Chemistry 120 Spring 17

Introduction to Inorganic Chemistry

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TR 10:00-12:00

Contact me trough phone or e-mail if you have questions

Online Tests on Following days

March 24, 2017: Test 1 (Chapters 1-3)
April 7, 2017 : Test 2 (Chapters 4-5)
April 28, 2017: Test 3 (Chapters 6,7 &8)
May 12, 2017 : Test 4 (Chapters 9, 10 &11)
May 15, 2017: Make Up Exam: Chapters 1-11)

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Basic Concepts of Matter

Table of Contents

Chemistry: The Study of Matter

What is Chemistry?

- The field of study concerned with the characteristics, composition, and transformations of **matter**.

Chemistry: The Study of Matter

Matter

- Anything that has mass and occupies space.
  - Mass refers to the amount of matter (substance) present in a sample.

Chemistry: The Study of Matter

Matter

- Includes all things – both living and nonliving as well as naturally occurring and manmade.
  - Examples: plants, soil, rocks, air, bacteria, plastics
- Various forms of energy such as heat, light, and electricity are not considered to be matter.
- The universe is composed entirely of matter and energy.

Physical States of Matter

- The classification of a given matter sample in terms of physical state is based on whether its shape and volume are definite or indefinite.
- Matter exists in three physical states:
  - Solid
  - Liquid
  - Gas

Physical States of Matter

Examples of the Three States of Matter

A solid has a definite shape and a definite volume.

A liquid has an indefinite shape—it takes the shape of its container—and a definite volume.

A gas has an indefinite shape and an indefinite volume—it assumes the shape and volume of its container.

a

b

c

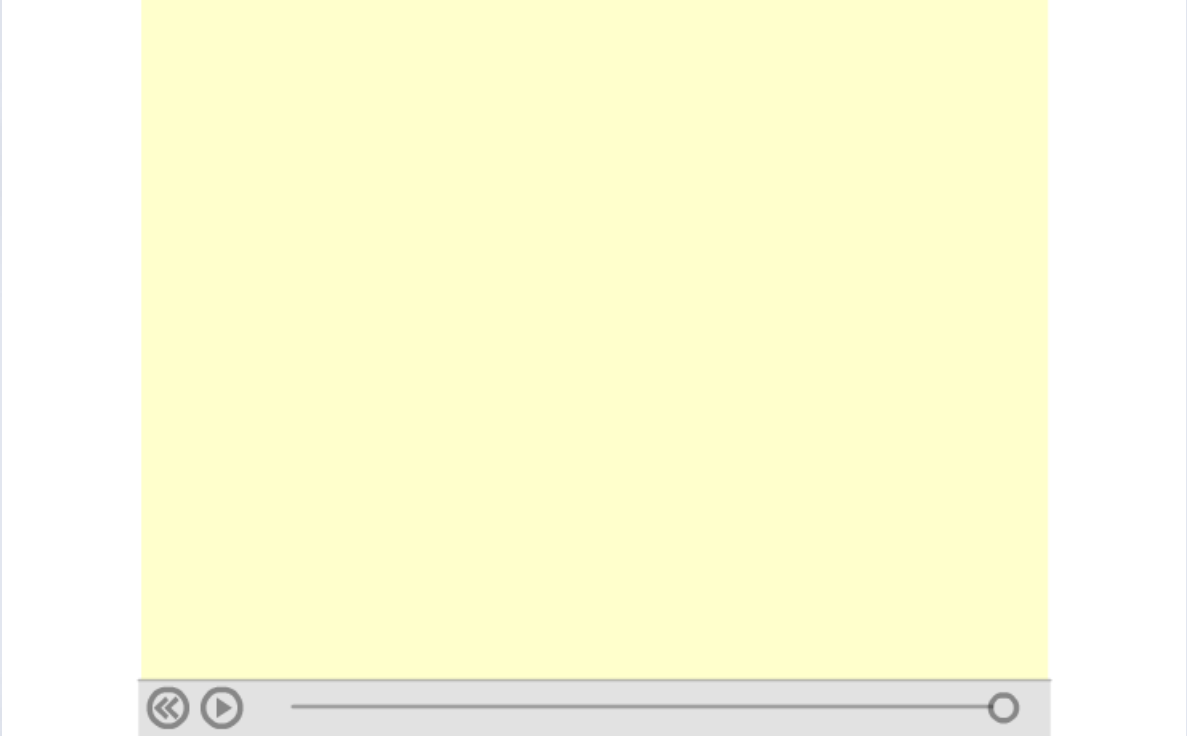
Physical States of Matter

Solid

- Physical state characterized by a definite shape and a definite volume.

