Unit 1--Properties of Matter

- What is matter?
  - Anything that has mass and takes up space
  - Everything around you is matter including air and bacteria that you cannot see
- What is a Pure Substance?
  - Matter that has a uniform and unchanging composition
  - Table Salt and water are pure substances
  - If you examine any part of a sample the composition will be the same

Unit 1--Properties of Matter

- Ocean water is NOT a pure substance because one sample may not have the same salt content as another sample

- What is a physical property?
  - Characteristic that can be observed or measured without changing the sample's composition
  - It is easy to identify objects by their properties
  - Properties can also be called characteristics

Unit 1--Properties of Matter

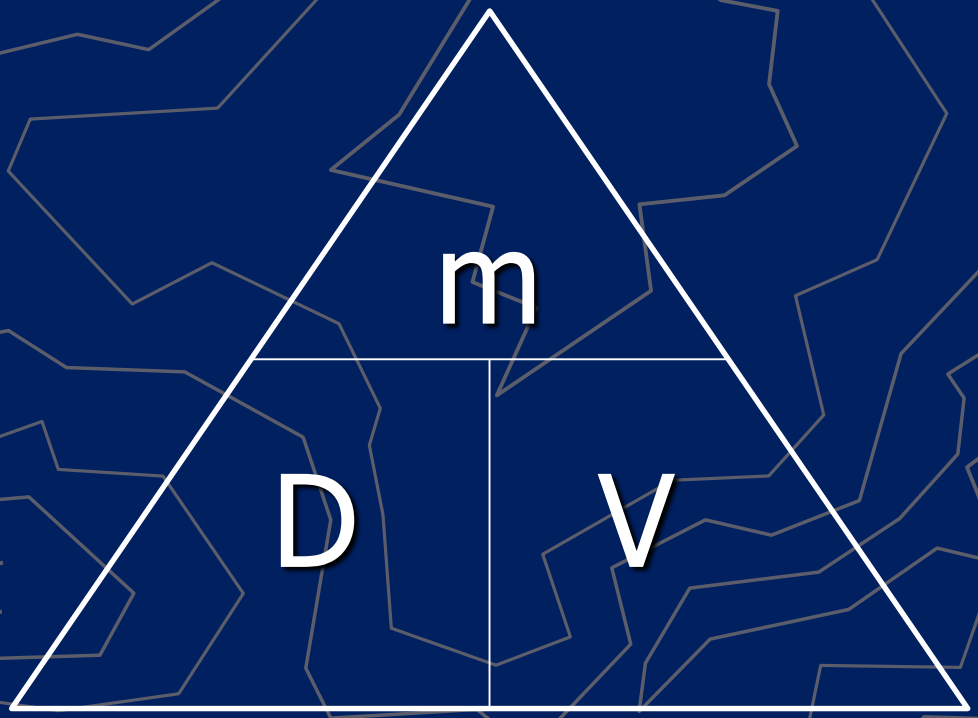
- Physical properties can be used to describe or identify any substances
- What are examples of physical properties?
  - Density
  - Color
  - Odor
  - Taste
  - Melting point
  - Boiling point

Density

- What is density?
  - Density is a physical property
  - It is a ratio that compares the mass of an object to its volume
  - Units for density are grams per cubic centimeter
  - This is written as g/cm^3 or g/cc
  - Density explains why a cement brick is much heavier than a foam brick of the same size
  - Density is calculated by dividing mass by volume

$$D = \frac{m}{v}$$

Density Triangle



Density

- Sample densities:
  - Water 0.998 g/cc (usually considered to be 1)
  - Cork 0.24 g/cc
  - Butter 0.86 g/cc
  - Lead 11.35 g/cc

Unit 1--Properties of Matter

- What are Chemical Properties?
  - Ability to combine with or change into one or more other substances
  - Cannot always be seen until the substance reacts with something else
  - Examples of chemical properties
    - Iron will form rust when exposed to *oxygen*
    - Iron will NOT rust when exposed to *nitrogen*
- All substances have their own unique physical and chemical properties

Properties of Copper

Physical Properties	Chemical Properties
Reddish brown, shiny	Forms green copper carbonate when in contact with moist air
Easily shaped into sheets (malleable) or drawn into wires (ductile)	Forms new substances when combined with nitric acid and sulfuric acid
Good conductor of heat and electricity	Forms a deep blue solutions with ammonia
Density = 8.92 g/cm^3	
Melting point = 1085^0C	
Boiling point = 2570^0C	

