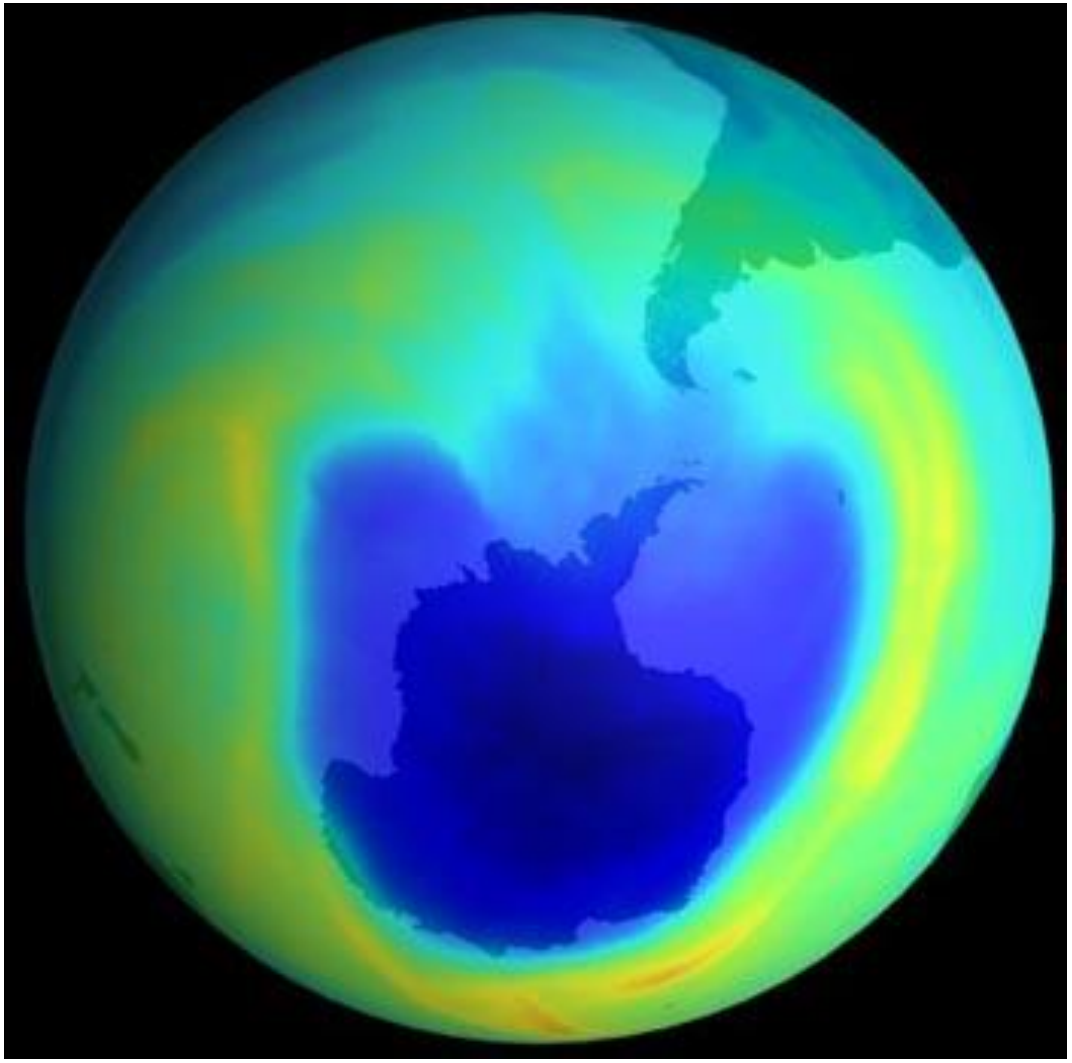
Fundamentals of Chemistry CHEM 1301

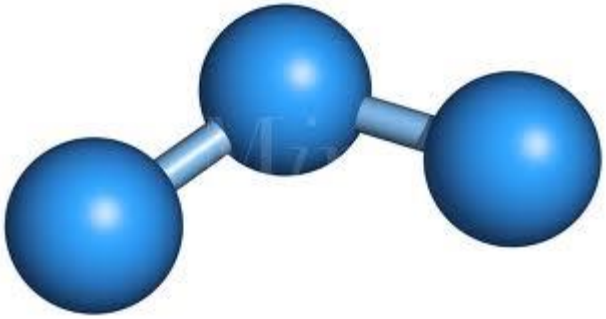
Module 1 Slides

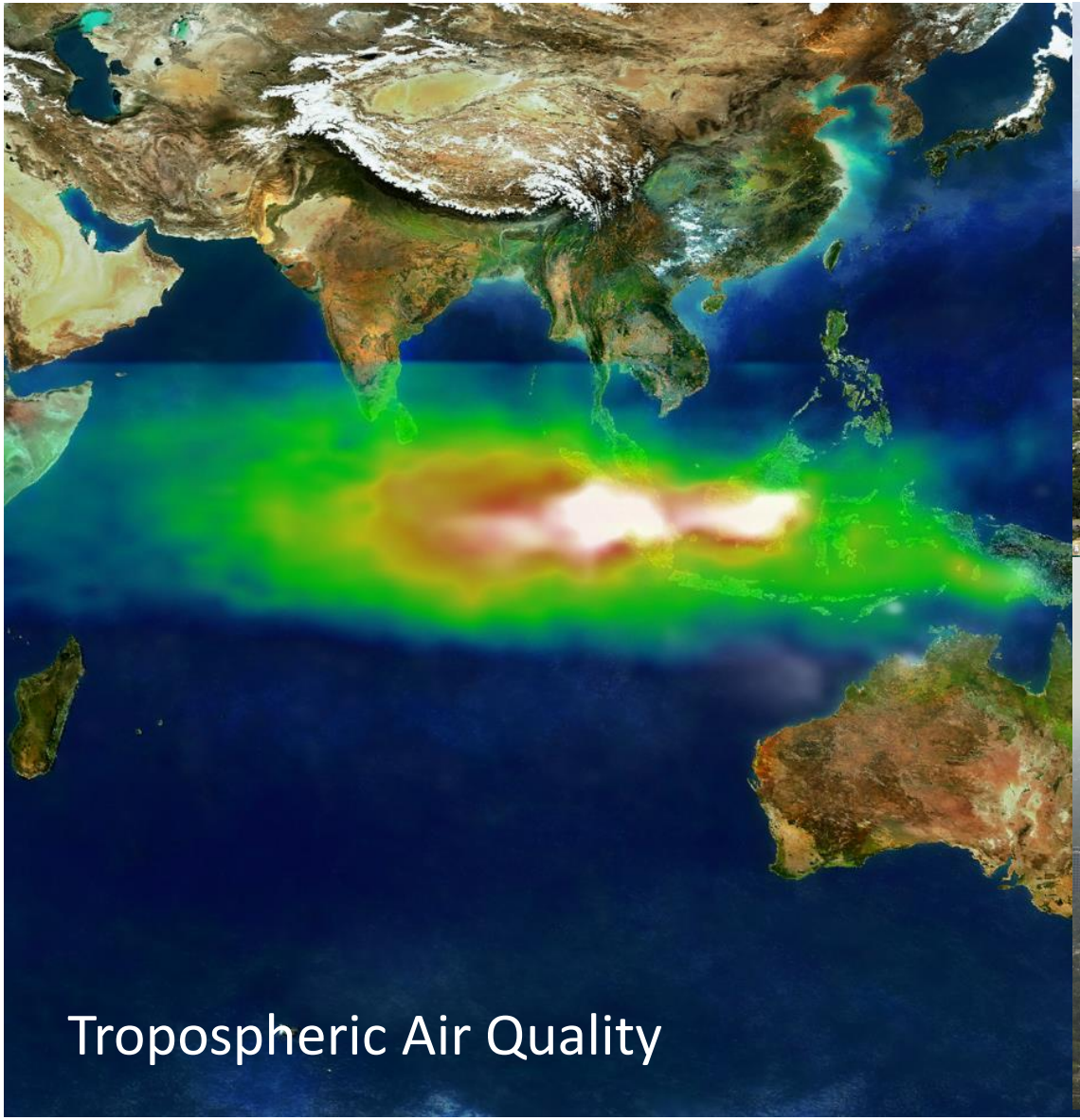
Chemistry:Why am I here?

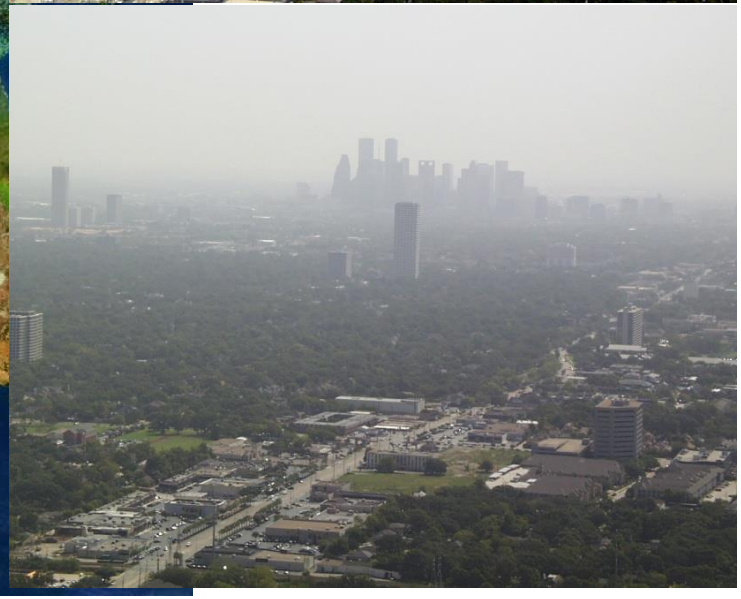
- Chemistry –
  - The science that seeks to understand the behavior of matter by studying the BEHAVIOR of atoms and molecules.
  - Not just a cause and effect… looks for the WHY and HOW
- One of my main objectives in this course is to help you KNOW atoms and molecules so that you can explain their behaviors.