Physical States of Matter

Structure of a Solid



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Physical States of Matter

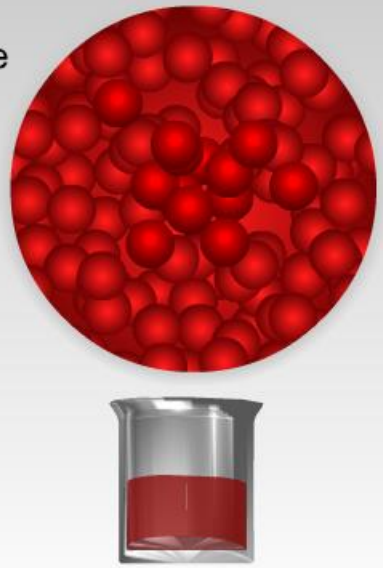
Liquid

- Physical state characterized by an indefinite shape and a definite volume.
- Always takes the shape of its container to the extent that it fills the container.

Physical States of Matter

Structure of a Liquid

Liquids are relatively incompressible because the particles which make up liquids are close together, though not as close together as the particles in a solid. Liquids conform to the shapes but not the volumes of their containers because their particles can and do slide randomly past one another.



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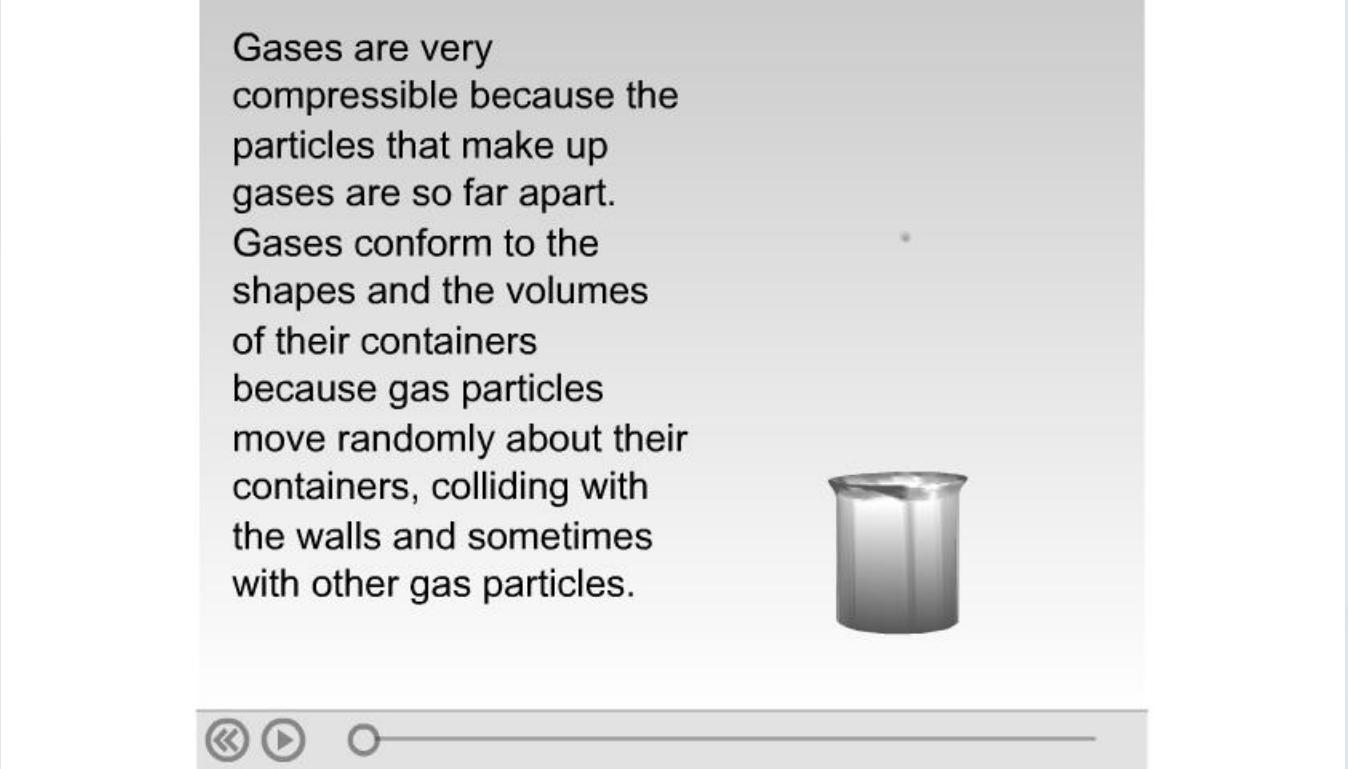
Physical States of Matter

