Chapter 2: Matter and Change

2.1 Properties of Matter

2.1 Describing Matter

- Properties used to describe matter can be classified as extensive or intensive.

2.1 Describing Matter

- Extensive Properties
  - The **mass** - measure of the amount of matter in object
  - The **volume** - measure of the space occupied by the object.
  - An **extensive property** is a property that depends on the amount of matter in a sample.

2.1 Describing Matter

- **Intensive Properties**
  - depends on the type of matter in a sample, not the amount of matter.
    - Ex: The hardness of a bowling ball

2.1 Identifying Substances

- Matter that has a uniform and definite composition is called a **substance**. (Ex: Copper)

2.1 Identifying Substances

- Every sample of a given substance has identical intensive properties because every sample has the same composition.

2.1 Identifying Substances

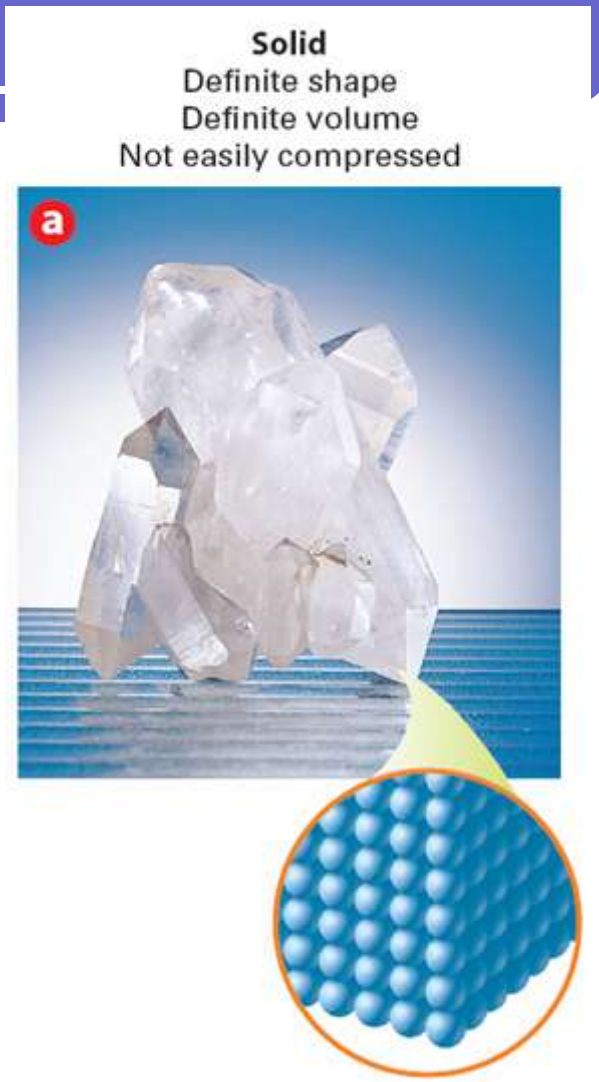
- A **physical property** is a quality or condition of a substance that can be observed or measured without changing the substance's composition.
- Hardness, color, conductivity, and malleability are examples of physical properties.

2.1 States of Matter

- Three states of matter are solid, liquid, and gas.