The Antarctic Ozone Hole

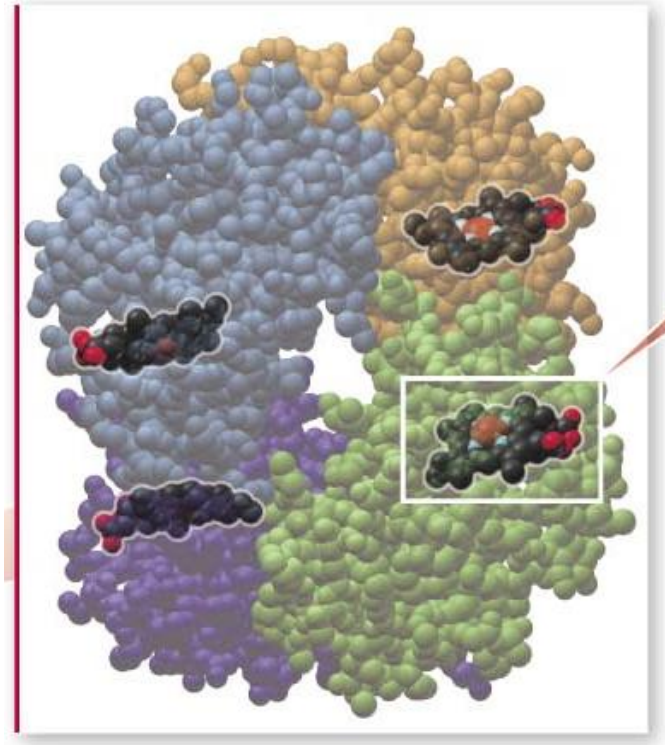




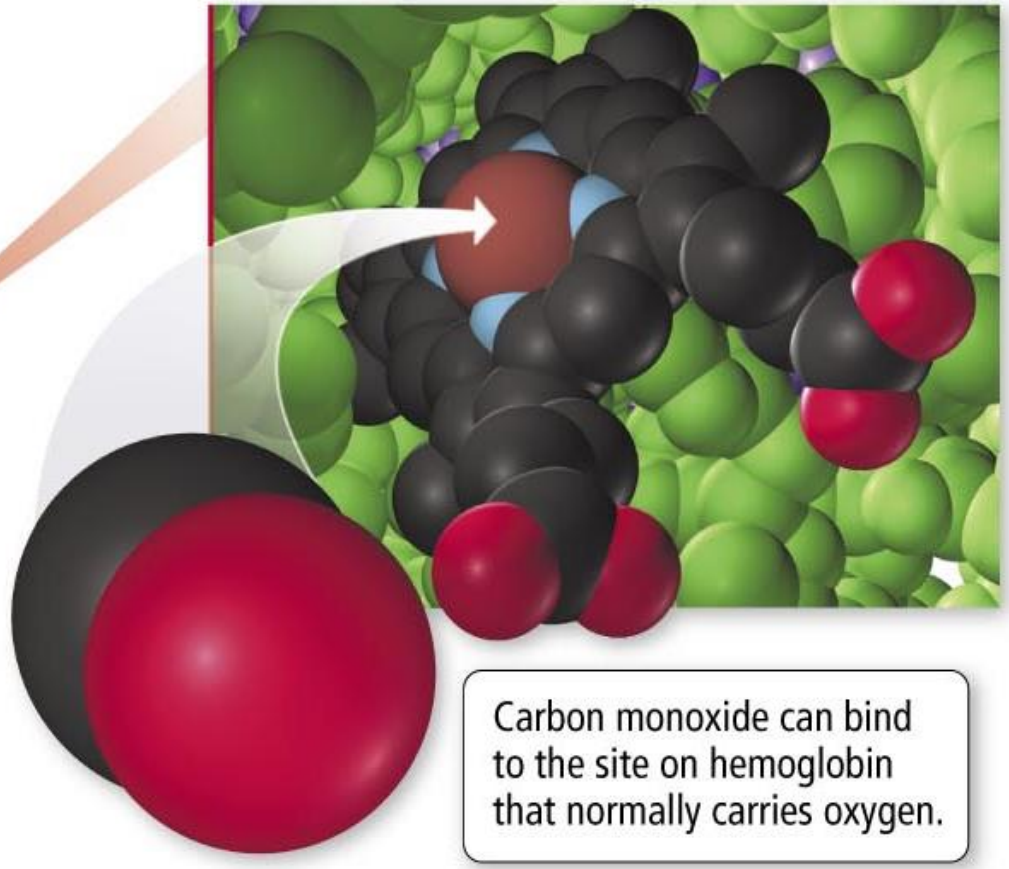

Tropospheric Air Quality



Hemoglobin and Carbon monoxide

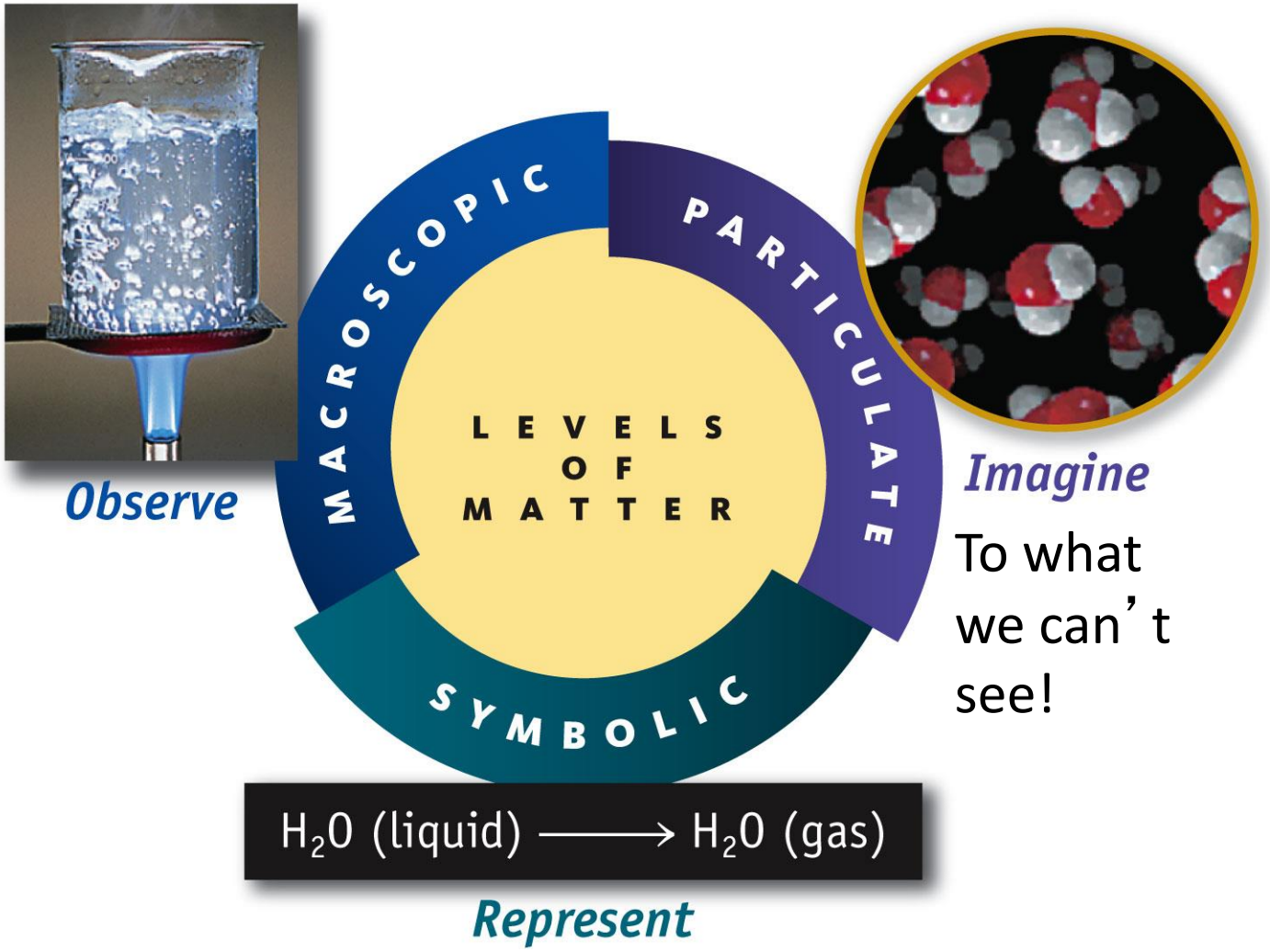


Hemoglobin, the oxygen-carrying molecule in red blood cells



Carbon monoxide can bind to the site on hemoglobin that normally carries oxygen.

What we observe…

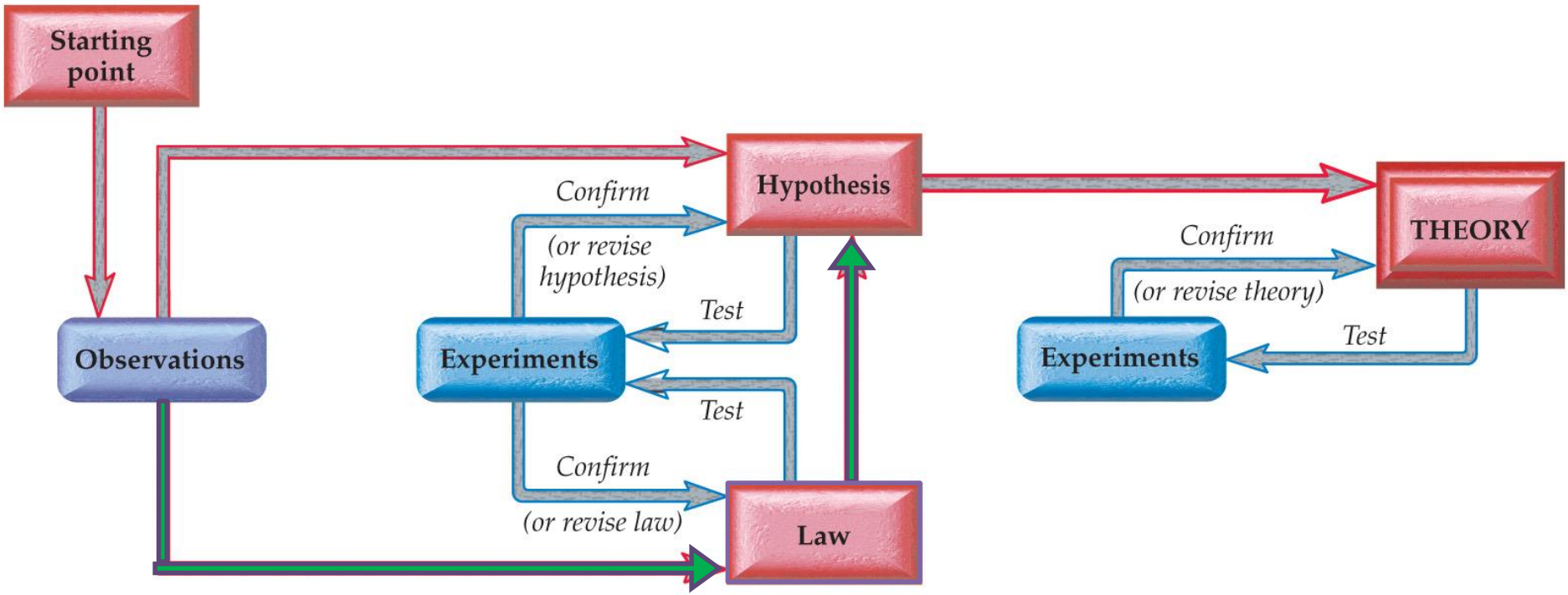


Chemical symbols allow us to connect…

The Scientific Method

- A process for trying to understand nature by observing nature and the way it behaves, and by conducting experiments to test our ideas.