Gas

- Physical state characterized by an indefinite shape and an indefinite volume.
- Always completely fills its container, adopting both the container's volume and its shape.

Physical States of Matter

Structure of a Gas



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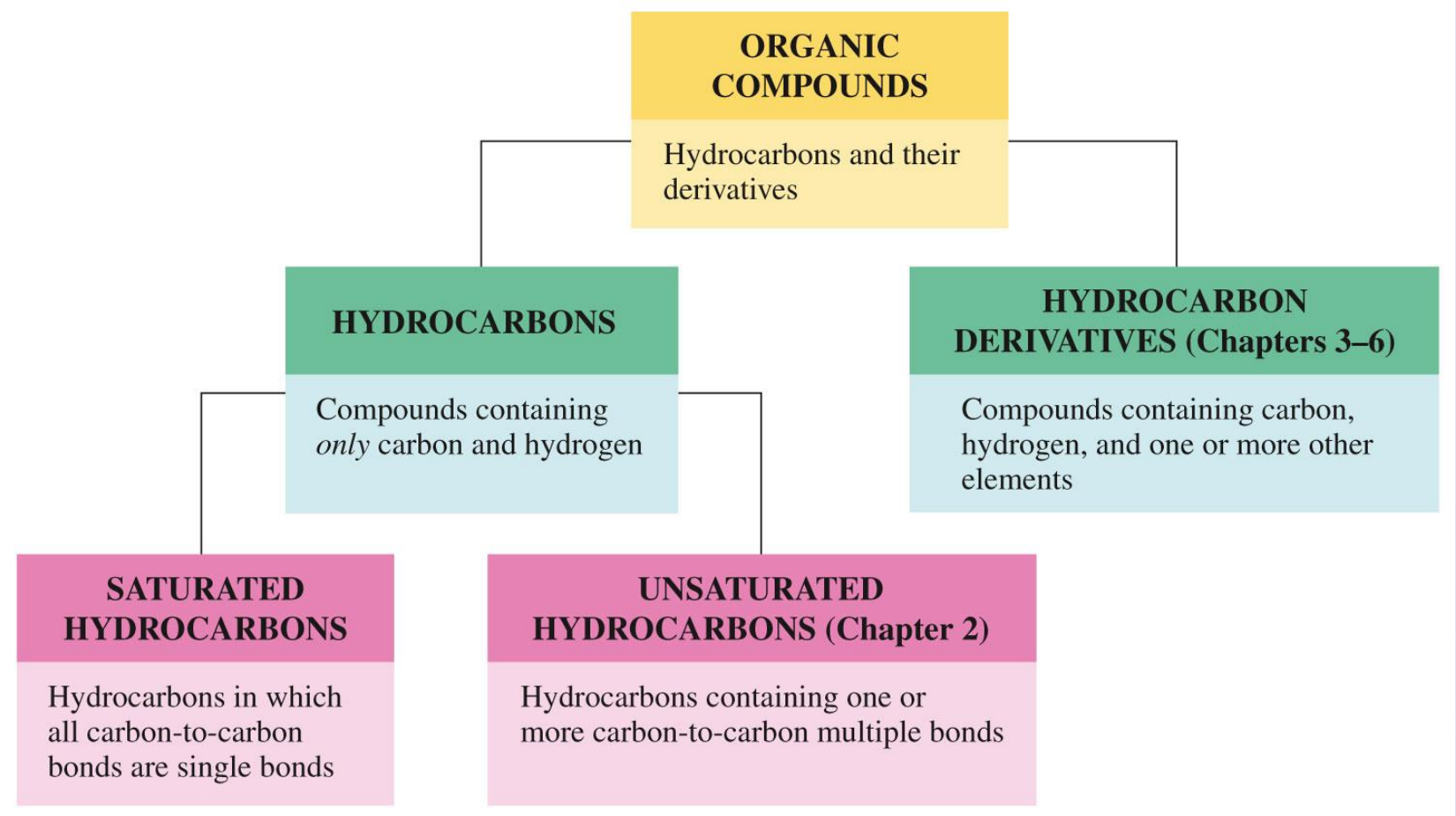
Physical States of Matter

