

MATTER

Matter is the stuff that's all around you: the metal and plastic of a telephone, the paper and ink of a book, the glass and liquid of a bottle of soda, the air you breathe, and the materials that make up your body.

A more formal definition of matter is anything that takes up space and has mass.

Mass or weight?
Is air matter, too?
Air has mass.
What about fire?

Section Review

- Which one is **not** matter and why?
 - Helium gas
 - Water
 - Salt
 - Space
- Matter includes all of the following EXCEPT?
 - Air
 - smoke
 - spray
 - nightmare
- Two features that distinguish matter are
 - Mass and velocity
 - Weight and velocity
 - Mass and volume
 - Weight and volume
- How do you describe a block of wood is a matter?*

Matter has two common properties, mass and volume. Mass of wood block can be measured and its volume is calculated from its height, depth and length.
- How does mass differ from weight?*

Mass is the quantity of matter, measured by equal arm balance, and is constant in everywhere. But weight is the force applied on matter by gravity, is measured by spring balance, and is not constant in everywhere.

2. States of Matter

In solid state,

- definite shape and volume,
- particles are very close to each other.

In liquid state,

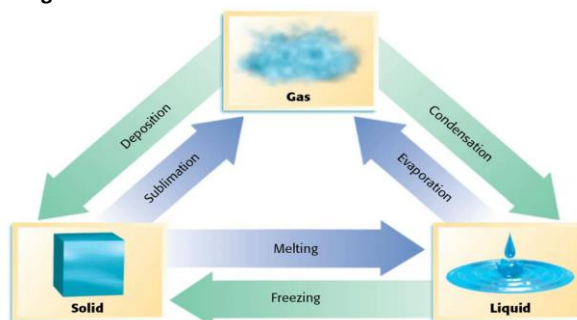
- definite volume, but not definite shape,
- particles move and slide over one another.

In gaseous state,

- not definite volume or shape,
- move freely in all directions,
- far apart from one another.

Plasma state can be seen at extremely hot temperatures. Stars, lightning, sun, fluorescent light are examples for plasma state.

Phase Change



Section Review

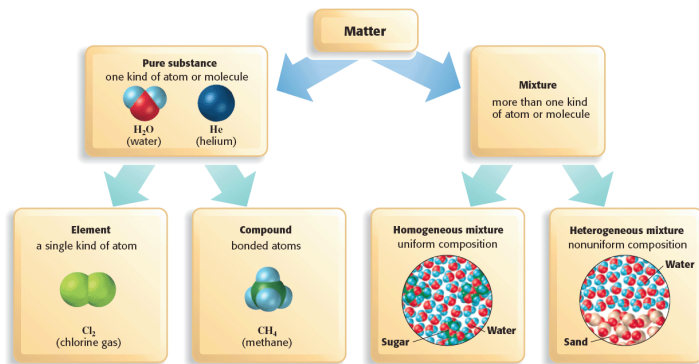
- In Which state of matter particles are able to move in all directions?
 - Liquid
 - Gaseous
 - Solid
 - Plasma
- What are the physical state of clouds, rain and snow?
 - solid, liquid, gaseous
 - liquid, gaseous, solid
 - solid, liquid, liquid
 - gaseous, liquid, solid
- Which of the following substances are able to expand and fill their containers?

apple, gasoline, air, orange juice, stone, water steam

 - apple, orange juice, stone
 - gasoline, air, water steam
 - air, water steam
 - orange juice, gasoline
- Which of the following characteristics of matter in liquid state?
 - Definite volume
 - Shapeless
 - Its particles can move and slide over one another.
 - All of the above
- What is called when matter becomes gaseous from solid state?
 - Sublimation
 - Deposition
 - Boiling
 - Freezing
- The state of matter in which particles are rigidly held in fixed positions is the
 - vaporous state.
 - gaseous state.
 - solid state.
 - liquid state.
- A sample of matter can be poured from container to container. It takes the shape of its container but only takes up a certain volume. Based on this information, the sample is in the **liquid** state.
- Why can a gas fill the entire volume of its container?

Solution: Gas particles have little attraction for each other and can easily and quickly move from one place to another.

3. Classification of Matter Classifying Matter



Pure substances

A pure substance is a sample of matter, either a single element or a single compound, that has definite chemical and physical properties.

Elements

- Elements are pure substances that contain one kind of atom. shown by symbols such as Ag, S, C, Na, Ca, Li, O, H...etc. There are 116 elements known today, 92 of them are natural.
- Cannot be broken down into another substances.
- Smallest unit of an element is an atom.
- Some elements, such as oxygen, phosphorus, sulfur, and carbon, have many different molecular forms.
- An allotrope is one of a number of different molecular forms of an element.

Elements are further classified as metals and non metals.

