsequently affect ______________________________.

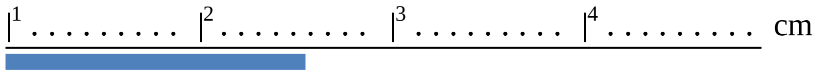
E. The maximum possible _______________ for a measuring tool is defined as ___________________ the smallest division marked on the tool. The uncertainty in the final digit of the measurement is assumed to be ________ (known as the ____________________________), unless otherwise noted.

- For rulers marked only by centimeters, the uncertainty in the last digit (estimated) is ________________________. Therefore, the plus-or-minus amount is _________________.
- For rulers with markings for millimeters in addition to centimeters, the plus-or-minus amount is ____________________________________. This ruler is __________________ than the first.



Ruler A:
Marked by Centimeters

- The length of the line is ____; therefore, a known digit in the measurement is "______".
- The second digit must be ____________________ because of the absence of markings.
- The length of the line can be measured as _____________ with an uncertainty of _____________, meaning the length measurement ranges from _________________________________.



Ruler B:
Marked by Millimeters

- The length of the line is ____; therefore, a known digit in the measurement is "______".
- The second digit is between ___________________________; due to the millimeter markings, a second known digit in the measurement is "______".
- The third digit must be ____________________.
- The length of the line can be measured as _____________ with an uncertainty of _____________, meaning the length measurement ranges from _________________________________.

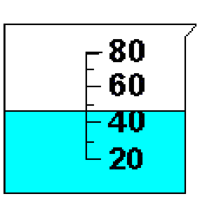
Reading Graduated Cylinders

A. To measure ___________________________, use a graduated cylinder

- Make volume readings at ____________________ with the graduated cylinder on a flat surface.
- View the curve or ______________________.
- Read the volume at the lowest point or _______________________________.

B. Typically, the smaller the graduated cylinder, the greater the ____________________.

- The markings on the cylinder give the _____________ digits in the volume reading.
- Digits between markings are ________________ and will be ________ the size of the smallest division.



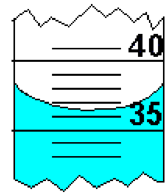
Cylinder A

Cylinder A is marked every _____________. Numbers only appear every 20 mL but the ___________________________________ divide the space evenly. The error or uncertainty is 1/10 of the 10-mL increment, making it _________.

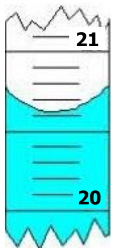
The liquid level in this cylinder could be measured as ________________, giving it a range of ___________________________.

Cylinder B is marked every _____________. The error or uncertainty is 1/10 of this increment, making it _________.

The liquid level in this cylinder could be measured as ________________, giving it a range of __________________________.



Cylinder B



Cylinder C

For Cylinder C, there are ___________ spaces between 20 mL and 21 mL; it is marked every _____________. The error or uncertainty is 1/10 of this increment, making it _________.

The liquid level in this cylinder could be measured as ________________, giving it a range of __________________________.

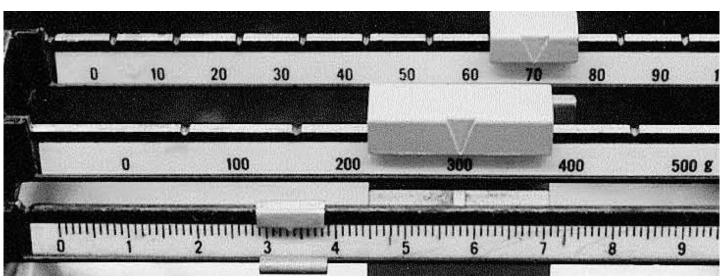
Reading Balances

A. Different types of balances differ in the ____________________ of their readings.

B. Electronic balances display all ___________ digits and one ________________ digit on the read-out.

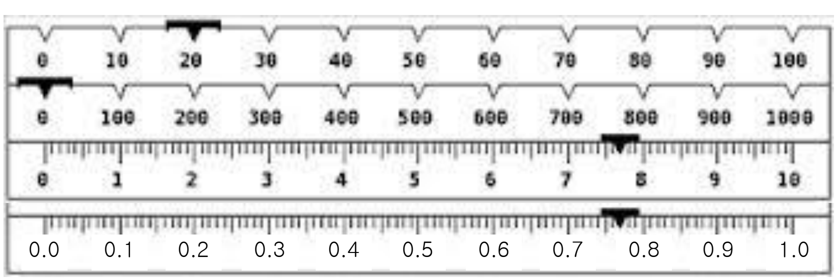
C. Triple beam balances have beams numbered for three place values: ____________________________ ___________. Four beam balances have an additional beam marked for the _____________ place value (one decimal place). In beam balances, the values for all beams are ________________________ to attain the total mass.