Unit 1--States of Matter

- What are the four states of matter (phases)?
- SOLIDS—definite shape, definite volume
  - Particles (atoms or molecules) are tightly packed together
  - Particles vibrate a little in one place but cannot move away from each other
  - Solids cannot be pressed into a smaller volume—they are incompressible
  - Expand when heated

Unit 1--States of Matter

- LIQUIDS—no definite shape, definite volume
  - Particles move more rapidly than solids and are able to flow past each other
  - Take the shape of their container
  - Cannot be pressed into a smaller volume (incompressible)
  - Expand when heated
- GAS—no definite shape, no definite volume
  - Particles move rapidly and bounce against each other, vibrating to the limits of their container

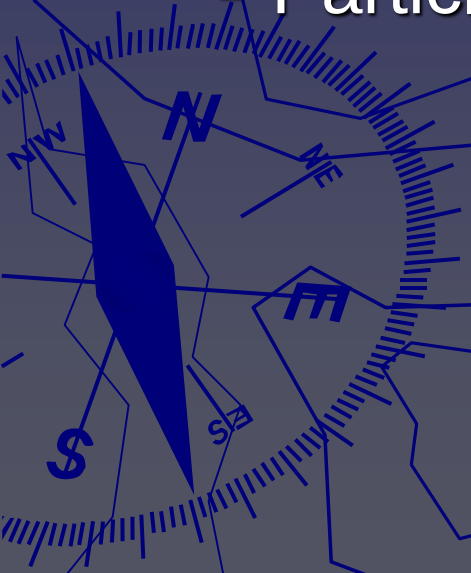
Unit 1--States of Matter

- Flow to take the shape of its container
- Fills the entire volume of whatever container it is in
- Are easily compressed because the particles have a lot of space between them
- Expand easily when heated

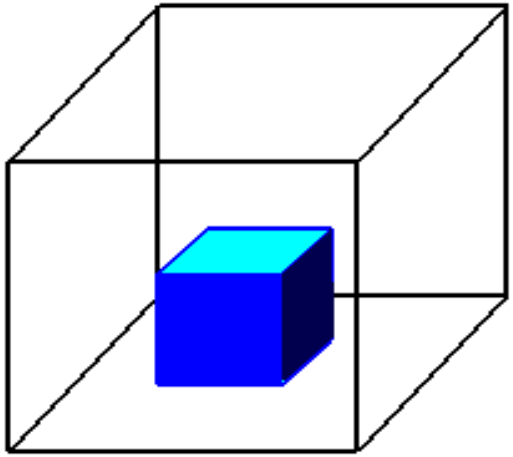
- What is the difference between a gas and a vapor?
  - Gas = substances that are in the gaseous state at room temperature
  - Vapor = a substance that is now a gas, but is usually a solid or liquid at room temperature

Unit 1--States of Matter

- PLASMA—no definite shape, no definite volume
  - High temperature physical state of matter where atoms lose their electrons.
  - Does not occur naturally on Earth except for lightning bolts
  - Particle motion is similar to gases.