The Scientific Method



What's the Difference Between an Observation and a Law?

- An **observation** tells you what happened in a single event.
- A **law** summarizes ***all*** the observations, effectively telling you what you will observe in future events.

What's the Difference Between a Hypothesis and a Theory?

- A **hypothesis** is an explanation of a single or small number of observations.
- A **theory** is an explanation that extends beyond individual observations to an understanding of the underlying causes for the way nature is or behaves.

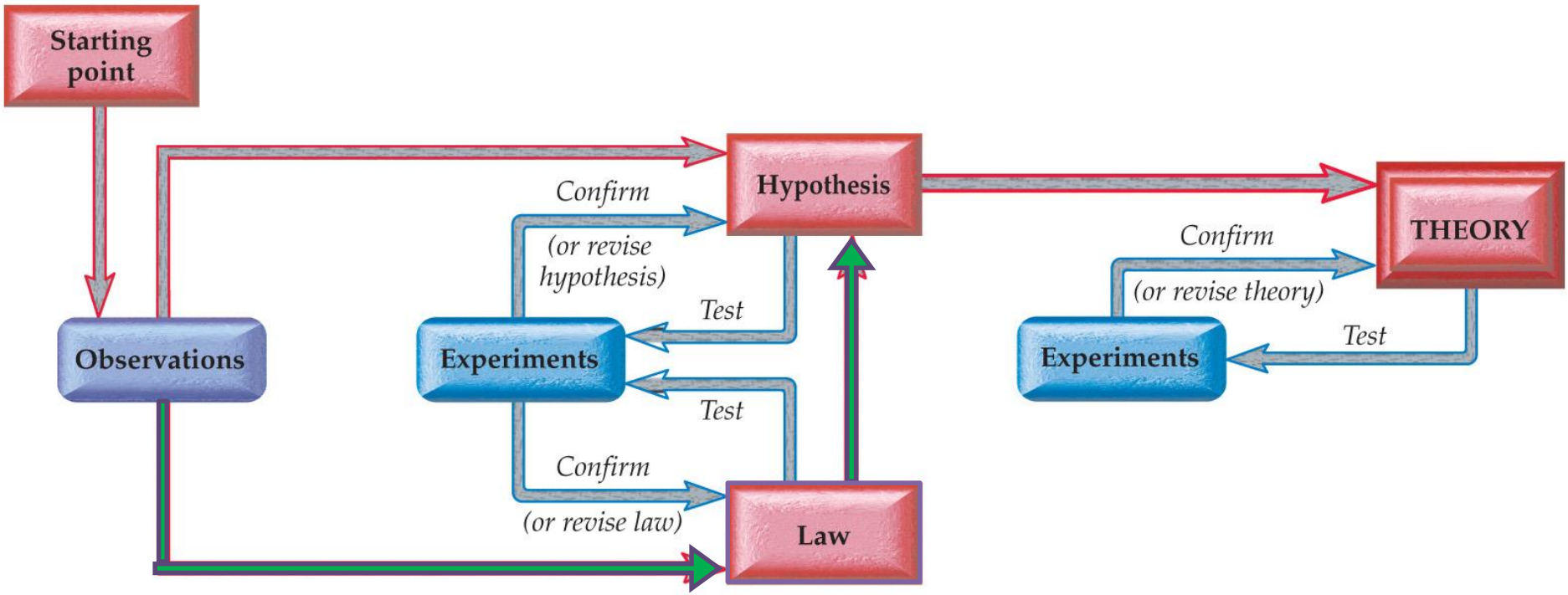
What's the Difference Between a Law and a Theory?

- **Laws** answer the question "***What"*** will happen.
- **Theories** answer the question "***Why"*** does something happen.
  - This allows you to predict what will happen!

Relationships Between Pieces of the Scientific Method

	Applies to single or **small number** of events	Applies to **all** events
Describes ***what*** happens	observation	law
Explains ***why*** things happen	hypothesis	theory

The Scientific Method



Scientific Notation

- Use Scientific Notation to write numbers that are very large or very small.

- Large Numbers: positive exponents

  1.302×10^4 means that 1.302 is multiplied by 10 a total of 4 times:

  1.302x10x10x10x10 or **13,020**

  Move the decimal **to the right** 4 times!

Scientific Notation

- Use Scientific Notation to write numbers that are very large or very small.

- Small Numbers: <u>negative</u> exponents

  1.302×10^{-4} means that 1.302 is <u>divided</u> by 10 a total of 4 times:

  $1.302 \div 10 \div 10 \div 10 \div 10$ or **0.0001302**

  Move the decimal **to the left** 4 times!

Scientific Notation

- You should be able to write a number in scientific or standard notation!

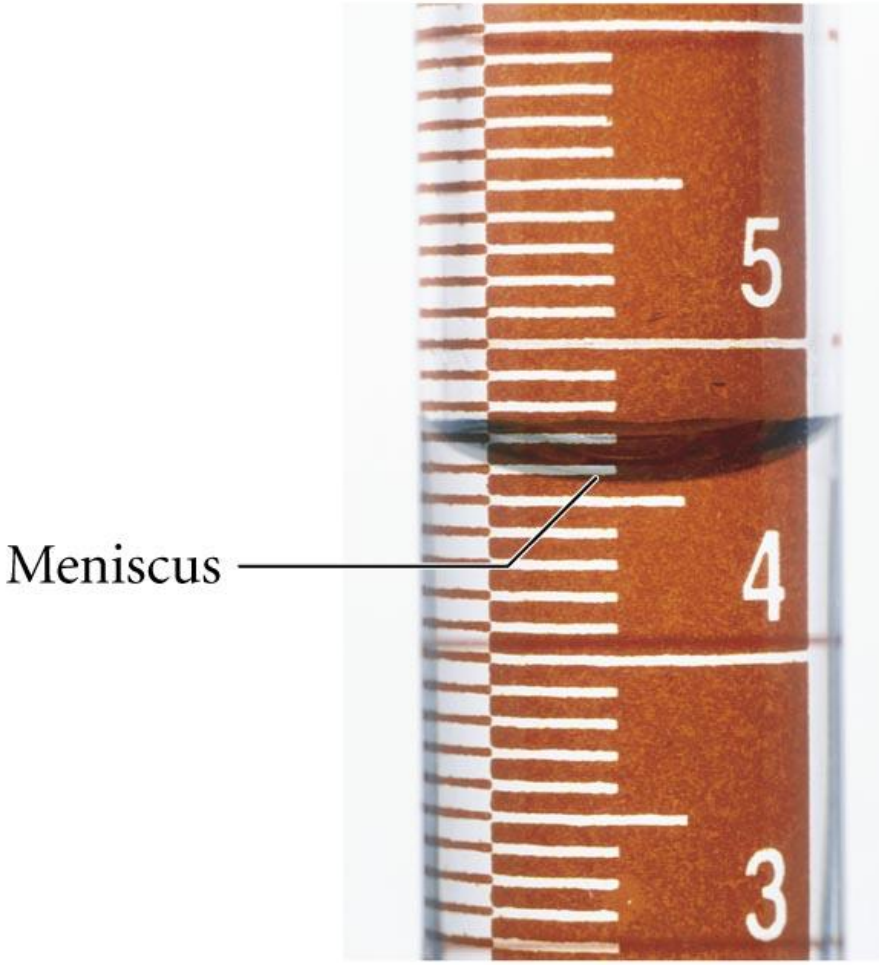
Mental Exponential Math

The Rules:

1. When you multiply exponentials, you ADD the exponents.
2. When you divide exponentials, you SUBTRACT the exponents.
3. When you raise an exponent to a power, you MULTIPLY the exponents.
4. When you move an exponent from the bottom to the top, CHANGE the SIGN of the exponent.
5. In ALL cases, handle the significands and the exponentials separately.

What Is a Measurement?

- Quantitative observation
- Comparison to an agreed standard
- Every measurement has a number and a unit



A Measurement

- The unit tells you what standard you are comparing your object to
- The number tells you
  1. what multiple of the standard the object measures
  2. the uncertainty in the measurement
- Scientific measurements are reported so that every digit written is certain, except the last one, which is estimated

Significant Figures

- Important to follow the sig fig rules in calculations so that the answer is certain in all digits except the last one which is assumed to be the estimated digit

The RULES for counting SIG FIGS (Must Memorize)

1. All non-zero digits in a number are SIGNIFICANT.
2. Leading zeros are NEVER significant (placeholders).
3. Interior (sandwiched) zeros that are between two significant digits are ALWAYS significant.
4. Trailing zeroes are significant AFTER the decimal place, but NOT before it (Ambiguous).

**So, write numbers in scientific notation to avoid this!!

Rounding to a specified number of SIG FIGS

- When you use measurements in calculations, the answer must be rounded to the correct number of sig figs.
  - How to know the correct number of sig figs to carry is the next topic..
- To round: start at the left-most significant digit, count the specified number of digits to the right, then, underline and round to that place value.