D. Estimating a final digit gives measurements written to _________ decimal places for triple beam balances and _________ decimal places for four beam balances.



The hundreds digit is _____________.
The tens digit is _____________.
The ones digit is _____________.
The tenths digit is _____________.
The hundredths digit is _____________.

___ ___ ___ . ___ ___ g



The hundreds digit is _____________.
The tens digit is _____________.
The ones digit is _____________.
The tenths digit is _____________.
The hundredths digit is _____________.
The thousandths digit is _____________.

___ ___ ___ . ___ ___ ___ g

Standards of Measurement

A. Measurement involves using a _________________________ to compare a specific dimension of an object to a _______________.

1. Ancient Egyptians used the length of _________________________ as the standard of measure.

2. What are some problems with this standard? ____ ____

B. In the 1790s, during the French revolution, the _________________________ was instituted as a standard system of measurement. A revision of this system began in 1948 and culminated in the publication of the ____ (or SI system) in 1960.

C. The building blocks of SI are the standard __________________ for seven quantities, which are defined in terms of objects or events in the physical world, while _________________________ are defined by combinations of the seven base units.

1. Time: __________________ (____)

2. Length: __________________ (____)

3. Mass: __________________ (____)

4. Temperature: __________________ (____)

5. Amount of a substance: __________________ (______)

   a. ____________________ items makes up one mole of that item

   b. AKA ____________________ Number

6. Electric current: __________________ (______)

7. Luminous intensity: __________________ (______)

Prefixes for SI Units

A. Prefixes are used to produce a __________________ of the original unit.

1. All multiples are ____.

2. Prefixes are used with the SI _________________________ but are never combined. Prefixes may also be used with certain _________________________, which are considered acceptable for use with SI.

3. Multiples for mass are named as if the _______________ is the base unit.

B. Memory aid: ____

			base unit			
1,000 or 10^3	100 or 10^2	10 or 10^1	1 or 10^0	.01 or 10^{-1}	.001 or 10^{-2}	.0001 or 10^{-3}

C. ______________________ can be made between different prefixes, using the ____________________ ____________________ between them.

1. Dimensional analysis: ____
   ____
   ____

2. ___________________________ express the relationships between two units for the same quantity.

   1 kg = _____________ g   1 g = _____________ dg

   1 hg = _____________ g   1 g = _____________ cg

   1 dag = _____________ g   1 g = _____________ mg

3. Short-cut conversions only work when ____.

Smaller → Larger	**Larger → Smaller**
_____________ by 10 for each increment	_____________ by 10 for each increment
Move the decimal point one place to the _____________ for each increment	Move the decimal point one place to the _____________ for each increment

Short-Cut Conversion Practice

1) 10 m = ___________ mm
2) 500 g = ___________ kg
3) 75 cs = ___________ s
4) 450 mg = ___________ g
5) 25 dm = ___________ dam
6) 750 hs = ___________ks
7) 0.50 kg = ___________ mg
8) 17.5 dm = ___________ hm
9) 32.5 dag = ___________ g
10) 25 ms = ___________ s

Dimensional Analysis

A. Dimensional analysis must be used when ____.

B. Dimensional analysis uses ___________________________, which identify the relationship between two values with different units that express the same quantity. These factors provide ______________ ________________ to go from the starting point to the ending point.

- Examples:

C. Conversion factors are _____________ and can be expressed as _____________. Each fraction can be written in ________________ and always equals a value of ______.

- Example: If you have one dozen eggs, how many eggs do you have? ________________________. Therefore, __________________________. Written as fractions —

D. Dimensional analysis is a problem-solving method consisting of specific steps.

1. ________________________________: identify (underline) the unknown in problem statement.
2. ________________________________: identify (circle) the given in the problem statement.
3. ________________________________: provides framework to get from start to finish.
4. ________________________________: determined by applicable conversion factors.