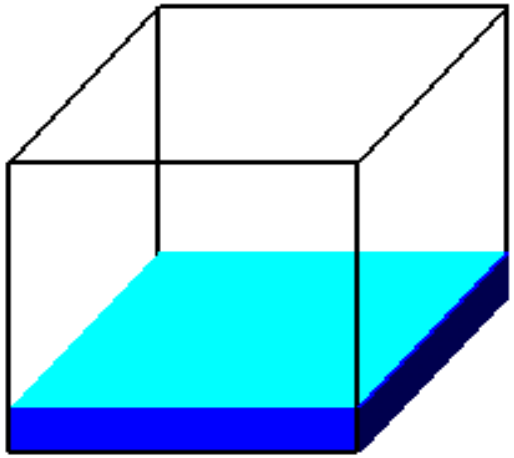
States of Matter



Solid

Holds Shape

Fixed Volume

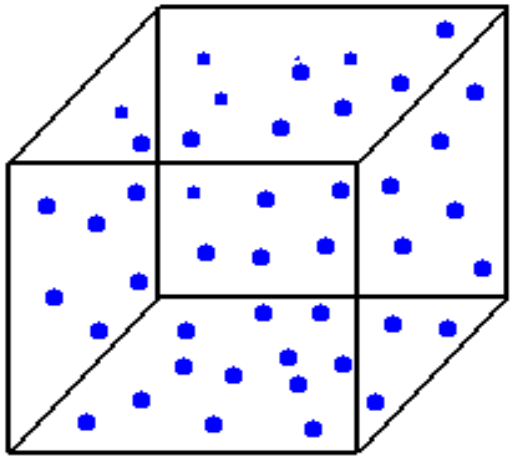


Liquid

Shape of Container

Free Surface

Fixed Volume



Gas

Shape of Container

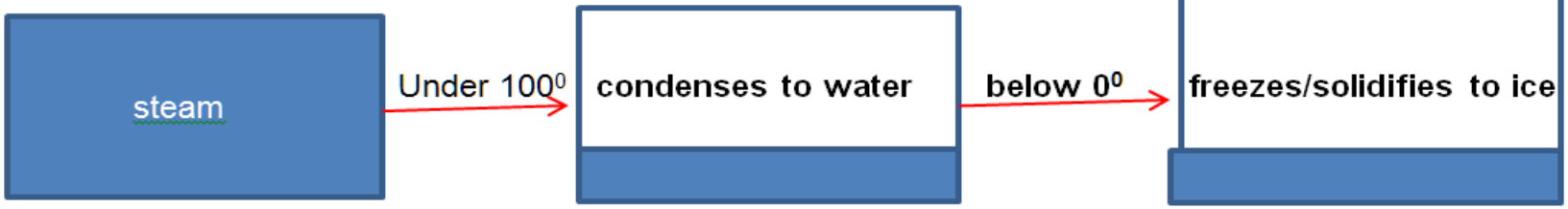
Volume of Container

Unit 1--CHANGES IN STATE

- How do substances change state?
- Substances can change their state by heating or cooling.
- Water can be a solid (ice), and liquid (water) or a gas (steam)
- Ice slowly changes to water when it is in a warm place
- This change is called melting
- The melting point of ice is 0^0 Celsius
- The temperature will stay at 0^0 until all of the ice is melted

- As the temperature of the water increases, some of it turns into water vapor
- Changing to water vapor is called evaporation
- Applying more heat to the water causes bubbles to appear
- This is called boiling
- When water turns to steam at the boiling point it is called vaporization
- The boiling point of water is 100^0 C
- The temperature will remain at 100^0 C until all the water has boiled off.

- Condensing is the opposite of evaporating
- Freezing is the opposite of melting
- The freezing point of water is the same as the melting point of ice
- Nearly all substances can exist as solid, liquid and gas.



Unit 1—Changes in Matter

- NOTE TAKING HINT: the Greek letter delta—shown by a triangle– Δ– means “change”
- What is a physical change?
  - Physical changes = a change in a substance that does not change its composition
- What are examples of physical changes?
  - Cutting
  - Bending
  - Grinding
  - Crumpling

Unit 1—Changes in Matter

- Splitting
- Crushing
- Changes in state (change in phase)

- Changes in state are physical changes
  - When water freezes it turns into ice, and looks different, but it is still water
  - The composition is still the same
- What are examples of phase changes (physical Δs)
  - Melting—change from solid to liquid
  - Freezing—change from liquid to solid
  - Evaporation—change from liquid to gas

Unit 1—Changes in Matter

- Boiling (vaporizing)—change from liquid to gas
- Condensation—change from gas to liquid
- Sublimation—change from solid to gas

- What is a chemical change?
  - Chemical change = process where one or more substances change into a NEW substance
  - Commonly called a *chemical reaction*
- What are the parts of a chemical reaction (rxn)?
  - Starting substances are called <u>reactants</u>
  - Ending substances are called <u>products</u>

Unit 1—Changes in Matter

- Chemical Reactions
  - Shown in chemical shorthand as:

Reactant + Reactant ⟶ Product(s)

  - Example:

Iron + Oxygen ⟶ Rust

  - Rust is an entirely new and different substance
  - What are some examples of chemical Δs ?
    - Explode
    - Rust
    - Oxidize

Unit 1—Changes in Matter

- Corrode
- Tarnish
- Ferment
- Burn
- Rot

- All of these processes produce NEW substances
- What is the evidence (clues) of chemical Δs ?
  - Formation of a gas
  - Formation of a new solid (precipitate)
  - Color change
    - Leaves changing

Unit 1—Changes in Matter

- Energy change
  - Production of heat—like burning of a log
- Change in smell
  - Rotting or decomposing
- A chemical reaction ALWAYS produces a change in properties

What is conservation of mass?

