

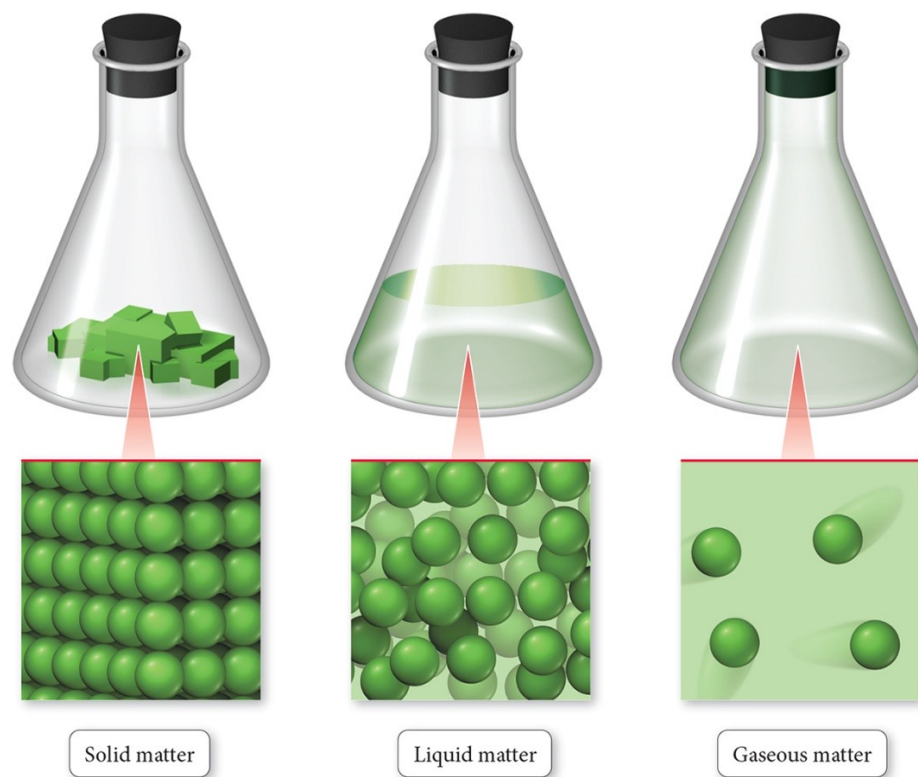
## 1.3: The Classification of Matter

(section 1.2 of OpenStax Chemistry 2e)

1. **Matter** is anything that occupies space and has mass.
  - Your textbook, your desk, your chair, and your body are all composed of matter.
2. We can classify matter according to its **state** (its physical form) and its **composition** (the basic components that make it up).
3. **Matter** can be classified as solid, liquid, or gas based on what properties it exhibits.
4. The state of matter changes from solid to liquid to gas with increasing temperature.

# Structure Determines Properties

- The atoms or molecules have different arrangements in solids, liquids, and gases—leading to different properties.



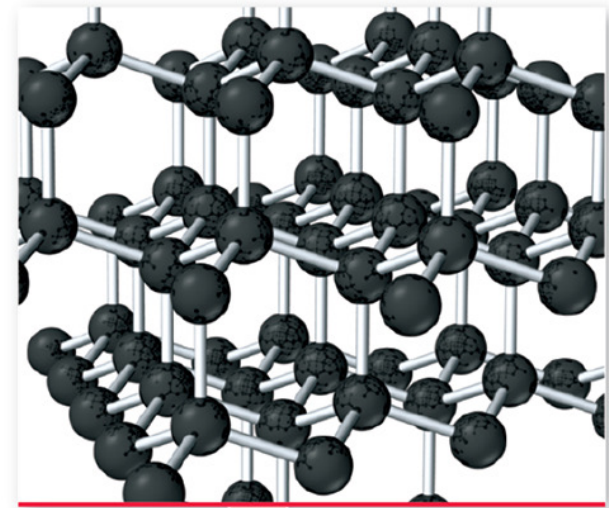
## Solid Matter (1 of 2)

- In **solid matter**, atoms or molecules pack close to each other in fixed locations.
- Although the atoms and molecules in a solid **vibrate**, they do not move around or past each other.
- Consequently, a solid has a **fixed volume** and **rigid shape**.
  - Ice, aluminum, and diamond are examples of solids.

## Solid Matter (2 of 2)

1. Solid matter may be **crystalline**, in which case its atoms or molecules are in patterns with long-range, repeating order.
  - Table salt and diamond are examples of crystalline solid matter.
2. Other solids may be **amorphous**, in which case their atoms or molecules do not have any long-range order.
  - Glass and plastic are examples of amorphous solids.

