1 Nature of Science

Chemistry Theme Songs? Sodium-Sodium-Sodium-Sodium Sodium-Sodium-Sodium-Sodium Batman

1.1 Lab Safety & Equipment

- Goggles must be worn over your eyes at all times! Wearing safety goggles correctly is required to protect your eyes during laboratory investigations.
- Your clothing should cover your legs - shorts are not appropriate for the laboratory. Lab aprons can be used to protect good clothing. No loose clothing! It can dip into chemicals or fall into a flame and catch fire.
- Sandals and open-toed shoes do not protect your feet from broken glass that is frequently found in the lab. Also, leather shoes protect your feet from chemical spills, shoes do not.
- Dangling hair can fall into the Bunsen burner and catch fire or can fall into a chemical solution.
- Do not apply cosmetics, eat, or drink in the lab - these activities are ways by which you can accidentally ingest harmful chemicals.
- Do not taste chemicals. Do not small any chemicals directly. If you smell chemicals, use your hand to waft vapors to your nose.
- Heat test tubes at an angle and away from you and others.
- Handle hot glassware with the appropriate tongs.
- Never work along in the lab - in the case of a problem, you may need another person to prevent injury or even save your life!
- Don't assume you dispose waste down the sink. Dispose of all waste materials according your instructional procedure.
- Never remove chemicals from the laboratory.
- Wash your hands with soap and water before leaving - this rule applies even if you have been wearing gloves!
- Report any accidents or unsafe conditions immediately!
- Remember that the lab is a place for serious work! Careless behavior may endanger yourself and others and will not be tolerated!

Know the safety equipment and how to use the following safety equipment.

- Eye wash fountain
- Safety shower
- Fire extinguisher
- Emergency exits

NFPA Chemical Hazard Label

- Blue - Health
- Red - Flammability
- Yellow - Reactivity (Stability)
- White - Special

Hazard Ratings

- 4 - Severe
- 3 - Serious
- 2 - Dangerous
- 1 - Minor
- 0 - Slight

MSDS

- Material Safety Data Sheet (now often just called Safety Data Sheet, SDS)
- On file for all purchased chemicals.
- Includes all information shown on a chemical label and more.

Lab Equipment

- Beakers hold liquids. They don't precisely measure.
- Test tubes hold small amounts of liquid.
- Erlenmeyer flasks are used to hold liquids and swirl mixtures.
- Test tube racks hold test tubes.
- Bunsen burners heat with intensity.
- Hot plates heat at a wide variety of temperatures, from low to high.
- Plastic pipettes transfer small, approximate amounts. Not for measuring.
- Volumetric flasks are used for making solutions of a specific volume. They only have one line for measuring.
- Beaker tongs are used to pick up a hot beaker.
- Test tube tongs are used to hold one test tube.
- Crucible tongs are used to pick up a crucible or hold something in flame.
- Ring stand & rings are used for holding items over flame for a long period of time or filtering.
- Wire gauzes are used to put hot beakers on to prevent shattering.
- Balances are used to measure the mass of an object.
- Glass pipettes measure small amounts of liquid by suction.
- Graduated cylinders measure the volume of a liquid.

Exercise List the Laboratory Safety DOs and DON'Ts

Exercise What are four pieces of safety equipment and how do you use them?

Exercise What does a Safety Data Sheet (SDS) tell you?

Exercise Which lab equipment measures chemicals?

1.2 Matter, Energy, & Change

Chemistry is the science that investigates structures and properties of matter.

- Matter - anything composed of atoms
- Mass - a measure of how much matter is in an object
- Weight - measure of gravity's pull on matter
- Volume - measure of how much space is taken up

Exercise What is the difference between mass and weight, and what instruments are used to measure mass and weight?