- Scientists measured mass before and after many chemical reactions
- Results were TOTAL MASS INVOLVED IN THE REACTION STAYED CONSTANT
- This happened so many times without fail that it became a scientific law
- What is the Law of Conservation of Mass?
  - This Law states that “Mass is never created or destroyed during a chemical reaction”
- Written scientifically as:

$$\text{Mass}_{\text{reactants}} = \text{Mass}_{\text{products}}$$

Conservation of Mass

- Who was the first scientist to prove the Law of Conservation of Mass?
  - Antoine Lavoisier
- He heated Mercury (II) oxide and produced liquid mercury and oxygen
- Written scientifically as:

Mercury (II) oxide $\longrightarrow$ mercury + oxygen

216 g $\longrightarrow$ 200 g + 16g

- The reaction must be done in a closed container in order to trap the oxygen (closed system)

Unit 1--Mixtures of Matter

- What is a mixture?
- Combination of two or more pure substances where each pure substance keeps its individual chemical properties
- What are the two kinds of mixtures?
  - HOMOGENEOUS mixtures = uniform in composition
    - Homogeneous mixtures are also called solutions
    - Ex. = salt water—salt is completely dissolved and uniformly distributed throughout the volume of the sample. The salt does not settle to the bottom of the sample if you leave it sitting around.

Unit 1--Mixtures of Matter

- HETEROGENEOUS mixtures = mixtures that are NOT uniform throughout.
  - Ex. = sand or dirt in water. You can swirl sand/dirt and water around, but if you leave it stand, the sand/dirt will sink to the bottom.
  - Ex. = Chicken noodle soup—every bowl contains a different amount of noodles, vegetable and chicken

Unit 1--Mixtures of Matter

- What are some types of solution systems?
- Gas dissolved in gas
  - Air is a mixture of nitrogen, oxygen and argon gas
- Gas dissolved in liquid
  - Carbonated beverages are carbon dioxide in a solution of flavors, etc.
- Liquid dissolved in gas
  - Moist or humid air contains water droplets