Dimensional Analysis Practice

How many kilograms are in 150 lbs? What conversion factor(s) apply to this problem? _________________

This conversion factor can be expressed as a fraction in two forms:

Write the ___________, start with the ___________, and then draw the ___________ to connect the two quantities.

Use dimensional analysis to solve the following problems.

1) How many seconds are in 22 days?

2) How many inches are in 127 miles?

3) How many calories are in 42 joules?

Volume

A. Volume: the _______________________________ occupied by a sample of matter

1. Derived unit for volume: ____________ __________ (______); ____________ ____________ (______ or ______) is more useful in chemistry

   - 1 m^3 = ________ cm^3

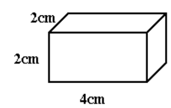
2. Some non-SI units are accepted for use with SI units; for example, the _______________ (____) is still an accepted unit for liquid volume.

   - 1 L = __________________

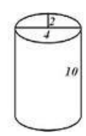
3. For smaller quantities of liquids, volume is measured in _______________ (____).

   - 1 cm^3 = 1 cc = ______ mL
   - 1 dm^3 = 1 L = __________ mL

C. Volume of _______________ Objects: solid objects with regular dimensions



1. For square/rectangular objects, V = (length)(width)(height)
   - Calculate the volume of the cube:



2. For cylinders, V = π(height)(radius), where π = 3.14
   - Calculate the volume of the cylinder:

D. Volume of _______________ Objects: solid objects with irregular shapes

1. Use the method called ____________ _________________________.

   ① Add water to a ______________________________. Measure and record the volume.

   ② Add the ____________________________ to the cylinder. Measure and record the new volume.

   ③ Use the initial and final volume readings to calculate the volume of the object.

   - V_{object} =
   - A toy dinosaur placed in a graduated cylinder causes the water to rise from 4.80 mL to 5.60 mL. What is the volume of the rock? _______________________________________

Density

A. Density (D): ____

B. Formula

D =

C. Using the Density Formula

1. Find the density of aluminum if a 13.5 g sample has a volume of 5.0 cm^3.

2. Find the mass of a liquid if 10. mL have a density of 2.1 g/mL.

D. The density of water (H_2O) is ____________ or ____________. Therefore, 1 mL of water has a mass of ______ g, meaning, for water, ________________________ (conversion factor).

- Given that the density of water can be expressed as 1 g/cm^3 or 1 g/mL, what can you say about the relationship between cm^3 and mL?

Temperature

A. Temperature defined: a measure of the average ____________ ____________ of particles of a substance

B. Used to compare the relative ___________________________________ of objects or substances

C. Measure with a _________________________

D. The Celsius scale is a __________________ temperature scale based upon the freezing point (______) and boiling point (______) of water. The distance between these two points was divided into 100 equal units known as ____________ ____________.

E. The kelvin scale is an __________________ temperature scale devised by Lord Kelvin and based upon the temperature known as __________________ ____________ (the lowest possible temperature where all molecular motion stops). There are no __________________ temperature values on the kelvin scale.

F. Formula for conversion:

Conversion Practice

1) 100°C = __________ K
2) 0°C = __________ K
3) 25°C = __________ K
4) 27°C = __________ K

4) 293 K = __________°C
5) 333 K = __________°C
6) 303 K = __________°C
7) 223 K = __________°C

Representing Data

A. _____________: a visual display of data that helps to reveal ________________

B. A ________________ graph shows parts, often as percentages, of a fixed whole (100%).

C. A ___________ graph shows how a quantity varies with specific factors.

D. A _________ graph, the most useful in chemistry, consists of points representing the intersection of data for two variables: the independent on the ____-axis and the dependent on the ____-axis.

1. ________________ plot: points are plotted based upon the values for the independent and dependent variables
2. _________ _______ line: does not have to touch all data points; drawn with as many points above the line as below it
3. Straight line indicates a ________________ relationship.
   - A ________________ slope (line rises to the right) indicates that the dependent variable ________________ with an increase in the independent variable.
   - A ________________ slope (line sinks to the right) indicates that the dependent variable ________________ with an increase in the independent variable.