There are two types of data

- Qualitative (qualities)
- Quantitative (quantities)

Graphs

- Independent Variable - the one that is controlled or consistent; found on the x-axis
- Dependent Variable - the result; found on the y-axis

Measurable Properties

- Extensive - property that depends on HOW MUCH matter you have
- Intensive - property that is INDEPENDENT of the amount of matter

Physical and Chemical Properties

- A physical property can be observed without a chemical change occurring.
- A chemical property can be observed only when a chemical change occurs. In physical changes:
  - atoms are not rearranged into new substances
  - include all changes of state
  - changes in size, shape, or dissolving

  In chemical changes:
  - bonds are broken between atoms and new bonds are formed to make new substances.
  - Chemical changes are usually more interesting than physical changes

Four Indicators of a Chemical Change

1. Energy change - heat or light is produced, or a decrease in temperature occurs
   - Exothermic - gives off heat, feels hot
   - Endothermic - absorbs heat, feels cool
2. Production or evolution of a gas
3. Precipitate - a solid is formed when two liquids are mixed together
   - The clue that a precipitate has formed is that the liquid turns cloudy, it could be any color.
4. Color Change

Exercise Is tarnishing a physical of chemical change/property?

Exercise Is breaking a physical of chemical change/property?

Exercise Is combustion a physical of chemical change/property?

Classification of Matter

- Mixture: two or more pure substances that can be separated by physical changes.
- Homogeneous Mixture: two or more pure substances mixed evenly. When you look at it, you can't see separate parts.
- Heterogeneous Mixture: two or more pure substances mixed unevenly.
- Element: one of the 118 pure substances that cannot be separated by chemical change or physical change. Represented by a symbol on the periodic table.
- Allotrope: same element with different bonding of atoms (different properties)

- Compound: made from atoms that are chemically bonded together. Can be separated by chemical change, but not physical change. Represented by a formula.

Exercise How is bonding different than mixing?

The Law of Definite Proportions (sometimes called Law of Constant Composition) states that all samples of a compound contain the same elements in the same proportion.

The Law of Multiple Proportions states that if elements combine to make more than one compound, the masses will be small, whole number ratios.

The Law of Conservation of Mass states that matter cannot be created or destroyed in any type of change. What you start with is what you end up with, just in a different form.

The Law of Conservation of Energy states that energy cannot be created or destroyed (but it can change forms).

The Periodic Table

- Find the zig-zag line.
- Metals are to the left of the zig-zag line (except for H)
- Non-metals are to the right of the zig-zag line
- Elements touching the line are called metalloids
- The vertical columns are called groups (or families)
- The horizontal rows are called periods.

1.3 Measurement

Accuracy vs. Precision

- Accuracy - how close a measurement is to the accepted value
- Precision - how close a series of measurements are to each other

Accuracy is correctness, precise is consistency.

Percent error indicates the accuracy of a measurement

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

Example

Juan calculated the density of aluminum three times: 2.75 g/cm^3, 2.68 g/cm^3, and 2.84 g/cm^3.

Aluminum has a density of 2.70 g/cm^3. Calculate the average percent error for the three trials.

The percent error for the trials are 1.85%, 0.74% and 5.19% respectively. The average of the three is 2.59%.

Exercise Suppose you calculate your semester grade in chemistry as 90.1, but you receive a grade of 89.4 on your report card. What is your percent error?

Exercise On a bathroom scale, a person always weighs 2.5 lbs less than on the scale at the doctor's office. What is the percent error of the bathroom scale if the person's actual weight is 125 pounds?

Significant Figures

- Indicate accuracy of a measurement.
- Sig figs in a measurement include the known digits plus a final estimated digit.

- It is important to be honest when reporting a measurement so that is does not appear to be more accurate than the equipment used to make the measurement.

Counting Sig Figs

Count all numbers except

- Leading zeroes
- Trailing zeros without a decimal point

Rules for Counting Sig Figs

- All nonzero digits are significant
- Sandwiched zeroes are significant
- Zeroes at the beginning are never significant
- Zeroes at the end are significant only if you can see the decimal point

Note:

- Non significant does mean unaccounted for
- Sig Figs keep track of the accuracy of our measurements

Exercise Count the number of sig figs in each number

1. 98
2. 0.0098000
3. 980.0

Scientific Notation Converting into scientific notation:

- Move decimal until there's 1 digit to its left. The places moved is the exponent.
- A number greater than 1 gets a positive exponent and a number less than 1 gets a negative exponent.

Exercise Write in scientific notation and keep the same number of significant figures:

1. 0.00007
2. 422000.