The RULES for SIG FIGS in calculations

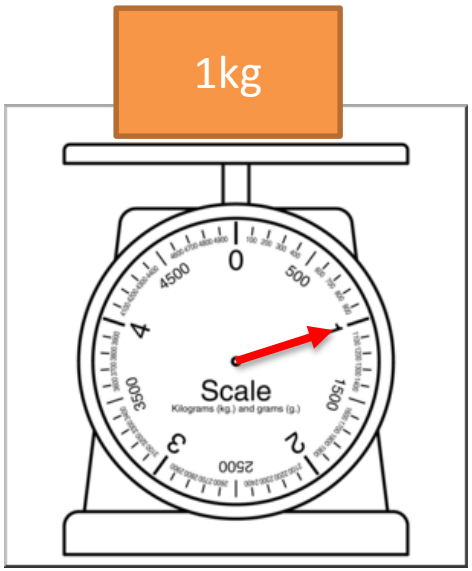
1. When you ADD/SUBTRACT, the answer carries the same number of DECIMAL PLACES as the number with the LEAST!
2. When you MULT/DIVIDE, the answer carries the same number of SIG FIGS as the factor with the LEAST.
3. When these processes are combined, use order of operations to complete the process!

Dimensional Analysis

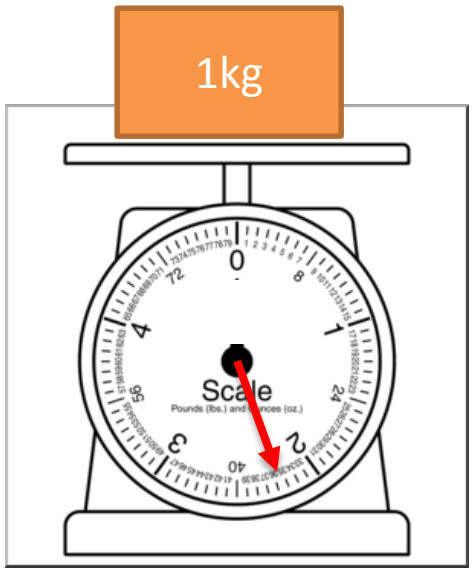
- A mathematical process where units are treated like numbers where they may be multiplied and divided.
- THE MOST POWERFUL TOOL YOU LEARN IN THIS COURSE!!

Conversion Factors

- A relationship where the same amount of a substance is measured using two different standards.



Kilogram Balance

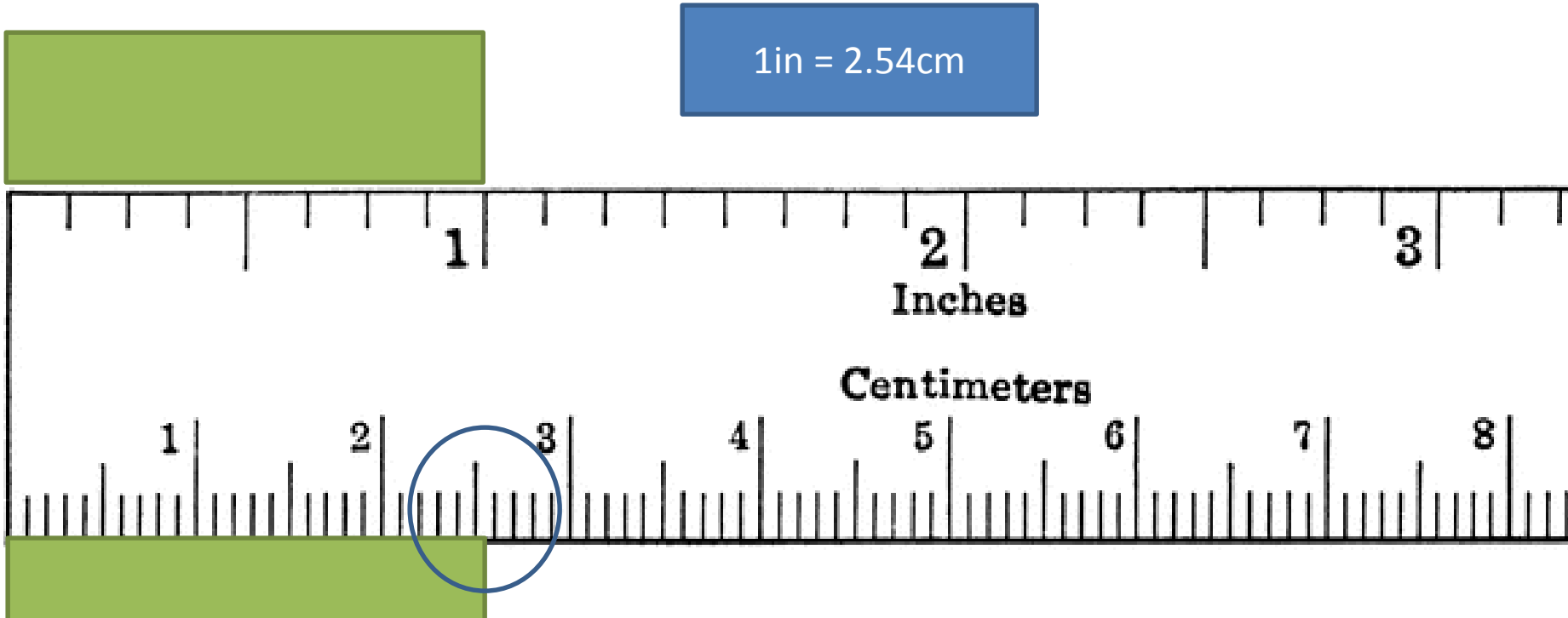


Pounds Balance

1kg = 2.2lbs

Conversion Factors

- A relationship where the same amount of a substance is measured using two different standards.



Conversion Problems Types

1. Simple Conversions
2. Metric Conversions

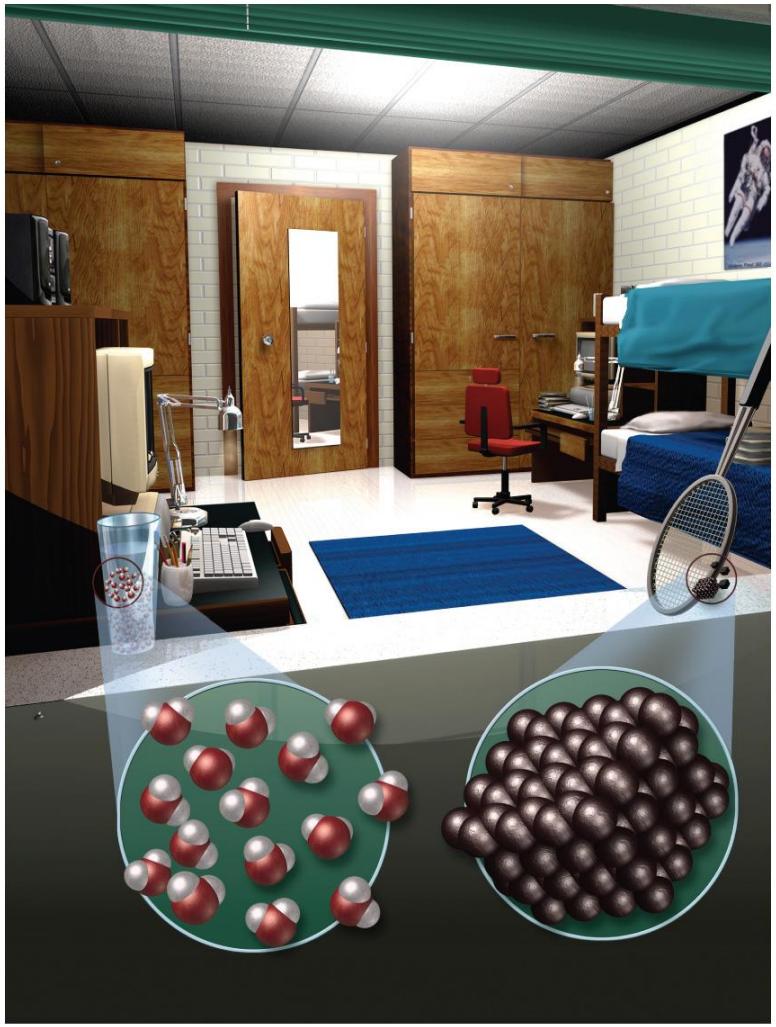
You need to write your own conversion factors from prefix multipliers.

3. Conversions where units are raised to a power

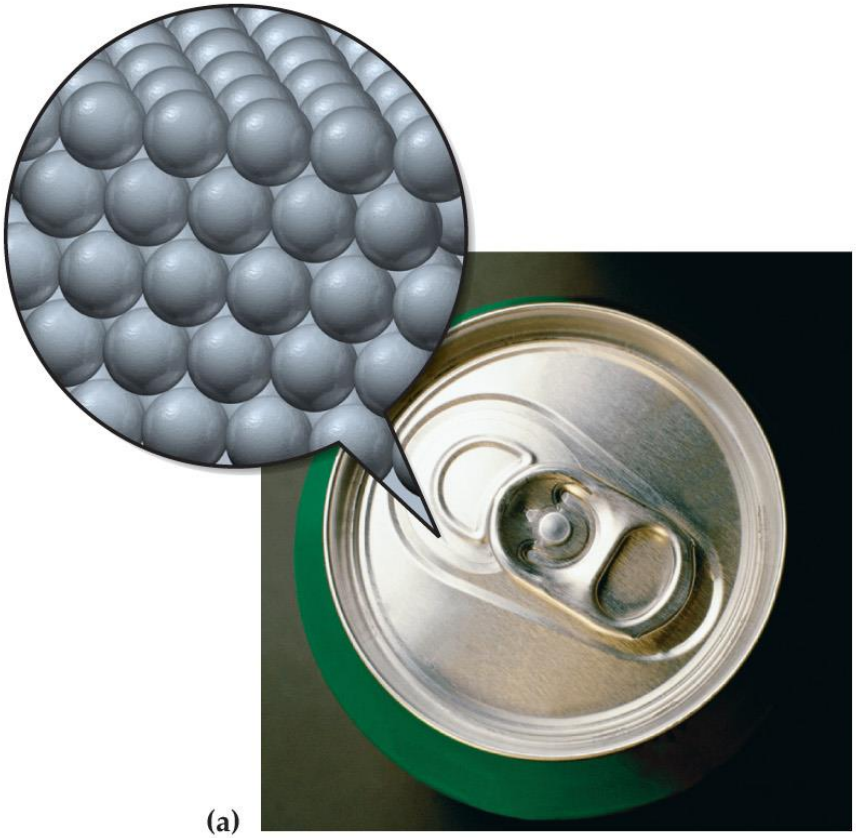
You need to raise conversion factors to a power as well.