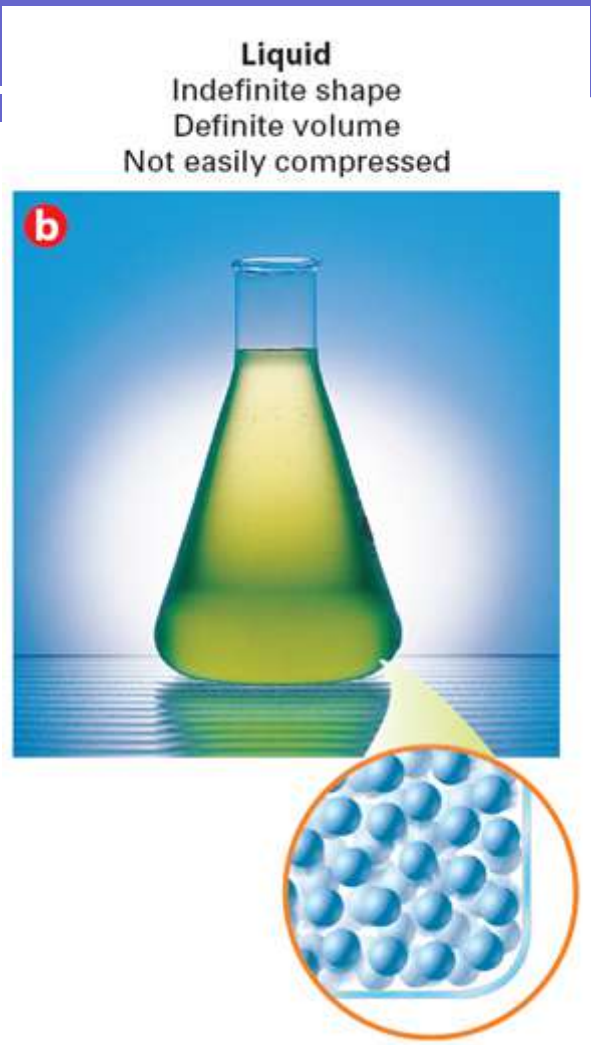
2.1 States of Matter

- Solids
  - A **solid** is a form of matter that has a definite shape and volume.



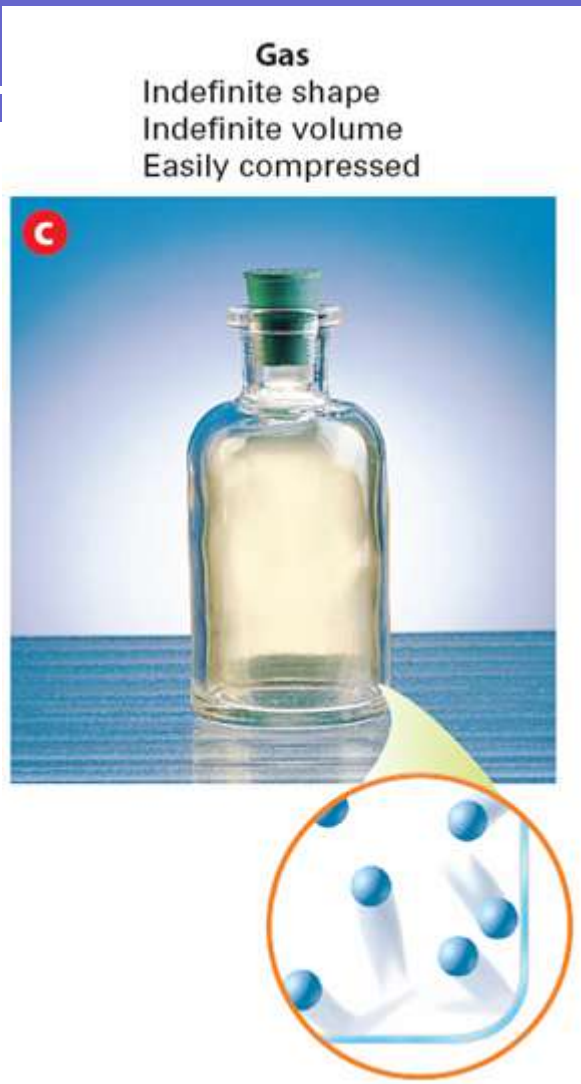
2.1 States of Matter

- Liquid
  - A **liquid** is a form of matter that has an indefinite shape, flows, yet has a fixed volume.



2.1 States of Matter

- Gases
  - A **gas** is a form of matter that takes both the shape and volume of its container.



2.1 States of Matter

- **Vapor** describes the gaseous state of a substance that is generally a liquid or solid at room temperature, as in water vapor.

2.1 Physical Changes

- During a **physical change**, some properties of a material change, but the composition does not change.
- Ex: gallium melts in a person's hand

2.1 Physical Changes

- Physical changes can be classified as reversible or irreversible.
  - All physical changes that involve a change of state are reversible.
  - Cutting hair, filing nails, and cracking an egg are examples of irreversible physical changes.