Unit 1--Mixtures of Matter

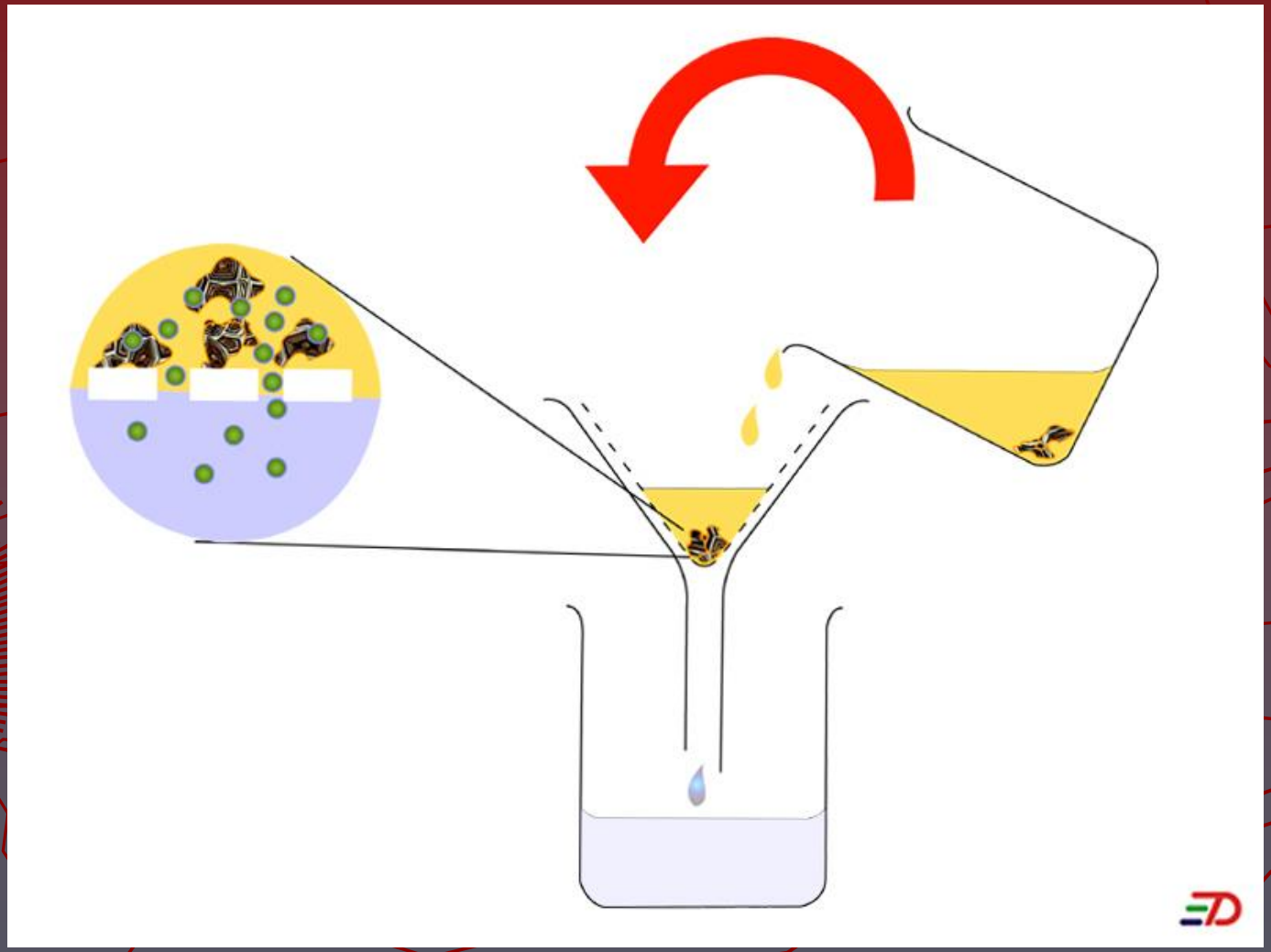
- Liquid dissolved in liquid
  - Vinegar is acetic acid in water
- Solid dissolved in liquid
  - "Kool-aid" contains sugar and other solid ingredients in water
- Solid dissolved in solid
  - These are called "alloys'
  - Steel is an alloy of iron containing carbon

Unit 1--Mixtures of Matter

- How can mixtures be separated?
  - Substances in mixtures are physically combined
  - They are separated based on physical properties
  - Once separated you can identify the unchanged original substances
- What methods are used to separate mixtures?
  - Filtration—using a porous barrier—like filter paper to separate a solid from a liquid

Unit 1--Mixtures of Matter

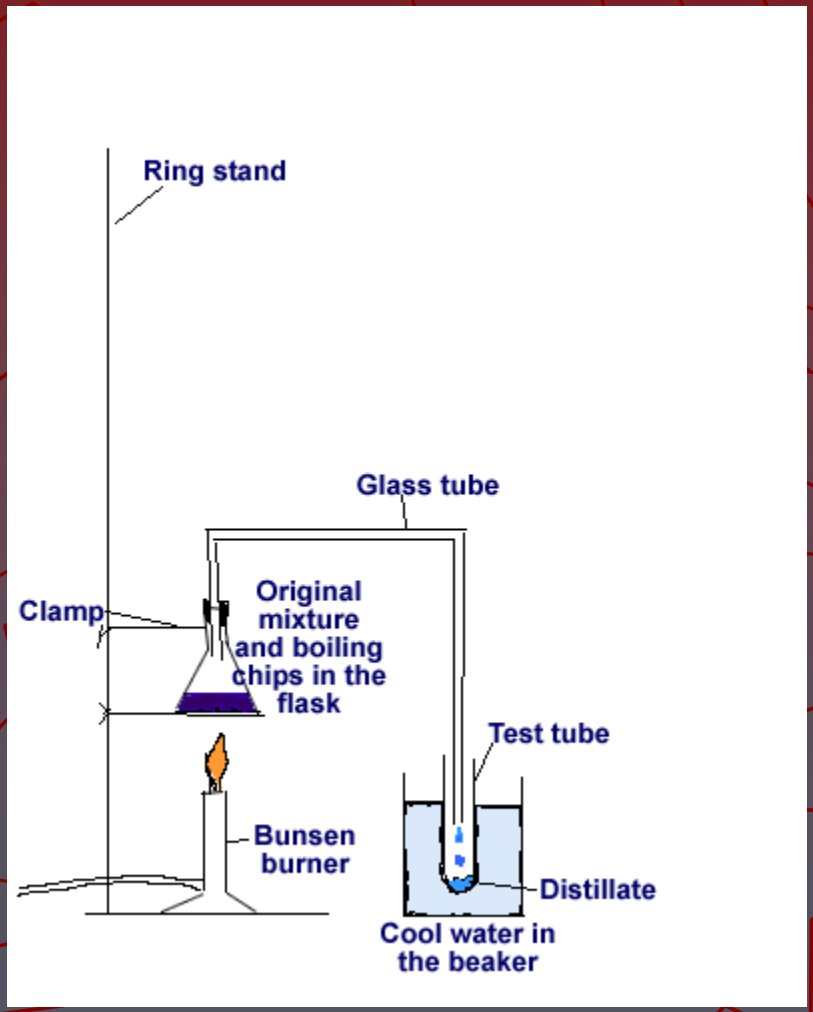
- Filtration:



Unit 1--Mixtures of Matter

- Distillation--Boiling off substances using heat

- Evaporation--Letting a liquid evaporate by itself leaving a solid

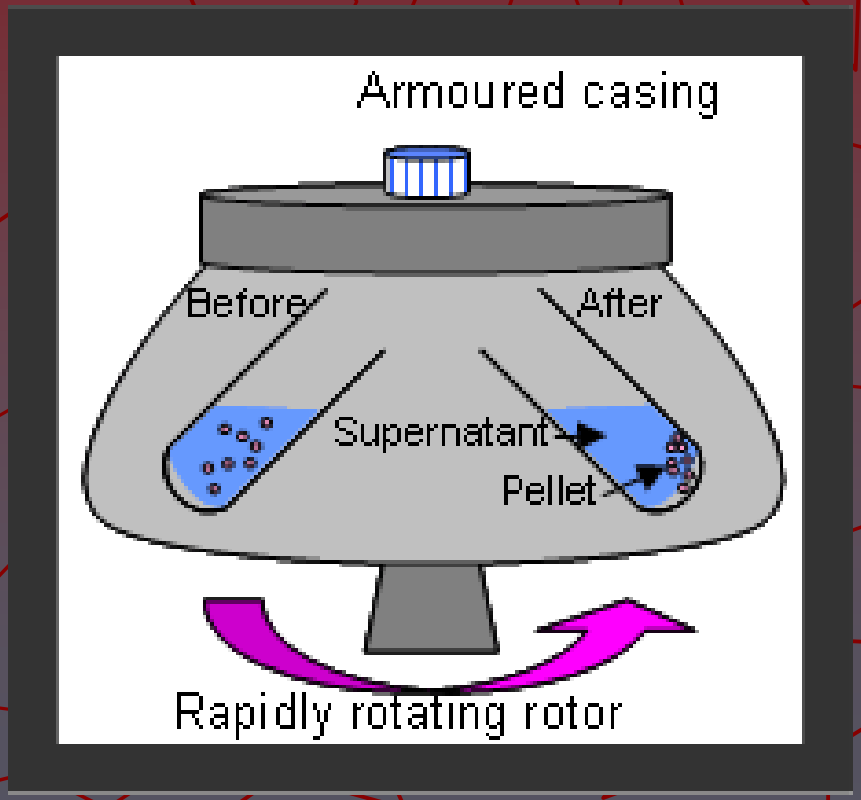


Unit 1--Mixtures of Matter

- Crystallization--The formation of a pure solid substance from a solution containing the dissolved substance (rock candy)