E. Creating a line graph requires specific steps.

1. General guidelines: ____ ____.
2. Calculate the ___________ for both the independent and dependent variables by taking the ________________ between the highest and lowest value for each. The ______________________ is graphed on the longest side of the graph paper, determining whether to use the paper in the ____.
3. Data collected for the independent variable usually appears in the ________________ column of the data table and is graphed on the ___________. Data for the ________________ variable is in the righthand column of the data table and is graphed on the ___________. Both axes should be labeled with the ______________________ followed by the appropriate _________ in parentheses.
4. The _____________ is the value represented by one box on the graph paper and can vary for each graph. The scale should be set as _____________ as possible based upon the size of the graph paper, but it usually equals _________________________________. Scales for the x- and y-axes do not have to be the same.

5. Mark the __________________ on each axis evenly, such as every line or every other line. Both axes do not have to be marked the same, but each should be marked ____________________. Increments are usually marked by ______________________________ and must make sense in terms of the __________.

6. Only one __________________ (upper right) of a graph is used and should be drawn to take up as much space on the graph paper as possible. Do not extend axes below or to the left of the origin and do not draw __________________. The intersection of axes (____________) is the starting point for both axes, but it does not have to be ________ and does not have to be the __________________ for both axes.

7. Draw a ________ representing the intersection of the x- and y-axes for each data value in the data table. The points must remain _______________ once the line is drawn but are only labeled with their ____________________ if the labeling does not clutter the graph.

8. Unless otherwise instructed, all lines should be drawn as ________________________, which may be ____________________________. Do not draw ____________ on the ends of lines.

9. The __________ of the graph should be written toward the top of the graph in any available space; do not allow the title to obscure the lines in any way. The title should use the __________ ________________________ for the x- and y-axes in the format __________________________ ________________________ to show the dependence of the dependent variable on the independent variable.

Graphing Practice

A sample of gas was collected at 100°C and then cooled. Changes in volume were recorded in the following data table. Graph the data shown on the graph paper provided on the next page.

Temperature (°C)	**Volume (mL)**
100	315
80	300
60	290
40	280
30	250
20	245
10	240
0	235
–10	225
–30	200

Reliability of Measurements

A. Accuracy:

B. Precision:

C. The ________________ of experimental data must be evaluated. An __________ is the difference between an experimental value and an ________________ value.

Error =

D. Percent error is a _____________ of an error to an accepted value.

$$\text{Percent Error} = \frac{\text{Error}}{\text{Accepted Value}} \times 100 =$$

Practice: *Using the data in the table below, calculate the average percent error (use average data, not trial data) for the three groups if the accepted value for density is 1.60 g/cm^3.*

Density Data	Group A (g/cm^3)	Group B (g/cm^3)	Group 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
Average	**1.57**	**1.51**	**1.70**

Which group's data was most accurate (using averages)? Which group's data was most precise (using trial data)?

Significant Figures or Digits

A. The precision of measurements is limited by the ____________________ ________ and is indicated by the ____________ of digits reported; these digits are known as ____________________ figures.

B. Significant figures include all __________ digits plus one _______________ digit.

C. Rules for determining significant figures

1. Non-zero numbers are ____________ significant.
2. Zeros between non-zero numbers are ____________ significant.
3. All final zeros to the right of the decimal place ______ significant.
4. Zeros that act as placeholders are ______ significant.
5. Counting numbers and defined constants have an ____________ number of significant figures.

PACIFIC

Decimal **P**resent

ATLANTIC

Decimal **A**bsent

0.003405800
____ SF

300700
____ SF

Practice How many significant figures are in each of the following measurements?

38.15 cm	__________	0.008 mm	__________	50.8 mm	__________
72.050 kg	__________	25,000 m	__________	200. yr	__________

Calculations with Significant Figures

A. Recall: propagation of uncertainty means ____

____

B. A calculated answer cannot be more _______________ than the measuring tool.

C. A calculated answer must match the ____________ precise measurement.

D. Addition and Subtraction

- The answer has the same number of decimal places as the measurement with the ____________ decimal places. For example, 2.51 + 3.064 = ____________.

E. Multiplication and Division

- Round result or add zeros to the calculated answer until it has the same number of significant figures as the measurement with the ____________ significant figures. For example, 3.50/2 = _________.
- Rounding is reserved for the ____________________; do not ____________________________ ________________________ for intermediate answers.