Crystalline Solid:  
Regular  
three-dimensional pattern



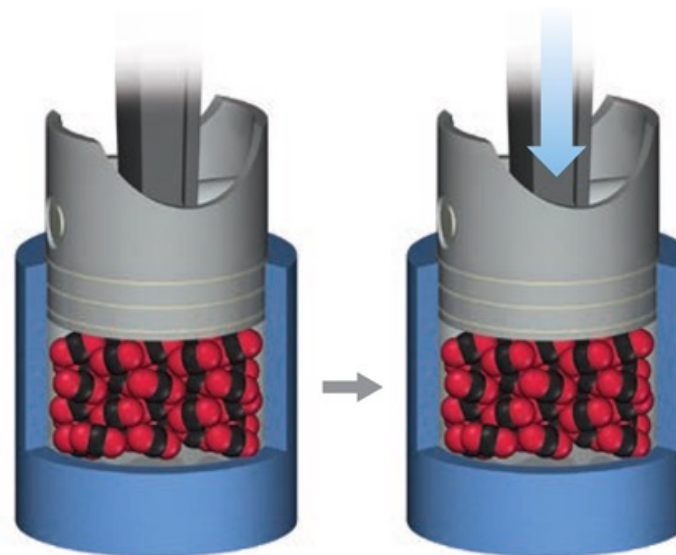
**Diamond**  
C (s, diamond)

# Liquid Matter

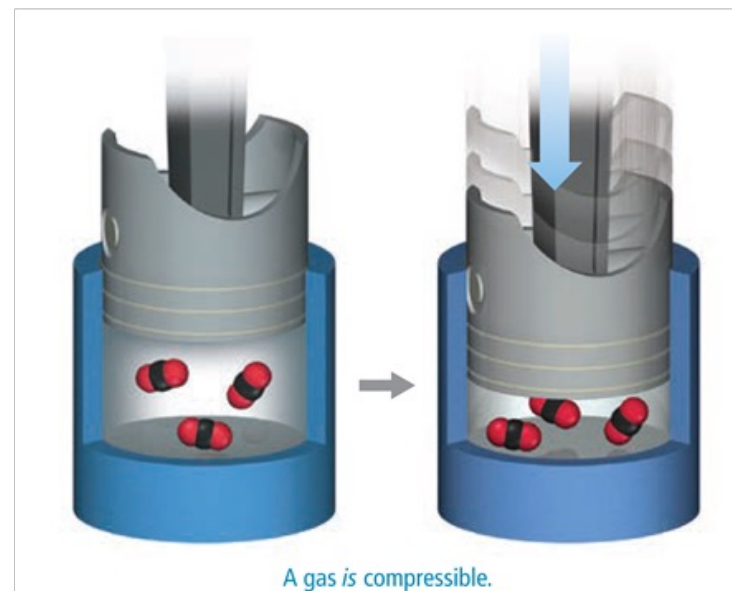
1. In **liquid matter**, atoms or molecules pack about as closely as they do in solid matter, but they are free to move relative to each other.
2. Liquids have **fixed volume** but not a fixed shape.
3. Liquid's ability to flow makes it assume the shape of its container.
  - Water, alcohol, and gasoline are all substances that are liquids at room temperature.

# Gaseous Matter

- In **gaseous matter**, atoms or molecules have a lot of space between them.
- Gases are therefore **compressible**.
- The particles are moving quickly and are independent of each other.
- Gases take the shape of their container and fill the volume of the container.



A solid is *not* compressible.



A gas *is* compressible.

## Some Properties of Solids, Liquids, and Gases

Property	Solid	Liquid	Gas
Shape	Has a definite shape	Takes the shape of the container	Takes the shape of its container
Volume	Has a definite volume	Has a definite volume	Fills the volume of the container
Arrangement of particles	Fixed, very close	Random, close	Random, far apart
Interaction between particles	Very strong	Strong	Essentially none
Movement of particles	Very slow	Moderate	Very fast
Examples	Ice, salt, iron	Water, oil, vinegar	Water vapor, helium, air