Exercise Write in standard notation and keep the same number of significant figures:

1. 3.1×10^4
2. 1.00×10^2

Mathematical Operations with Sig Figs

- When combining measurements with differing degrees of accuracy and precision, the accuracy of the final answer can be no greater than the least accurate measurement.
- This principle can be translated into simple rules for mathematical operations.
- Remember the order of operations and always include units in your answer if units are given in the problem.

When adding or subtracting, the answer cannot go beyond the last significant place of the least precise measurement.

When multiplying or dividing, the # with the fewest sig figs determines the # of sig figs in the answer.

Exact numbers do not limit the number of significant figures.

Exercise

1. 150.0 grams + 0.507 grams
2. 98.0 grams ÷ 2.33 liters

Tips:

- Determine which rule you are dealing with first! Add/Sub = least decimal places. Mult/Div = least number of sig figs.

Density

- Density is the measure of how much mass is contained in a given unit of volume.
- It depends on what the matter is, not how much you have.
- Density is an intensive property.

Density depends on two things:

1. How tightly packed the atoms are
2. What kind of atoms they are

Density is calculated with the formula

$$D = \frac{m}{V}.$$

This can be arranged to solve for mass or volume.

Exercise Use algebra to rearrange the density formula to solve for volume.

When working density problems, use the following steps:

1. Write the correct formula you'll be using
2. Substitute in the correct values with units
3. Work the problem with your calculator and give the answer with the correct number of sig figs and correct units

Exercise A metal cylinder is placed into a graduated cylinder with a 24.0 mL of water. After the cylinder is added, the volume of water rised to 30.4 mL. The density of the cylinder is known to be 8.9 g/mL. What is the mass of the cylinder?

Exercise A metal cylinder has a diameter of 4.4 cm and a height of 10.5 cm. If the cylinder is silver, which has a density of 10.5 g/cm^3, what is its mass? The volume of a cylinder is $\pi r^2 h$. (Use 3.14 for pi.)

Proportions In a direct proportion, the relationship should be linear.

In an inverse proportion, the relationship will be non-linear and decreasing.

1.4 Dimensional Analysis

First, off the metric system!

S.I. or metric units are: Mass in grams (g), Length in meters (m), Volume in liters (L)

Prefixes to know: kilo = 1000, centi = 1/100, milli = 1/1000

Memorize these conversions!

- 1 kg = 1000 g
- 1 g = 100 cg
- 1 g = 1000 mg
- 1 km = 1000 m
- 1 m = 100 cm
- 1 m = 1000 mm
- 1 cm = 10 mm
- 1 L = 1000 mL

Dimensional analysis is the method that chemists (and other scientists) use to solve conversion problems.

Exercise

1. Convert 23.9 km to m
2. If 1 inch = 2.54 cm, convert 3.00 cm to inches
3. Convert 25 inches to cm
4. If 1 gallon = 4.1 L, convert 2.5 gal to L

Exercise

1. What is the length of a football field in cm if there are 2.54 cm in an inch and 36 inches in a yard?
2. Diamonds are measured in units called a carat. One carat equals 200 mg. If a diamond is 0.600 carat, what is the mass of the diamond in ounces?

Chapter Problems

1. How many significant figures are in 1.003?
2. Write 0.00007 in scientific notation, keeping the same number of significant figures.
3. Write 1.00×10^2 in floating decimal notation (standard notation), keeping the same number of significant figures.
4. Round 0.003008 to 3 significant figures.
5. Calculate 45.0 cm - 9.2 cm and round to the correct number of significant figures and include the correct units.
6. Round 400×600 to the correct number of significant figures.
7. If candy bars are 3 for one dollar, how much money will you need to buy 46 candy bars?
8. What volume will be occupied by 7.0 kg of helium if 4.003 g of helium occupies 22.4 L?
9. Twenty five paper clips are dropped into a graduated cylinder and the water level rises from 10.8 mL to 12.2 mL. If the density of the paper clips is 7.87 g/mL, what is the mass of the 25 paper clips? What is the mass of one paper clip?
10. A block of wood with a density of 0.548 g/cm^3 has a mass of 34.49 g. If two dimensions of the block are 2.5 cm and 7.8 cm, what is the 3rd dimension?