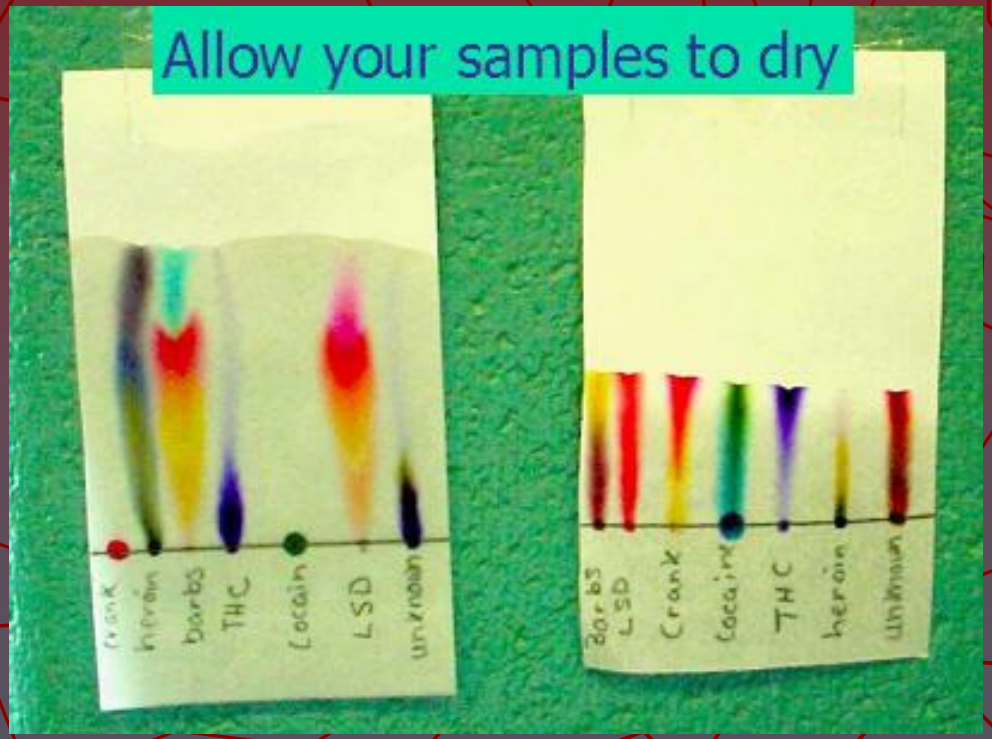
Unit 1--Mixtures of Matter

- Centrifugation—Spinning materials at very high speed to cause them to separate into layers
  - Centrifugation is used to separate blood into plasma, red blood cells, etc.



Unit 1--Mixtures of Matter

- Chromatography--Separating a mixture by using a piece of filter paper that allows the different components to move through it at different rates



Unit 1--Elements and Compounds

What is an Element?

Element = pure substance that cannot be separated into simpler substance by physical or chemical processes

- There are 91 elements that occur naturally on Earth
- Other elements have been developed by scientists
- All elements are not present on Earth in equal amounts
  - Hydrogen is estimated to make up 75% of the mass of the universe