4. Complex Units (Density and speed)

Classifying Matter



Elemental Matter



(a)

Molecular Matter

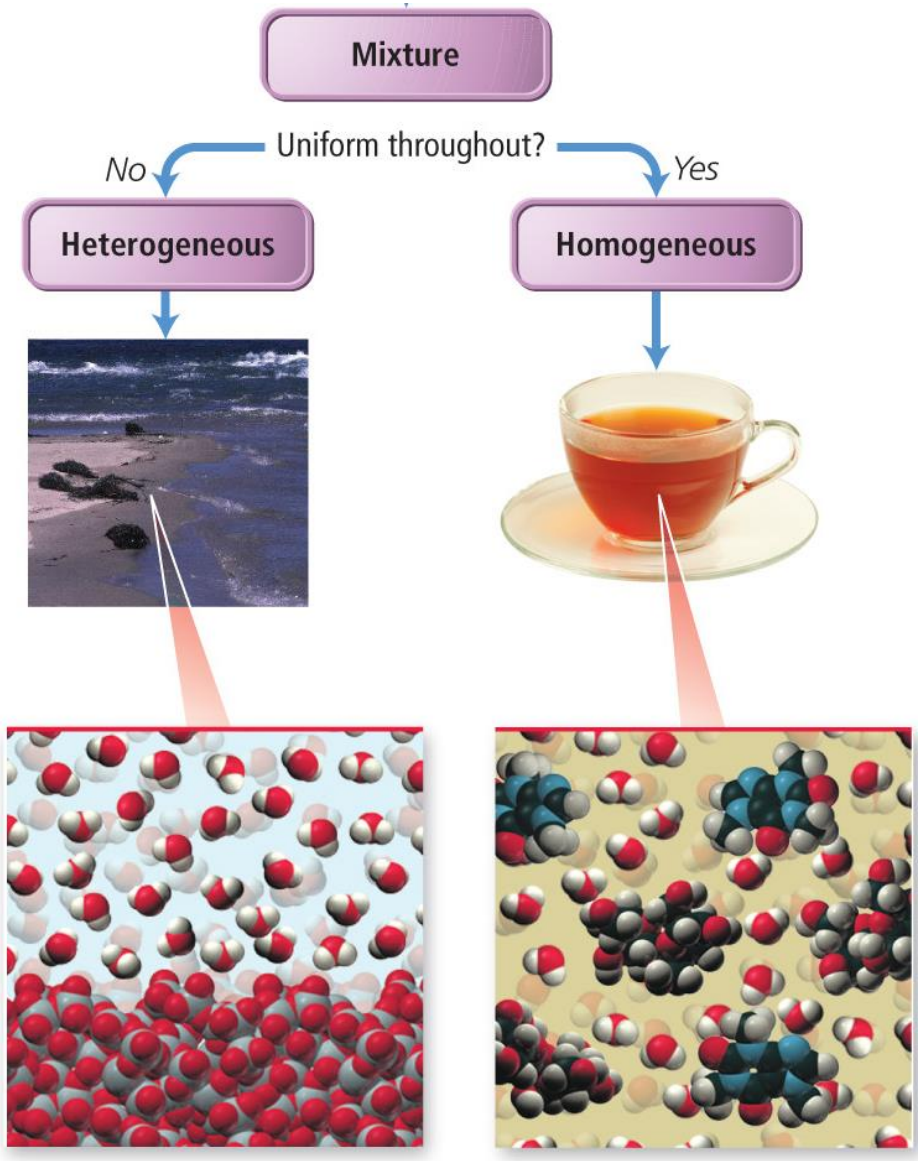
(b)

Determine if the following matter is elemental or molecular:

1. Table Salt
2. Iron
3. Rust (Iron Oxide, FeO_2)
4. Graphite (carbon) in your pencil
5. Acetone (fingernail polish remover)
6. $AgNO_3$ in solution
7. Oxygen (O_2) in the atmosphere

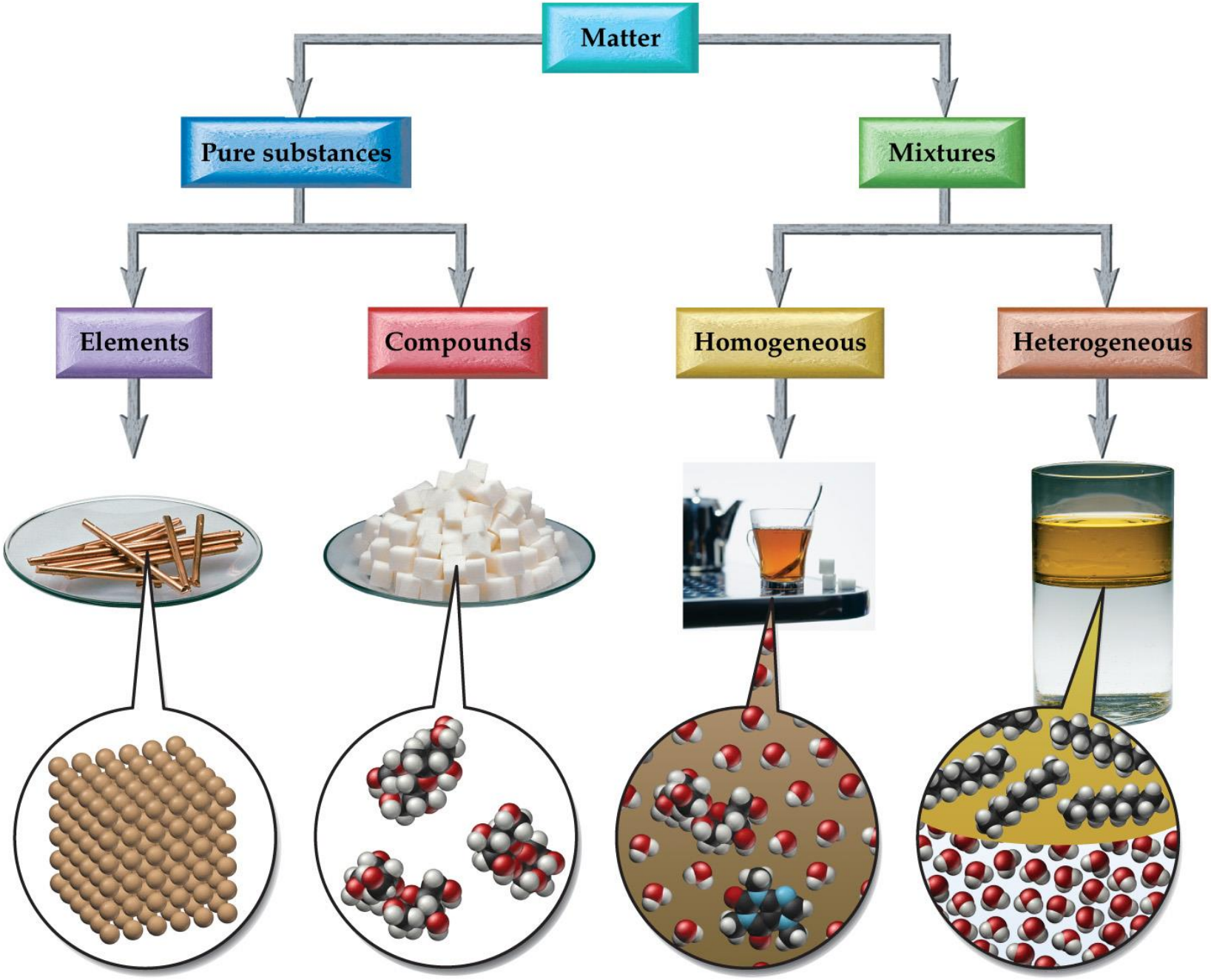
Pure Substance vs. Mixture

Classification of Mixtures



Determine whether the following mixtures are homogeneous or heterogeneous:

1. Chocolate chip cookie
2. Sweet Tea
3. Paint
4. Milk
5. Salad Dressing (Italian)

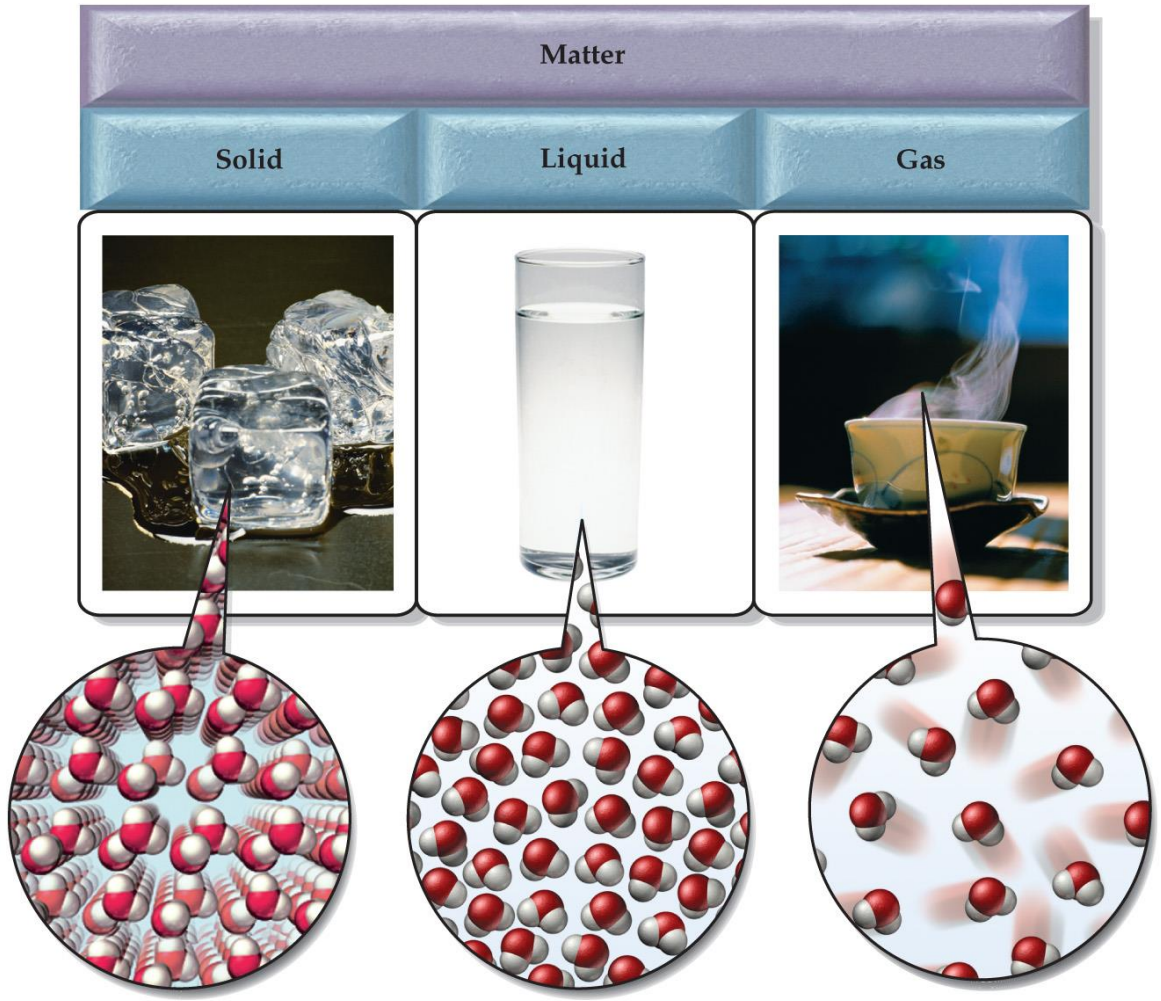


Quiz

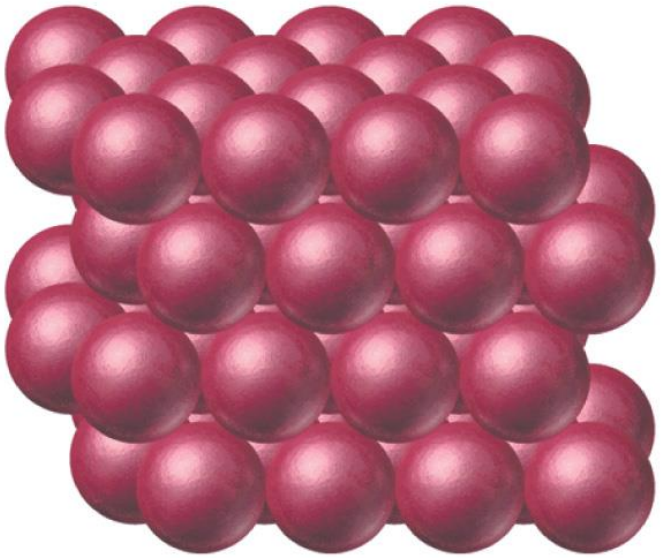
- Classify the following as Elemental, compound, heterogeneous mixture, or homogeneous mixture:

1. Helium (balloons)
2. Apple juice
3. Propane
4. Blueberry muffin
5. Sulfur
6. Wine
7. Baking soda (sodium bicarbonate)
8. Salad dressing (oil and vinegar)
9. Air we breathe (Nitrogen, Oxygen, Carbon Dioxide
10. water

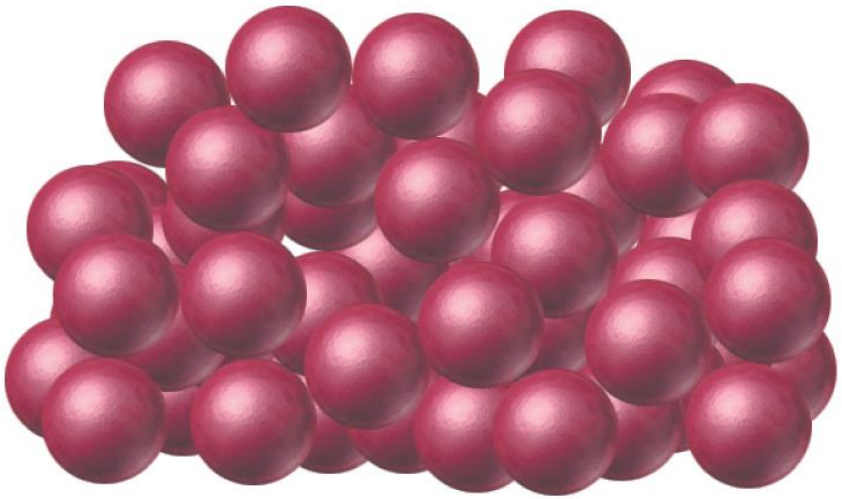
States of Matter



Solids



(a) Crystalline solid



(b) Amorphous solid

Summary: Solid/Liquid/Gas

State	***Shape***	***Volume***	***Compress***	***Flow***
Solid	Fixed	Fixed	No	No
Liquid	Indefinite	Fixed	No	Yes
Gas	Indefinite	Indefinite	Yes	Yes

Properties Distinguish Matter

- Each sample of matter is distinguished by its characteristics.
- The characteristics of a substance are called its **properties**.
- Some properties of matter can be observed directly.
- Other properties of matter are observed when it changes its composition.

Physical Properties/Physical Change

Physical Property	Physical Change
Color	Color Change
Boiling Point	Liquid to Gas
Melting Point	Solid to Liquid
Temperature	Heated or Cooled

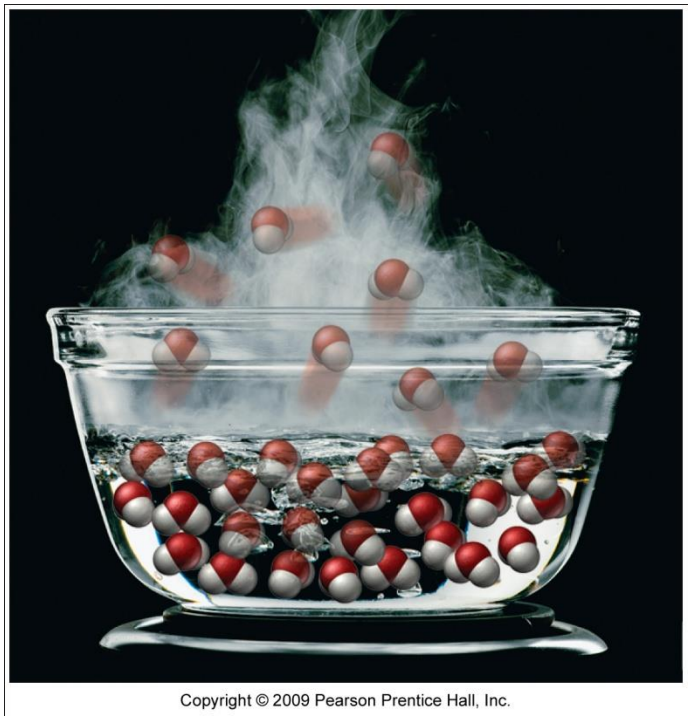
Physical Property: Density

- The amount of Matter in a given Volume.

- Density=Mass ÷ Volume

Phase Changes Are Physical Changes

- Boiling = liquid to gas.
- Melting = solid to liquid.
- Subliming = solid to gas.
- Freezing = liquid to solid.
- Condensing = gas to liquid.
- Deposition = gas to solid.



- **Phase changes require heating or cooling the substance.**

Some Physical Properties of Iron

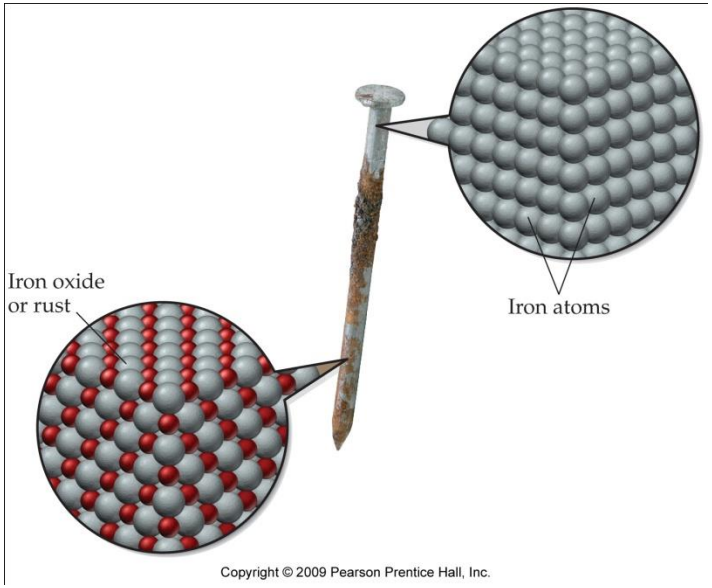
- Iron is a silvery solid at room temperature with a metallic taste and smooth texture.
- Iron melts at 1538 °C and boils at 4428 °C.
- Iron's density is 7.87 g/cm^3.
- Iron can be magnetized.
- Iron conducts electricity, but not as well as most other common metals.
- Iron's ductility and thermal conductivity are about average for a metal.

Chemical Properties/Chemical Change

Chemical Property	Chemical Change
Flammability	Burning
Reactivity	Reaction
Corrosiveness	Corroding or Rusting
Stability	Decomposition

Some Chemical Properties of Iron

- Iron is easily oxidized in moist air to form rust.
- When iron is added to hydrochloric acid, it produces a solution of ferric chloride and hydrogen gas.
- Iron is more reactive than silver, but less reactive than magnesium.

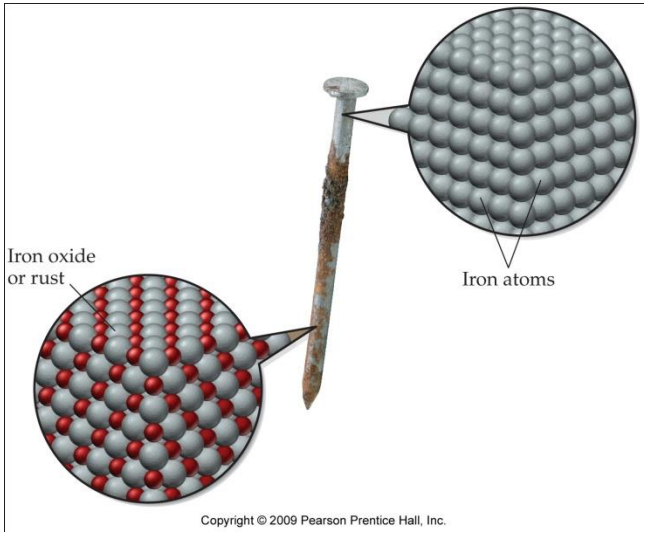


Practice—Decide Whether Each of the Observations About Table Salt Is a Physical or Chemical Property

1. Salt is a white, granular solid.
2. Salt melts at 801 °C.
3. Salt is stable at room temperature, it does not decompose.
4. 36 g of salt will dissolve in 100 g of water.
5. Salt solutions and molten salt conduct electricity.
6. When a clear, colorless solution of silver nitrate is added to a salt solution, a white solid forms.
7. When electricity is passed through molten salt, a gray metal forms at one terminal and a yellow-green gas at the other.