2.1 Section Quiz.

- 1.Which of the following would be described as an extensive property of matter?

  a)temperature

  b)color

  c)mass

  d)hardness

2.1 Section Quiz.

- 2.Which properties can be observed without changing the composition of a substance?

  a)all properties of a substance

  b)intensive properties

  c)chemical properties

  d)physical properties

2.1 Section Quiz.

- 3.Match the states of matter with the following descriptions:

  (1) takes the volume and shape of its container

  (2) has a definite shape and volume

  (3) has a definite volume but an indefinite shape

a)(1) liquid, (2) solid and (3) gas
b)(1) gas, (2) solid, and (3) liquid
c)(1) gas, (2) liquid, and (3) solid

2.2 Mixtures

2.2 Classifying Mixtures

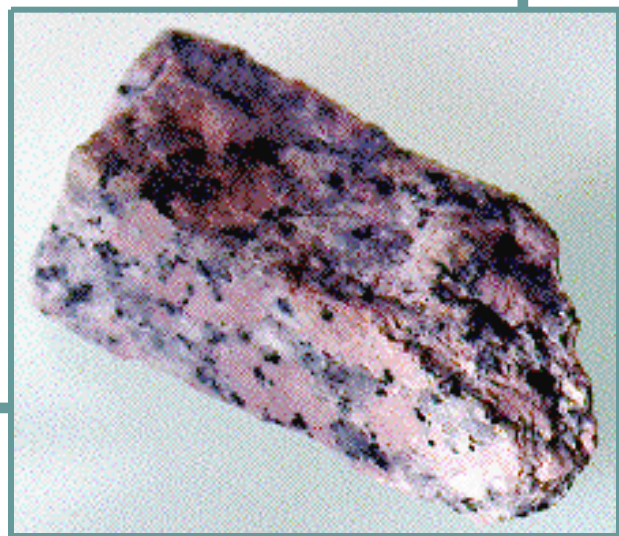
- A **mixture** is a physical blend of two or more components.
- Ex: Salad Bar

2.2 Classifying Mixtures

- Based on the distribution of their components, mixtures can be classified as heterogeneous mixtures or as homogeneous mixtures.

2.2 Classifying Mixtures

- Heterogeneous Mixtures
- A mixture in which the composition is not uniform throughout is a **heterogeneous mixture**.
- 2 or more phases



2.2 Classifying Mixtures

- Homogeneous Mixtures
- A mixture in which the composition is uniform throughout is a **homogeneous mixture.**
- Another name for a homogeneous mixture is a **solution.**
- All in same phase

Conceptual Problem 2.1

Separating a Heterogeneous Mixture

Sometimes plastic signs are used to mark trails used by hikers or vehicles. The sign in the photo is used to mark locations along a trail where an all terrain vehicle (ATV) is permitted. Aluminum nails are used to attach signs at eye level to trees or posts. How could a mixture of aluminum nails and iron nails be separated?

Conceptual Problem

10. Air is mainly a mixture of nitrogen and oxygen, with small amounts of other gases such as argon and carbon dioxide. What property could you use to separate the gases in air?

2.2 Separating Mixtures

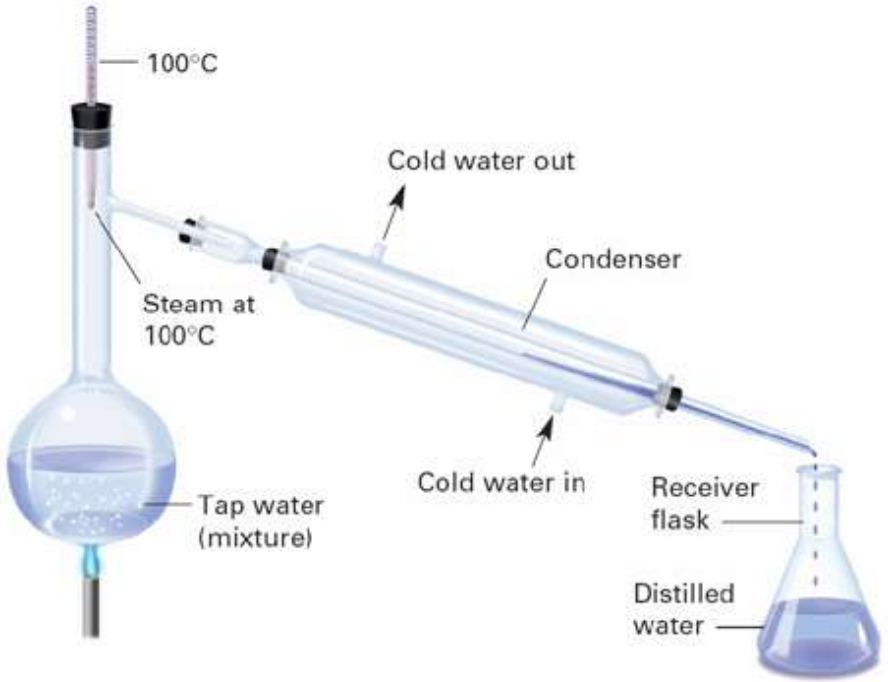
- Differences in physical properties can be used to separate mixtures.