# Learning Check 1

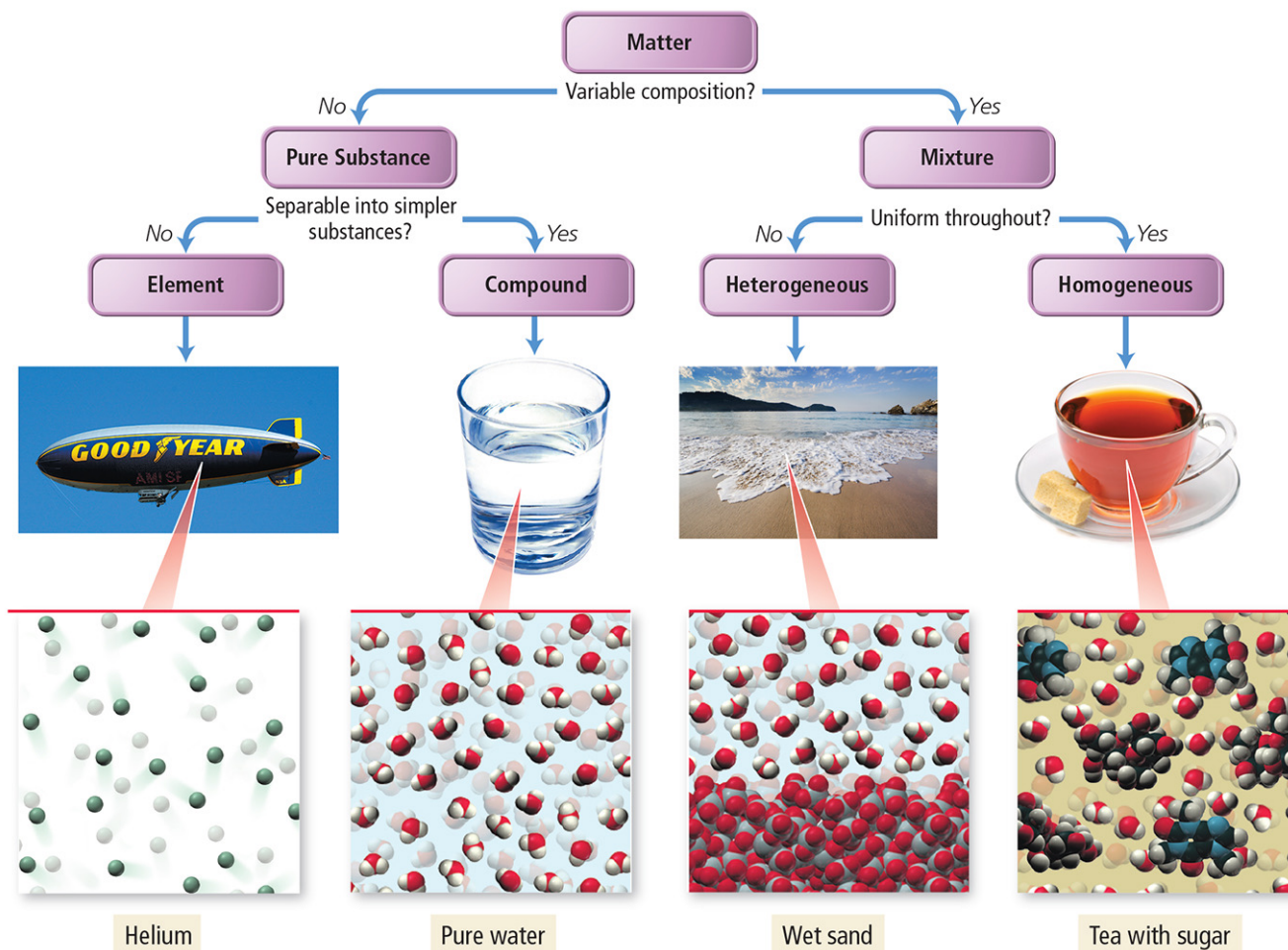
Identify each description as that of a solid, liquid, or gas.

- A. It has definite volume and takes the shape of the container. **liquid**
- B. Its particles are moving very rapidly. **gas**
- C. Its particles fill the entire volume of a container. **gas**
- D. Its particles have a fixed arrangement. **solid**
- E. Its particles are close together but can move relative to each other. **liquid**



# The Classification of Matter by Components

- Matter can also be classified according to its composition: elements, compounds, and mixtures.



# Classification of Matter by Components

- The first division in the classification of matter is between a *pure substance* and a *mixture*.
- A **pure substance** is made up of only one component, and its composition is invariant.
- A **mixture**, by contrast, is a substance composed of two or more components in proportions that can vary from one sample to another.

# Classification of Pure Substances (1 of 2)

- There are two types of **pure substances**.
  - Elements
  - Compounds
- This categorization depends on whether or not they can be broken down (or decomposed) into simpler substances.

## Classification of Pure Substances (2 of 2)

- An **element** is a substance that can't be chemically broken down into simpler substances.
  - Basic building blocks of matter
  - Composed of single type of atom, like helium
  - Are displayed in the Periodic Table.
- A **compound** is a substance composed of two or more elements in fixed definite proportions.
- Most elements are chemically reactive and combine with other elements to form compounds like water, sugar, etc.

# Classification of Mixtures

- **Mixtures** can be categorized into two types:
  - Heterogeneous mixtures
  - Homogeneous mixtures
- This categorization depends on how *uniformly* the substances within them mix.