3.10

Which of the following is NOT a chemical property?



1. The density of a liquid
2. The ability of iron to rust
3. Flammability of gasoline
4. Reactivity of acids with metals
5. All of these are chemical properties.

3.10

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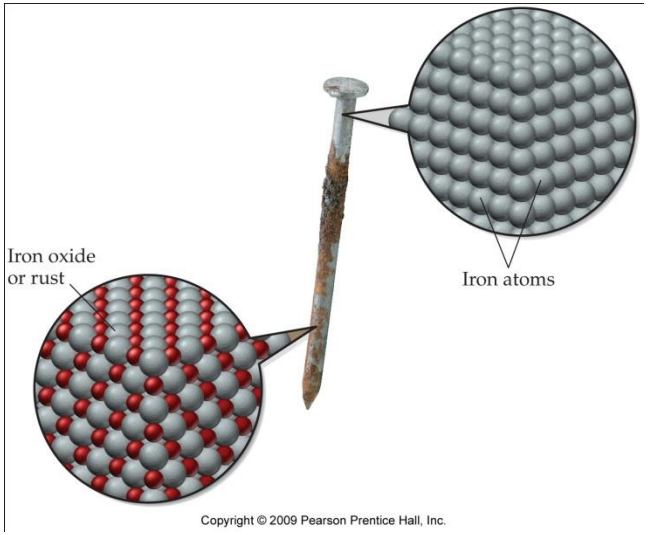
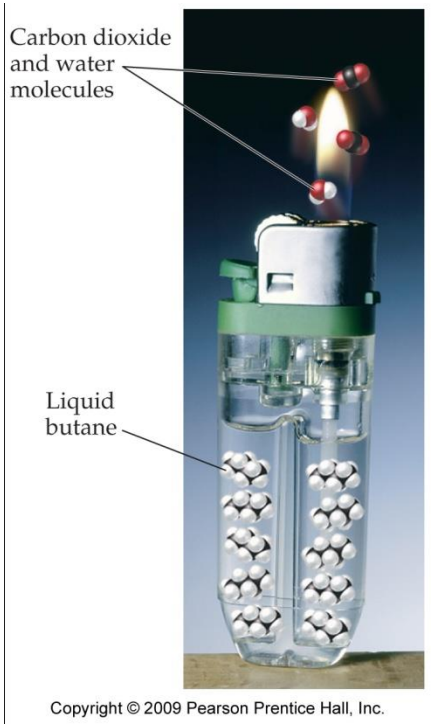


3.11

Which of the following is a physical change?

1. Burning wood
2. Barbequing a steak
3. Splitting water into hydrogen and oxygen gases
4. Breaking a piece of glass
5. Baking a cake



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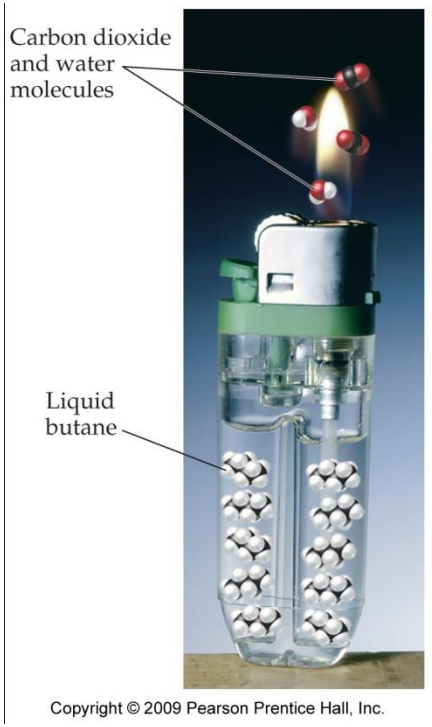


3.12

Which of the following statements is FALSE?

1. The freezing of water is a physical change.
2. The conversion of compounds into elements is a physical change.
3. The combination of sodium metal and chlorine gas to form sodium chloride is a chemical change.
4. Photosynthesis is an example of a chemical change.
5. Distilling alcohol from water is a physical change.

3.12

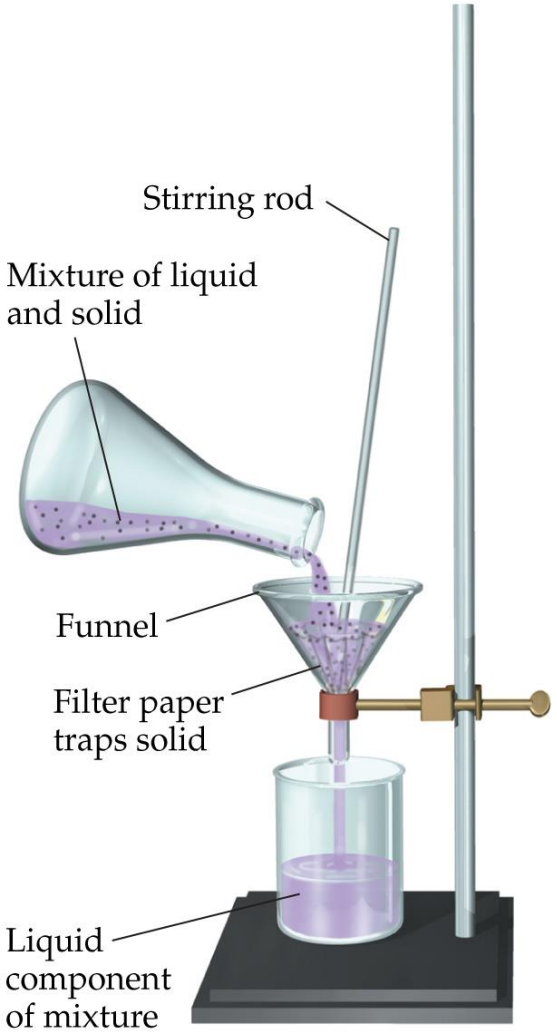
Which of the following statements is FALSE?

1. The freezing of water is a physical change.
2. The conversion of compounds into elements is a physical change.
3. The combination of sodium metal and chlorine gas to form sodium chloride is a chemical change.
4. Photosynthesis is an example of a chemical change.
5. Distilling alcohol from water is a physical change.

Separation of Mixtures using Physical Properties

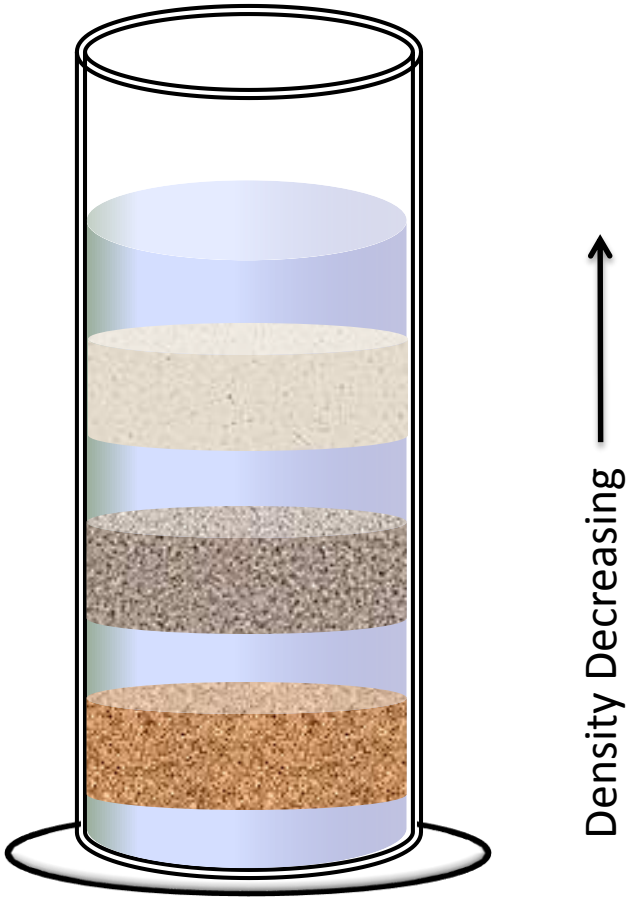
- Determine what the physical properties of the components of the mixture are.
- Determine one property that distinguishes all of the components.
  - Different Boiling Points/Melting points
  - Different Densities
  - Different Phases