2.2 Separating Mixtures

- Filtration
  - The process that separates a solid from the liquid in a heterogeneous mixture is called **filtration**.
  - Ex: colander

2.2 Separating Mixtures

- During a **distillation**, a liquid is boiled to produce a vapor that is then condensed into a liquid.

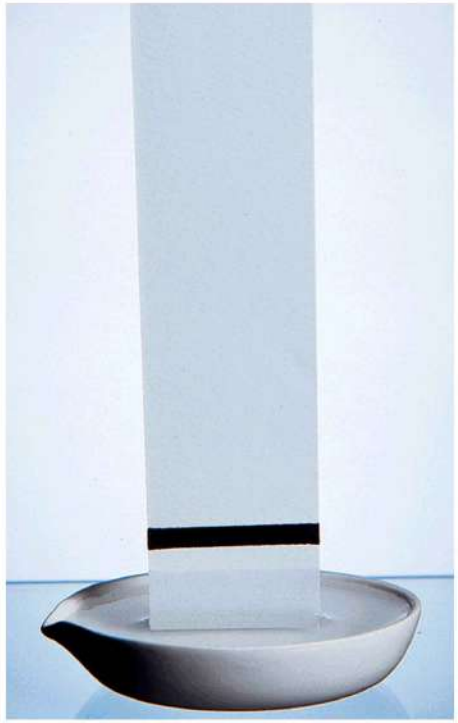


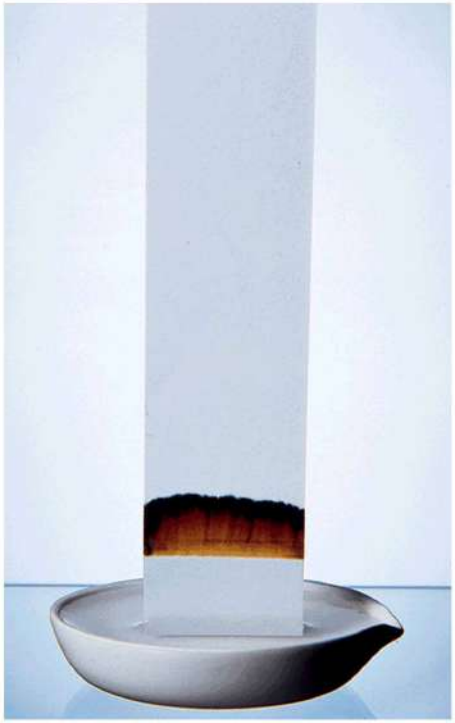
Physical Separation Techniques

- Decanting- when liquid is poured off after solid has settled to bottom

Other Methods

- Chromatography – separates on basis to travel across another material





2.2 Section Quiz.

- 1.Which of the following is a homogeneous mixture?

  a)vinegar

  b)iron filings in sand

  c)chicken noodle soup

  d)muddy water

2.2 Section Quiz.

- 2.Which technique is used to separate homogeneous mixtures?