Metals,

- are good conductors of electricity,
- are solids at room temperature (25°C), except Hg,
- have metallic shiny color,
- can be hammered into sheets, malleability
- can be drawn into wires, ductility.

Nonmetals,

- don not conduct electricity, except for graphite.
- can be solid, liquid, or gaseous at room temperature,
- have dull color,
- are brittle,
- can not be drawn into wires.

Compounds

- A compound is a chemical combination of two or more different elements joined together in a fixed proportion with a unique set of chemical and physical properties.
- A molecule is the smallest unit of a compound.
- Water we drink, hydrochloric acid in our stomach, sodium chloride as a table salt...etc are all compounds.
- More than 10 million compounds are known and the number keeps growing.
- The properties of the compound are different from the properties of the elements that compose the compound.
- A formula is a combination of the chemical symbols that show what elements make up a compound and the number of atoms of each element. Caffeine (C₈H₁₀N₄O₂), Sugar (C₆H₁₂O₆), Salt (NaCl)

- Compounds can be broken down into their elements, though often with great difficulty.

Mixtures

- A mixture is a combination of two or more substances that are not chemically combined.
- An alloy is a solid mixture.
- proportions of materials can change,
- properties reflect the properties of the substances it contains,
- can be decomposed into components by physical methods,
- can be either homogeneous or heterogeneous.

A homogeneous mixture describes something that has uniform structure or composition throughout. Air, gasoline, syrup, vinegar, coins, salty water,...etc are homogeneous mixtures. They are called solutions as well.

A heterogeneous mixture has different properties in different regions of the mixture. Sand-water, oil-water, soil, tea, milk, blood, fog, ...etc are heterogeneous mixtures. A heterogeneous mixture has different properties in different regions of the mixture. Sand-water, oil-water, soil, tea, milk, blood, fog, ...etc are heterogeneous mixtures.

Section Review

- Which is NOT a property of metals?
 - malleability
 - ability to conduct heat and electricity
 - unreactivity
 - capable of being stretched
- A list of pure substances could include
 - bread dough.
 - vinegar (5% acetic acid).
 - vitamin C (ascorbic acid).
 - sea water
- Which of the following is an element?
 - BaCl₂
 - CO
 - Ne
 - CaCO₃
- The mixtures which have uniform structure are
 - blood, rain water and air.
 - carbon dioxide in water, bronze and steel.
 - soil, cement and dust in air.
 - alcohol-water, tea, aspirin.
- Which of the following statements about compounds is true?
 - A compound contains only one element.
 - A compound can be classified as either heterogeneous or homogeneous.
 - A compound has a defined ratio by mass of the elements that it contains.
 - A compound varies in chemical composition depending on the sample size.
- The two types of matter that are pure substances are **elements** and **compounds**. Identify the pure substances below
Air, He, brass, soil, water, vinegar, ketchup, ice, milk, sodium, sugar, tea, cake, table salt, blood
 - Air, vinegar, ice, blood, sugar, milk

- B. Cake, water, ice, sodium, He
- C. Water, tea, milk, table salt, sugar, brass
- D. He, water, ice, sodium, sugar, table salt

7. Iron and sulfur, when heated, form an iron sulfide that has different properties from either iron or sulfur. This iron sulfide is an example of a *compound*.

4. Properties of Matter

Chemical Properties

- The ability of a substance to combine with or change into one or more other substances is called a **chemical property**.
- Flammability, rusting, acidity, reactivity with water are examples for chemical properties.
- A chemical change occurs whenever a new substance is made.

Physical Properties

- A physical property of a substance is a characteristic that does not involve a chemical change. Physical properties can be extensive or intensive.
- Mass, volume, or weight are extensive properties of matter.
- Intensive properties of matter do not depend on the amount given. They are sometimes called distinctive or characteristic properties.
- Color, odor, taste, solubility, density, conductivity, melting and boiling points, hardness, luster,...etc are all intensive properties.
- Physical properties of a substance can be determined without changing the nature of a substance.

a. Density

- The density of an object is the mass of the object divided by volume of the object.
- Densities are expressed in derived units such as g/cm³ or g/mL.

$$\text{density} = \frac{\text{mass}}{\text{volume}} \text{ or } d = \frac{m}{v}$$

- The density of a substance is the same no matter what the size of the sample is.
- Because the density of a substance is the same for all samples, you can use this property to help identify substances.

Example 1

Calculate the density of 105 g silver with a volume of 10 cm³.