- The state of matter observed for a particular substance depends on its:
  - Temperature
  - Surrounding pressure
  - Strength of the forces holding its structural particles together

Physical States of Matter

Water Can Be Found in All Three States Simultaneously



Properties of Matter

Property

- Distinguishing characteristic of a substance that is used in its identification and description.
- Each substance has a unique set of properties that distinguishes it from all other substances.
- Two General Types:
  - Physical
  - Chemical

Properties of Matter

Physical Property

- Characteristic of a substance that can be observed without changing the basic identity of the substance.
  - Color, odor, physical state, melting point, boiling point, and hardness

Properties of Matter

Concept Check

To measure the boiling point of a substance, a liquid must be changed into a gas. Why is boiling point considered a physical property when a gas' appearance is much different from that of a liquid?

Properties of Matter

Concept Check

To measure the boiling point of a substance, a liquid must be changed into a gas. Why is boiling point considered a physical property when a gas' appearance is much different from that of a liquid?

Although the appearance is different, the substance is still the same. It's chemical identity has not changed (remains the same irrespective of the physical state).

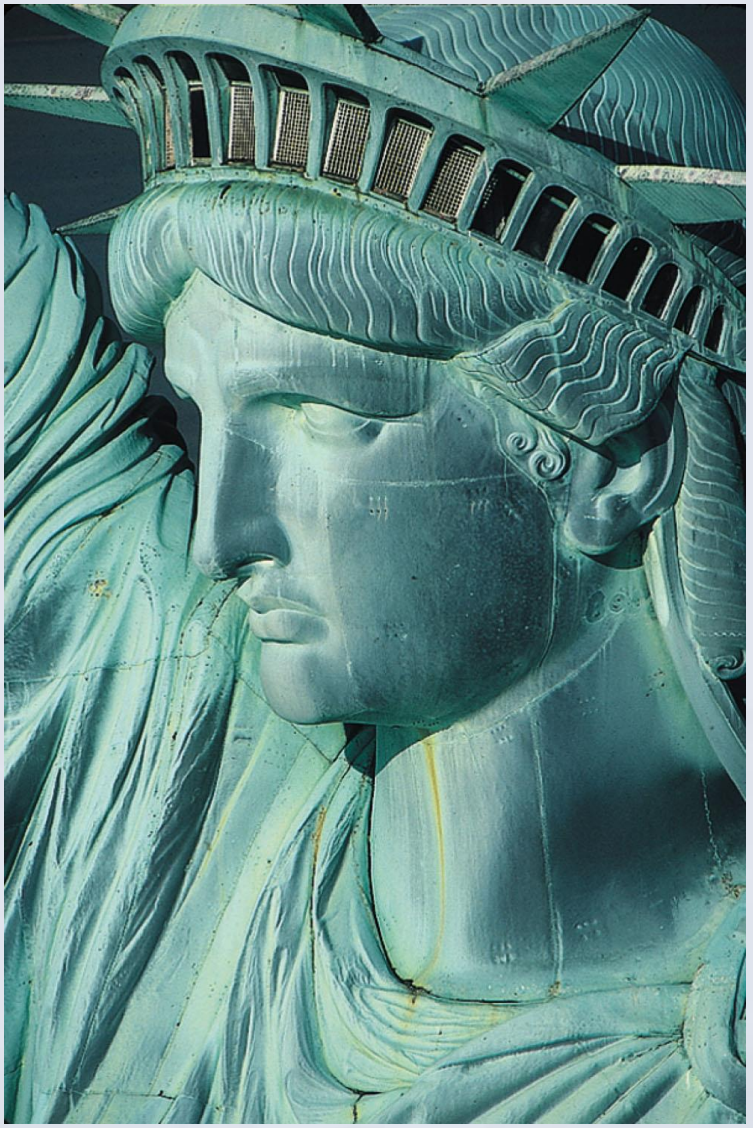
Properties of Matter

Chemical Property

- Characteristic of a substance that describes the way the substance undergoes or resists change to form a new substance.
  - Example: copper objects turn green in air
- Most often the changes result from the reaction of a substance with one or more other substances.
- Sometimes energy (like heat or light) can trigger a change (decomposition).