  a)filtration

  b)distillation

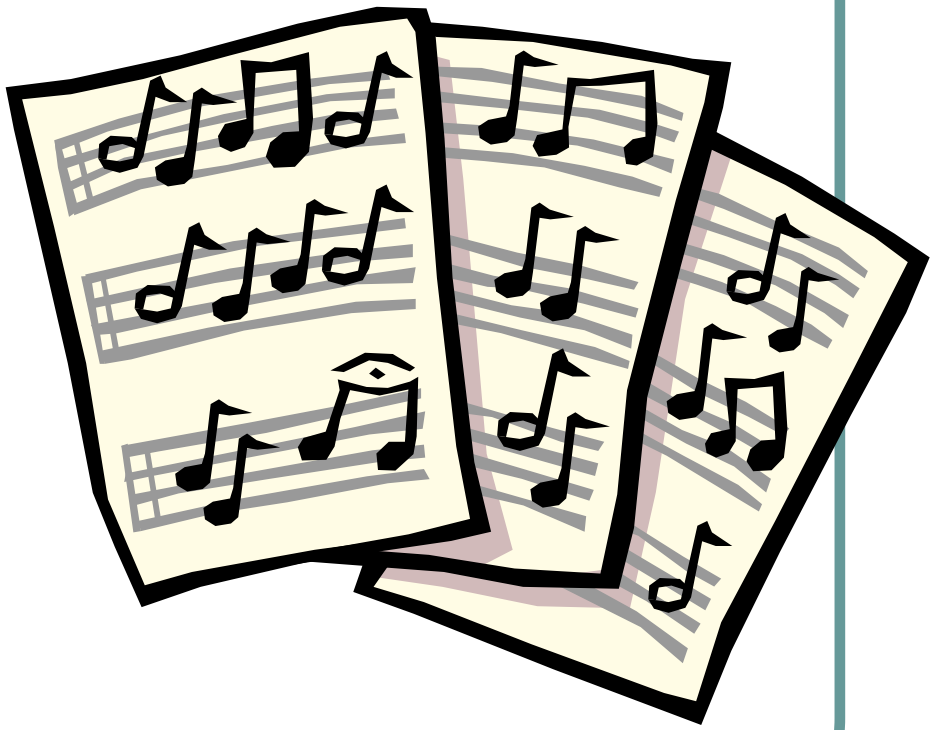
  c)magnetism

  d)dissolving

2.3 Elements and Compounds

Elements

- Are all atoms alike?
- Matter is composed of about 100 types of atoms that we call elements



Distinguishing Elements and Compounds

2.3

- An **element** is the simplest form of matter that has a unique set of properties.
- A **compound** is a substance that contains two or more elements chemically combined in a fixed proportion
  - Can be broken down by chemical means

Law of Definite Proportions

- States that compound is always composed of the same elements in the same proportion by mass.
- Percent by mass – ratio of mass of each element to the total mass of the compound expressed as a percentage

Percent by Mass

- A 78.0 g sample of an unknown compound contains 12.4 g of hydrogen. What is the percent by mass of hydrogen in the compound?
- If 3.5 g of element X reacts with 10.5 g of element Y to form the compound XY, what is the percent by mass of element X? Of element Y?

Percent by Mass

- Two unknown compounds are tested. Compound 1 contains 15.0 g of hydrogen and 120.0 g of oxygen. Compound 2 contains 2.0 g of hydrogen and 32.0 g of oxygen. Are the compounds the same? Explain.

Law of multiple proportions

- States when different compounds are formed by a combination of the same elements, different masses of one element combine with the same relative mass of the other element in a ratio of small whole numbers.

Law of multiple proportions

- Ex: water (H_2O) and hydrogen peroxide (H_2O_2). When you compare the mass of oxygen in hydrogen peroxide to the mass of oxygen in water, you get the ratio of 2:1

Law of multiple proportions

- Three compounds containing potassium and oxygen are compared. Analysis shows that for each 1.00 g of O, the compounds have 1.22 g, 2.44 g, and 4.89 g of K, respectively. Show how these data support the law of multiple proportions.

Distinguishing Elements and Compounds

2.3

- Breaking Down Compounds
  - A **chemical change** is change that produces matter with a different composition than the original matter.
  - Ex: heating table sugar

Distinguishing Elements and Compounds

2.3

- Properties of Compounds
  - In general, the properties of compounds are quite different from those of their component elements.
  - Ex: sodium and chlorine combine chemically to form sodium chloride