# Heterogeneous Mixture

- A **heterogeneous mixture** is one in which the composition varies from one region of the mixture to another.
  - Made of multiple substances whose presences can be seen
  - Examples: salad dressing or a pizza
- Different portions of a sample of **heterogeneous** mixture have different composition and properties.

# Homogeneous Mixture

- A **homogeneous mixture** is made of multiple substances but appears to be one substance.
- All portions of a sample have the same composition and properties (like sweetened tea).
- Homogeneous mixtures have uniform compositions because the atoms or molecules that compose them mix uniformly.

## Learning Check 2

Identify each of the following as pure substance or mixture. If pure substance, classify as element or compound; if mixture, classify as homogeneous or heterogeneous:

- A. copper     **pure substance, element**
- B. cereal in milk     **mixture, heterogeneous**
- C. air     **mixture, homogeneous (nitrogen, oxygen, more)**
- D. table salt, NaCl     **pure substance, compound**

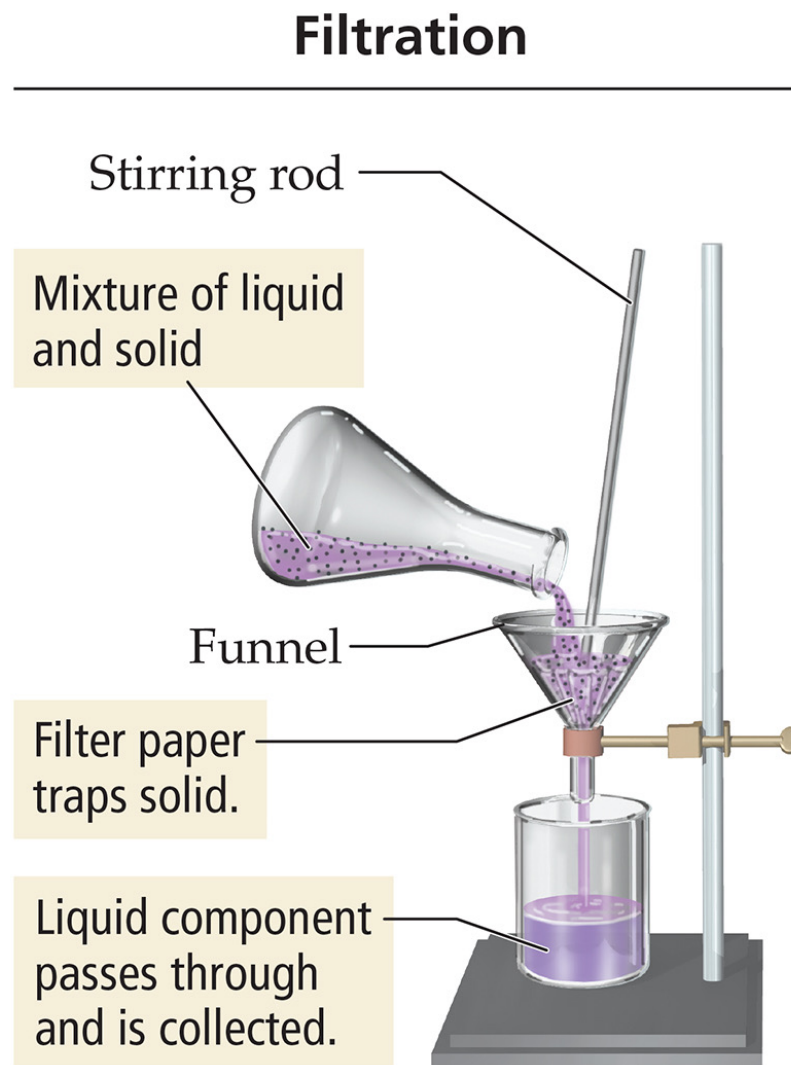


# Separating Mixtures (1 of 3)

- Mixtures are separable because the different components have different physical or chemical properties.
- Various techniques that exploit these differences are used to achieve separation.
- A mixture of sand and water can be separated by **decanting**—carefully pouring off the water into another container.

## Separating Mixtures (2 of 3)

- A mixture of an insoluble solid and a liquid can be separated more efficiently by **filtration**—a process in which the mixture is poured through filter paper in a funnel.



# Separating Mixtures (3 of 3)

- A homogeneous mixture of liquids can often be separated by **distillation**, a process in which the mixture is heated to boil off the more **volatile** (easily vaporizable) liquid.
- The volatile liquid is then **re-condensed** in a condenser and collected in a separate flask.

## Distillation

When a mixture of liquids with different boiling points is heated...

... the most volatile component boils first.

The vapor is then cooled and collected as pure liquid.