Solution

$$d = \frac{m}{V} \Rightarrow d = \frac{105\text{g}}{10\text{cm}^3} = 10.5 \text{ g/cm}^3$$

Example 2

Calculate the mass of a cubic iron block with a 3-cm side length. ($d_{\text{Fe}} = 7.86 \text{ g/cm}^3$)

$$\text{Volume of Cubic Iron Block, } V = a^3 = 3^3 = 27\text{cm}^3 \quad d = \frac{m}{V} \Rightarrow m = d \times V = 7.86 \times 27 = 212.22\text{g}$$

As it's known, substance expands in volume when it is heated. Whereas, temperature of water raises from 0°C up to 4°C, its volume instead of increasing decreases. That's why ten thousand tones icebergs in spite of their weight floats on the water.

b. Melting Point (mp) and Freezing Point (fp)

Melting point is the temperature at which a solid starts to become a liquid. And freezing point is the temperature of the reverse change. For example water melts or freezes at 0°C whereas iron melts 1535°C.

Boiling Point (bp)

- A boiling point is a temperature at which a liquid becomes a gas. For instance alcohol boils at 78°C, but it is 1°C for butane gas.
- Boiling point depends on pressure.
- Evaporation or boiling?

Example 3

Find the physical states of the substances A, B and C at room temperature.

Substance	Melting Point (°C)	Boiling Point (°C)
A	-35	10
B	45	350
C	15	75

Solution

A is gas, B is solid, C is liquid.

d. Solubility

- Solubility is the amount of substance dissolved in a given solvent at a given temperature.
- A solution is prepared by dissolving a solute in a solvent.
- Solubility of substances are measured in 100 g H₂O at a particular temperature. For instance solubility of sugar is 190 g /100 g H₂O at 20°C, while it is 10 g /100 g H₂O for baking soda.

1. Osmium, Os, is the densest metal known. What is its density in g/cm³ when 50 g of a sample of Os occupies 2.22 cm³ volume?

$$d_{\text{Os}} = \frac{m}{V} = \frac{50 \text{ g}}{2.22 \text{ cm}^3} = 22.52 \text{ g/cm}^3$$

2. You are given three samples of wood, copper and plastic rod with densities of 0.6 g/cm³, 7.86 g/cm³ and 1.02 g/cm³, respectively. How do they stand when they are put in water? (Assume density of water is 1 g/cm³)

3. The densest one is copper, it is placed at the bottom. Plastic rod has the same density with water, therefore it stands wherever it is put. Wood, has the least density among all, floats above water.

4. How many phase changes occur when an ice cube is heated until all becomes gas at 130°C?

- A. 1
- B. 2
- C. 3
- D. 4

5. Which of the following can be used to identify substances?

- A. Volume
- B. Solubility
- C. Mass
- D. Length

6. Find the physical states of the substances X, Y and Z at 45°C.

Substance	Melting Point (°C)	Boiling Point (°C)
X	-5	30
Y	35	175
Z	15	75

X is gas, Y and Z are liquids.

7. Why does water boil at the peak of Mt. Everest at 70°C but not at 100°C?

7. Because liquids boil when their vapor pressures equal to air pressure. And air pressure is lower at higher altitudes than that of sea level.

5. Separation of Mixtures

A. By Means of The Use of Electricity

In a mixture if one component is attracted by electricity it can be separated from the mixture by electrified objects. For example in pepper-salt mixture pepper can be removed by electrified ebonite rod.

B. By Means of The Use of A Magnet

Which are attracted by magnet. Mixtures containing one of these metals can be separated by use of magnet. For example iron-sulfur powder is separated by magnet.

C. By Means of Density Differences

Mixtures containing immiscible liquids can be separated by using density differences. For instance oil-water mixture is separated by using a separatory funnel in this technique.

D. By Means of Solubility

Some mixtures such as sand-salt contain substances with different solubilities. These type of mixtures can easily be separated by using filter paper. Only soluble component is able to pass through filter paper.

E. By Means of The Process of Distillation

Mixtures containing miscible liquids can be separated by distillation process. For example alcohol-water solution in which its components have different boiling points is separated by distillation. Petroleum refining is a good example for distillation in industry.

Section Review

1. Which method can be used to separate salty water?

- Distillation
- Filtration
- Evaporation
- By using magnet

2. Which of the following substances can be separated by physical methods?

- oil-water, CO₂ gas, vinegar, Zn, salt-Iron powder, soil, HCl, ayran, H₂O
- CO₂ gas, H₂O, Zn, HCl

- oil-water, CO₂ gas, vinegar, H₂O
- salt-Iron powder, ayran, HCl, soil
- ayran, oil-water, vinegar, salt-Iron powder, soil

3. In the separation of petroleum which property of matter is used?

- Density
- Solubility
- Conductivity
- Boiling point

4. In the separation of salt-sand-naphthalene mixture which component is separated first?

- naphthalene
- sand
- salt

5. Suggest a method to separate a mixture of salt-chalk dust.

First mixture is put in some water. Salt is miscible in water but not chalk dust, it dissolves thus chalk dust separated from the mixture by filtration. To separate salt from water it must be evaporated.