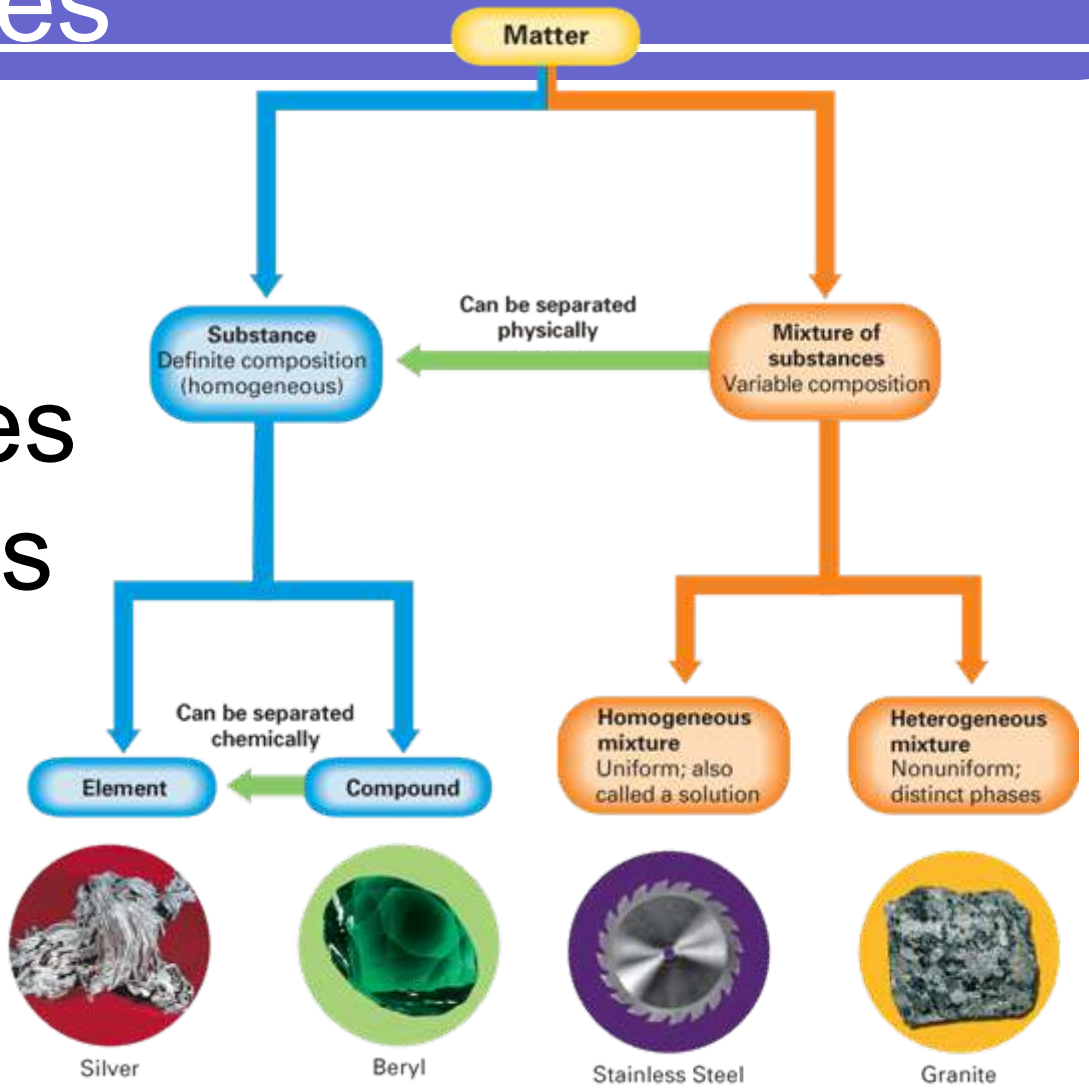
Distinguishing Substances and Mixtures

- If the composition of a material is fixed, the material is a substance. If the composition of a material may vary, the material is a mixture.

Distinguishing Substances and Mixtures

2.3

- This flowchart summarizes the process for classifying matter.



Conceptual Problem 2.2

Classifying Materials

When the blue-green solid in the photograph is heated, a colorless gas and a black solid form. All three materials are substances. Is it possible to classify these substances as elements or compounds?

Analyze *Identify the relevant concepts.*

List the known facts and relevant concepts.

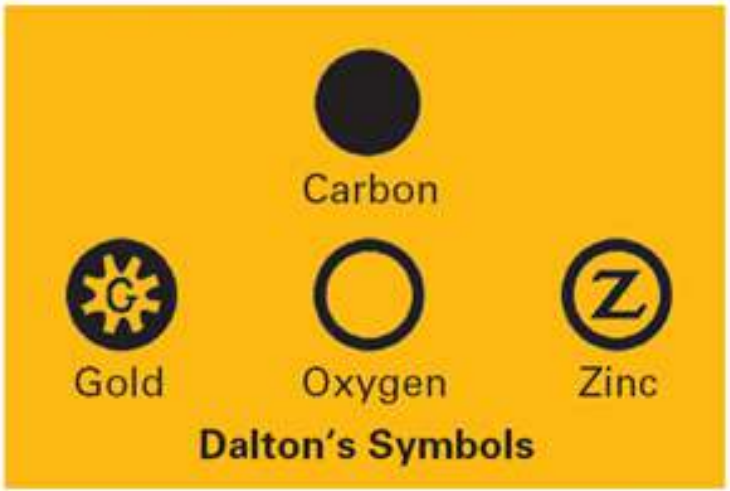
- A blue-green solid is heated.
- A colorless gas and a black solid appear.
- A compound can be broken down into simpler substances by a chemical change, but an element cannot.
- Heating can cause a chemical change.

for Conceptual Problem 2.2

19. A clear liquid in an open container is allowed to evaporate. After three days, a solid is left in the container. Was the clear liquid an element, a compound, or a mixture? How do you know?