Properties of Matter

A Chemical Property of Copper



Exercise

Classify each of the following as a physical or chemical property.

a) A marshmallow gets black when roasting it in a campfire.

b) Zinc is a solid at room temperature.

c) When rubbing alcohol is rubbed on your skin, it evaporates very quickly.

Properties of Matter

Exercise

Classify each of the following as a physical or chemical property.

a) A marshmallow gets black when roasting it in a campfire.

chemical property

b) Zinc is a solid at room temperature.

physical property

c) When rubbing alcohol is rubbed on your skin, it evaporates very quickly.

physical property

Changes in Matter

Physical Change

- Process in which a substance changes its physical appearance but not its chemical composition.
- A new substance is never formed as a result of a physical change.
  - Example: boiling or freezing water

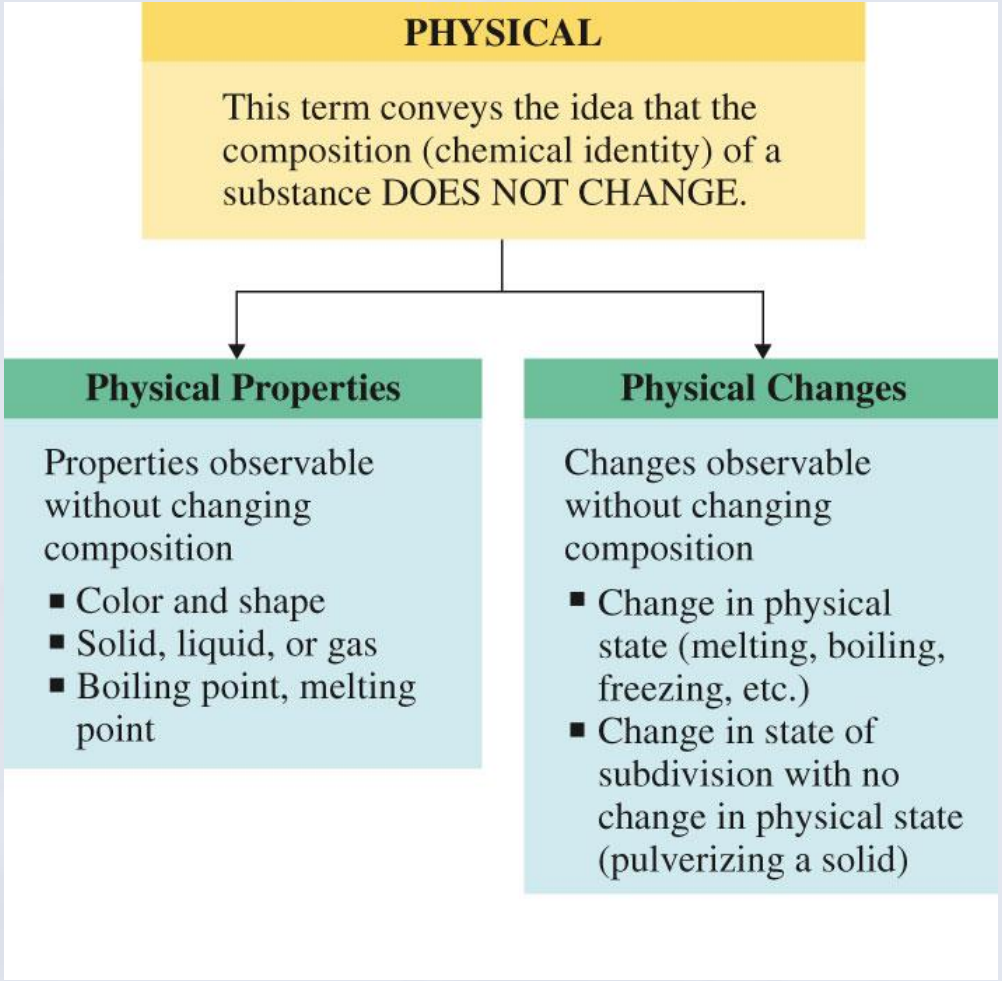
Changes in Matter

Chemical Change

- A process in which a substance undergoes a change in chemical composition.
- Involves conversion of the material(s) into one or more new substances.
  - Example: methane reacts with oxygen to form carbon dioxide and water