Filtration

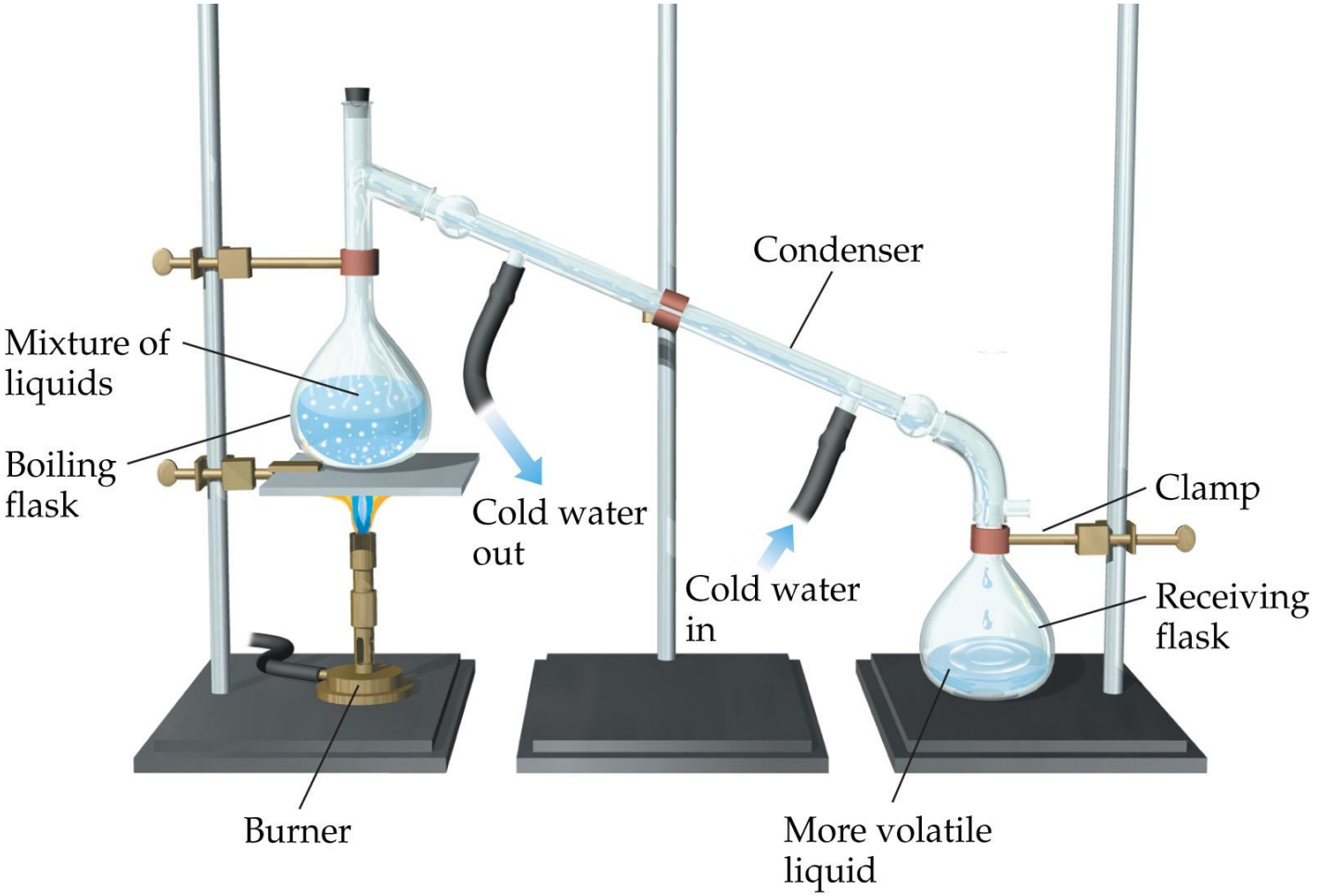


Density Gradient Method

- Soil Separation in Criminal Labs
- Multiple Liquids are placed in the cylinder that have varying densities.
- Soil particles are separated by density.



Distillation



Separation of Mixtures

Different Physical Property	**Technique**
Boiling point	Distillation
State of matter (solid/liquid)	Filtration
Density	Density Gradient
Volatility	Evaporation

Conservation of Mass

- Matter is neither created or destroyed in a chemical reaction.

COM Example

- 44. In the explosion of a hydrogen-filled balloon, 0.50 g of hydrogen reacted with 4.0 g of oxygen to form how many grams of water vapor? (Water vapor is the only product.)

COM Example

- 46. Is the following data set on chemical changes consistent with the law of conservation of mass?

a) A 12.8 g sample of sodium completely reacts with 19.6 g of chlorine to form 32.4 grams of sodium chloride.

COM Example

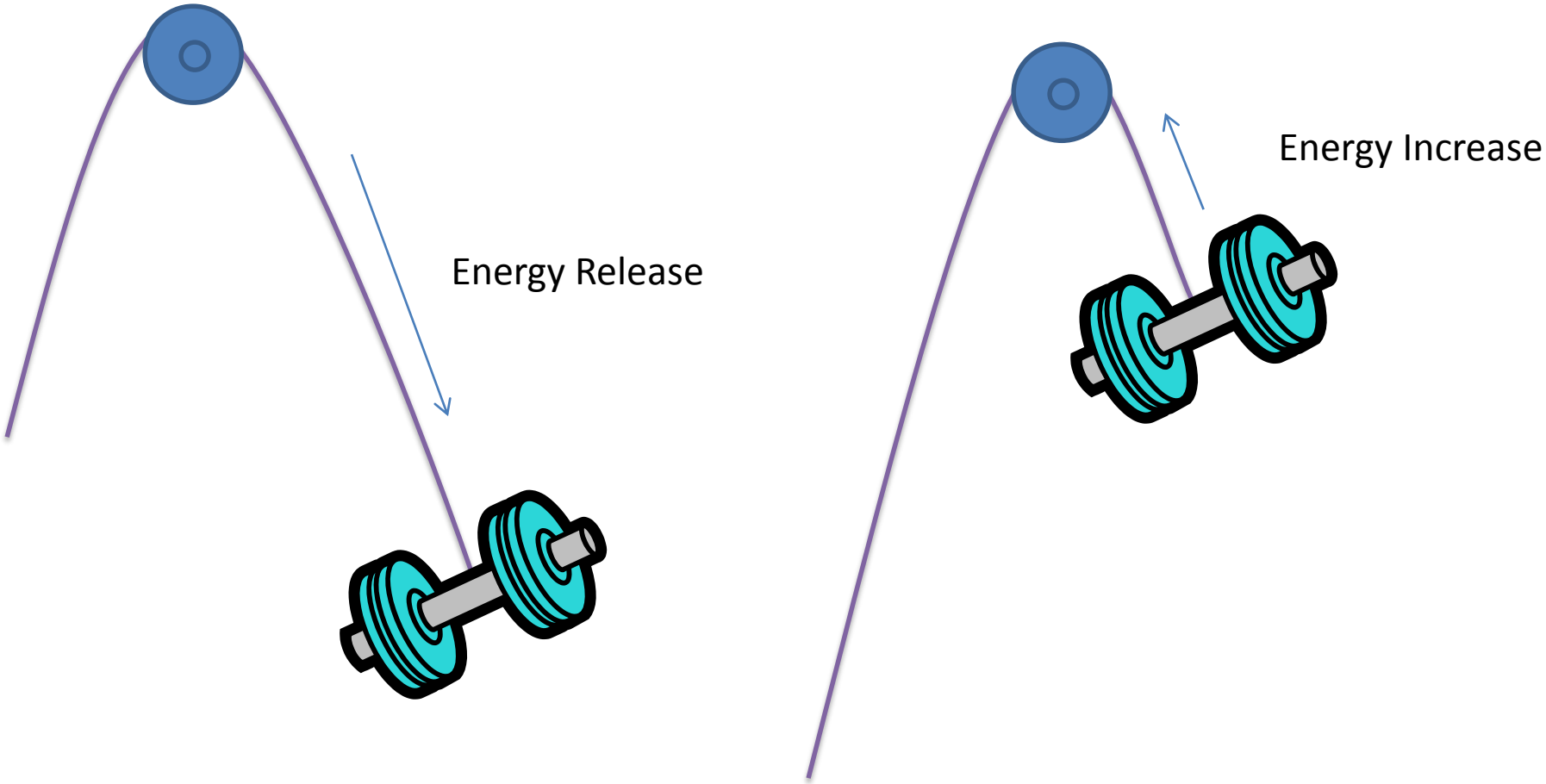
- 46. Is the following data set on chemical changes consistent with the law of conservation of mass?

b) An 8 g sample of natural gas completely reacts with 32 g of oxygen to form 17 g of carbon dioxide and 16 g of water.

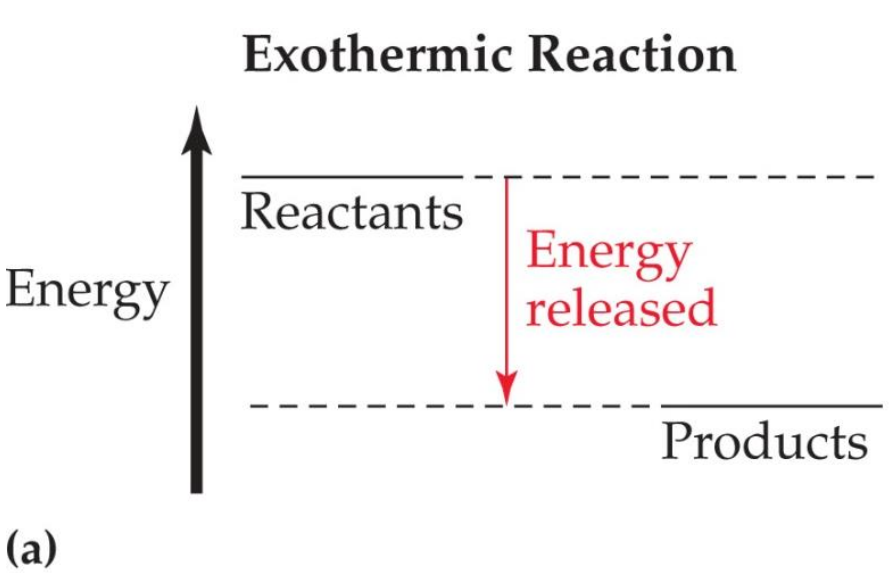
COM Example

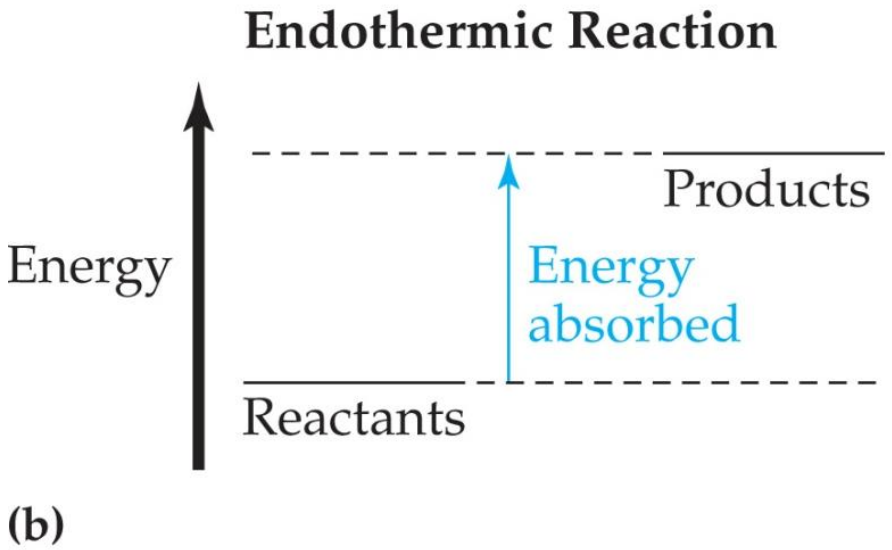
- If your car burns 47 g of gasoline (gasoline reacts with oxygen when it burns) to form 132 g of carbon dioxide and 34 g of water, how many grams of oxygen did you burn?

Energy: Introduction



Endothermic and Exothermic Reactions





Temperature Conversion Equations

$$^{\circ}F = \frac{9}{5}{}^{\circ}C + 32$$

$$^{\circ}C = \frac{5}{9}(^{\circ}F - 32)$$

$$K = {}^{\circ}C + 273$$

Temperature Example

- Convert 212K to Celsius.

Temperature Example

- The freezing point of water is -32°F. What is the freezing point of water in Kelvin?