2.3 Symbols and Formulas

- Chemists use chemical symbols to represent elements, and chemical formulas to represent compounds.
- **These chemical symbols were used in earlier centuries.**



2.3 Symbols and Formulas

- Each element is represented by a one or two-letter **chemical symbol**.

Table 2.2

Symbols and Latin Names for Some Elements

Name	Symbol	Latin name
Sodium	Na	*natrium*
Potassium	K	*kalium*
Antimony	Sb	*stibium*
Copper	Cu	*cuprum*
Gold	Au	*aurum*
Silver	Ag	*argentum*
Iron	Fe	*ferrum*
Lead	Pb	*plumbum*
Tin	Sn	*stannum*

Determine whether each of the following is an element, compound, homogeneous mixture or heterogeneous mixture.

- air
- wood
- chlorine
- granite
- aluminum
- sugar in water
- blood
- sucrose
- stainless steel
- sodium chloride
- brass
- whole milk
- apple
- table salt
- soft drinks
- vinegar
- concrete
- sodium
- baking soda ($NaHCO_3$)
- gravel

2.3 Section Quiz

- 1.Passing an electric current through a certain substance produces oxygen and sulfur. This substance cannot be a(n)

  a)compound.

  b)mixture.

  c)element.

  d)solution.

2.3 Section Quiz

- 2.Which of the following is a mixture?
  - a)sodium chloride
  - b)carbon dioxide
  - c)sucrose
  - d)air

2.3 Section Quiz.

- 3.The symbol for the element potassium is

  a)K.

  b)Po.

  c)P.

  d)Pt.

2.4 Chemical Reactions

2.4 Chemical Changes

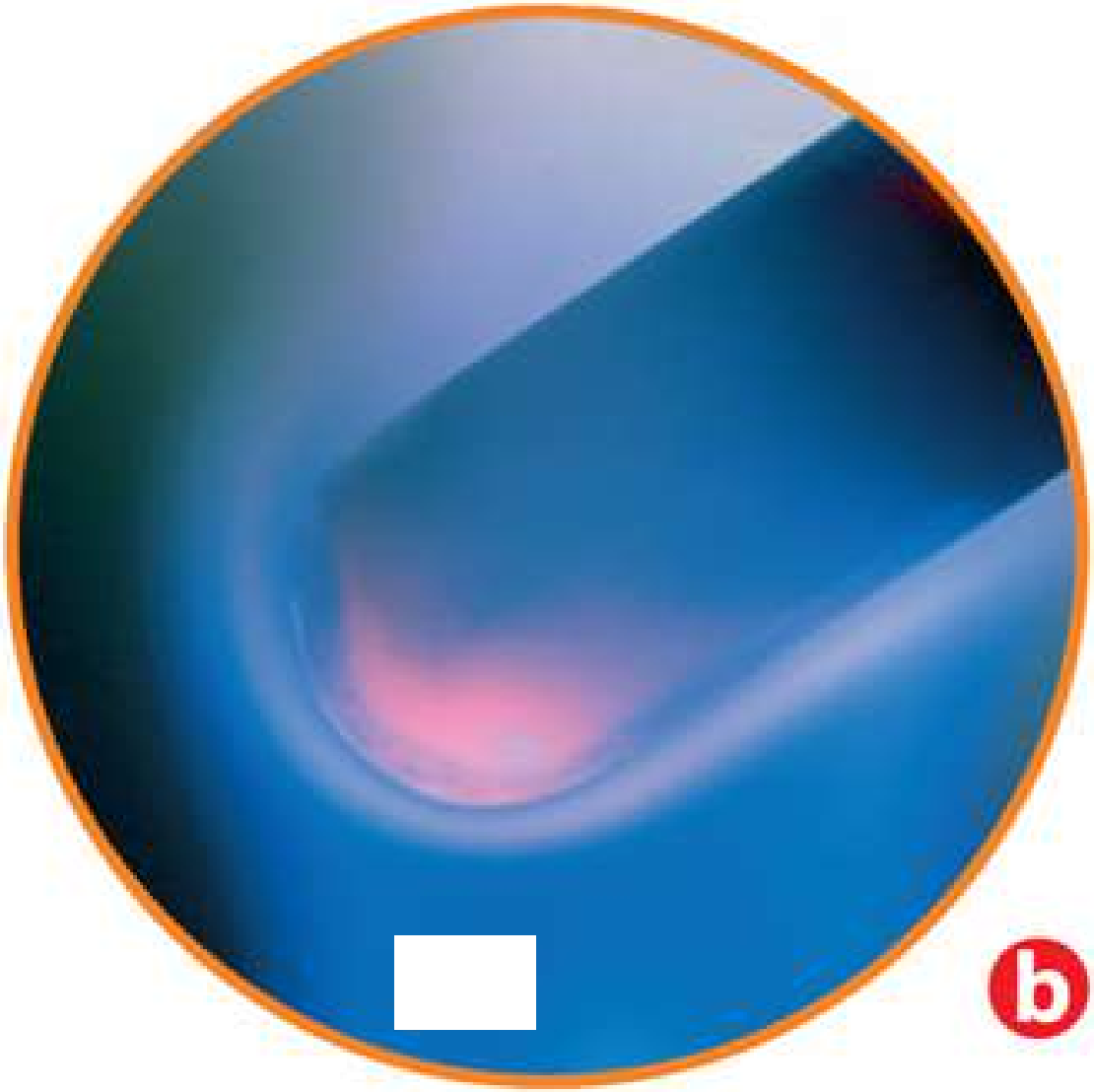
- The ability of a substance to undergo a specific chemical change is called a **chemical property.**
- Chemical properties can be used to identify a substance.
- They can only be observed when a substance undergoes a chemical change.