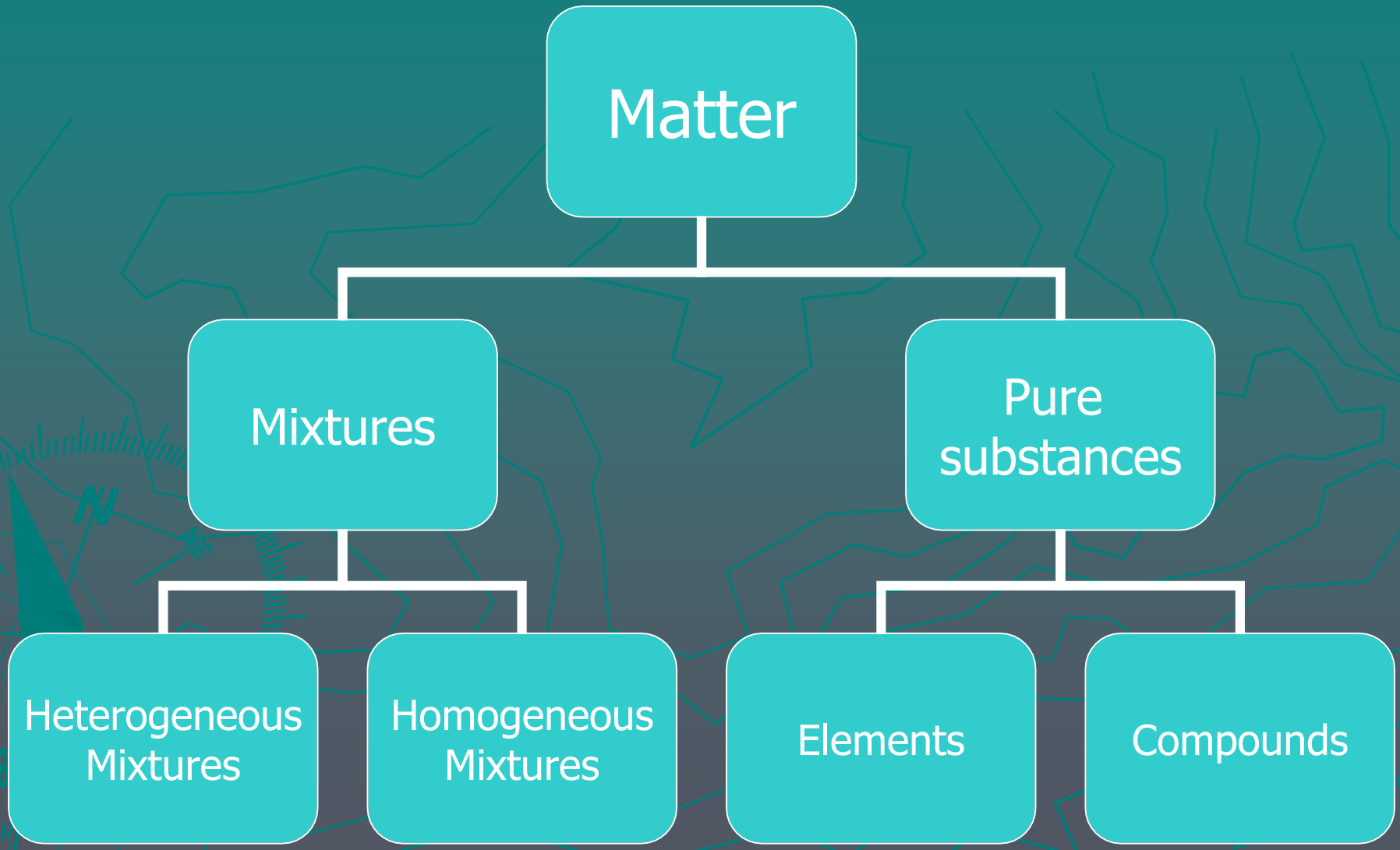
Unit 1--Elements and Compounds

- What is a chemical symbol?
- Each element has a unique chemical name and symbol
- The symbol is an abbreviation for the name of the element
- Chemical symbols are written in a specific format
- Chemical symbols consist of 1, 2, or 3 letters
- The first letter is ALWAYS capitalized and the remaining letters are ALWAYS lowercase
- By following this method, all scientists can understand the chemical information being shared by others

Unit 1--Elements and Compounds

- What are the parts of the Periodic Table (PT) of Elements?
  - The columns (up and down) on the PT are called groups or families
  - The rows (across) on the PT are called periods
- What is a compound?
  - Compounds = two or more different elements combined chemically
  - Some common compounds are water, table salt, and table sugar
  - Using chemical symbols from PT makes it easy to write formulas for compounds

Unit 1--Elements and Compounds



Unit 1--Elements and Compounds

- Compounds
  - Properties of compounds are DIFFERENT from the elements that make it up
    - Water—combination of two gases—hydrogen and oxygen
    - Water the compound is a colorless liquid—very different
    - Table salt—combination of a soft metal--sodium and a green, poisonous gas—chlorine
    - Compound sodium chloride is a white, unreactive solid

Unit 1--Elements and Compounds

- What is percent by mass?
  - Percent by mass is a ratio of the mass of one particular element to the mass of the entire compound.

$$\frac{Part}{Whole}$$

Unit 1--Elements and Compounds

- How do we find percent by mass?

  $$\text{Percent by mass} = \frac{\text{mass of element}}{\text{mass of compound}} \times 100$$

  - Example: A 78.0 g sample of an unknown compound contains 12.4 g of hydrogen. What is the percent by mass of hydrogen?
  - Percent by mass $= \frac{12.4\ \text{g}}{78.0\ \text{g}} \times 100$

    $= 0.1589743 \times 100$

    $= 0.159 \times 100$

    $= 15.9\%$ (3 sig figs)