2.4 Chemical Changes

- During a chemical change, the composition of matter always changes.
- **Recall that during a physical change, the composition of matter never changes.**

2.4 Chemical Changes

- A mixture of iron and sulfur is heated. The iron and sulfur react and form iron sulfide. This is an example of a chemical change.



2.4 Chemical Changes

- A chemical change is also called a chemical reaction.
- One or more substances change into one or more new substances during a **chemical reaction.**
- A substance present at the start of the reaction is a **reactant.**
- A substance produced in the reaction is a **product.**

2.4 Recognizing Chemical Changes

- Possible clues to chemical change include:
  - **a transfer of energy**
  - **a change in color**
  - **the production of a gas**
  - **the formation of a precipitate.**

2.4 Chemical Changes

- A **precipitate** is a solid that forms and settles out of a liquid mixture.

2.4 Conservation of Mass

- During any chemical reaction, the mass of the products is always equal to the mass of the reactants.

2.4 Conservation of Mass

- The **law of conservation of mass** states that in any physical change or chemical reaction, mass is conserved.
  - The conservation of mass is easily observed when a change occurs in a closed container.

Law of Conservation of Mass

- In an experiment 10.00 g of red mercury (II) oxide powder is placed in an open flask and heated until it is converted to liquid mercury and oxygen gas. The liquid mercury has a mass of 9.26 g. What is the mass of oxygen formed in the reaction?

Law of conservation of mass

- A student carefully placed 15.6 g of sodium in a reactor supplied with an excess quantity of chlorine gas. When the reaction was complete, the student obtained 39.7 g of sodium chloride. Calculate how many grams of chlorine gas reacted.

Physical or Chemical?

1) Iron metal is melted
2) Iron combines with oxygen to form rust
3) Wood burns in air
4) A rock is broken into smaller pieces

Physical or Chemical?

- 5) Milk turns sour
- 6) Wax is melted over a flame then catches fire and burns
- 7) You make scrambled eggs

Physical or Chemical

- 8) You step on a piece of chalk and it becomes powdered
- 9) You light a candle when the electricity goes out
- 10) Steam from your hot shower condenses on a cold mirror

2.4 Section Quiz.

- 1.Which of the following is a chemical reaction?

  a)melting of lead

  b)dissolving sugar in water

  c)rusting of iron

  d)crushing of stone

2.4 Section Quiz.

- 2.Which of the following is NOT a possible clue that a chemical change is taking place?

  a)a change of state

  b)a change in color

  c)production of a gas

  d)formation of a precipitate

2.4 Section Quiz.

- 3.During any chemical change, the mass of the products is

  a)always equal to the mass of the reactants.

  b)always greater than the mass of the reactants.

  c)always less than the mass of the reactants.

  d)sometimes different than the mass of the reactants.