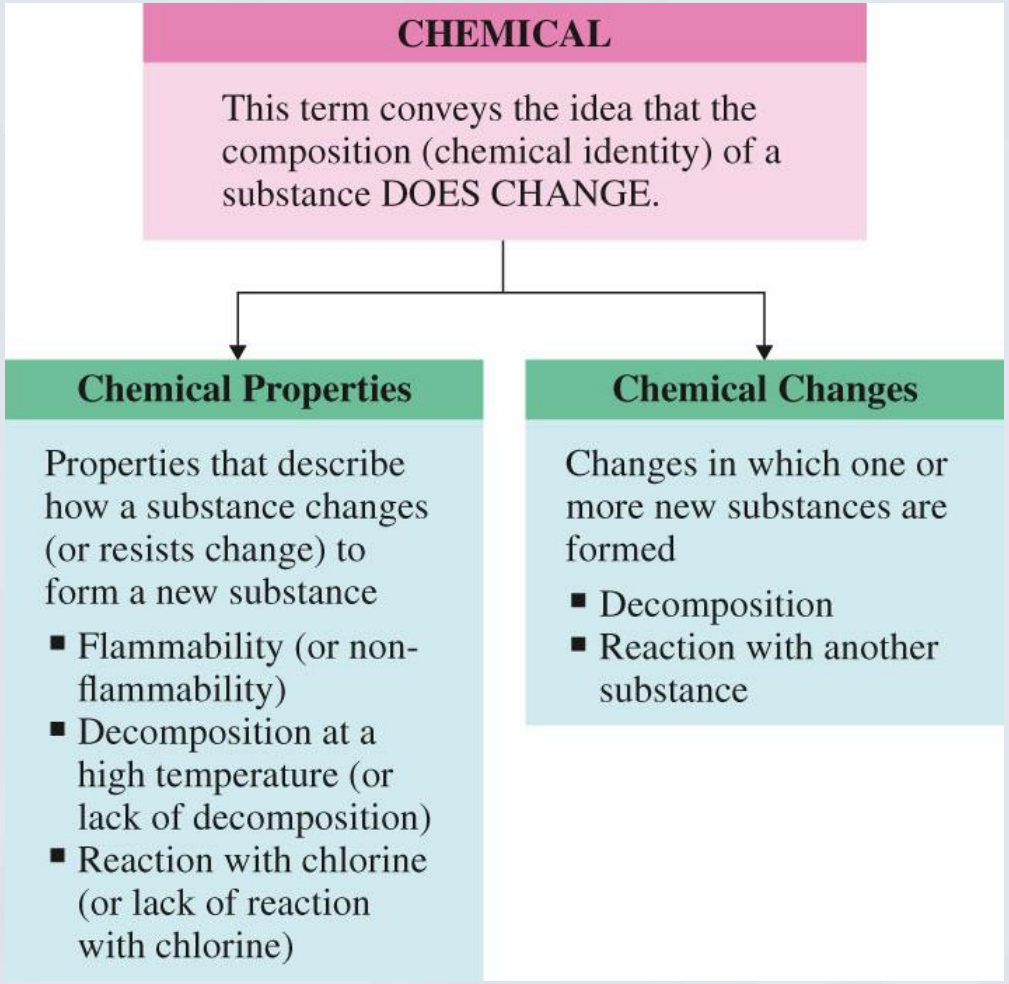
Changes in Matter

Use of the Term *Physical*



Changes in Matter

Use of the Term *Chemical*



Changes in Matter

Concept Check

Which one of the following are examples of a chemical change?

- Pulverizing (crushing) rock salt
- Burning of wood
- Dissolving of sugar in water
- Melting a popsicle on a warm summer day

Changes in Matter

Concept Check

Which one of the following are examples of a chemical change?

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Pure Substances and Mixtures

Pure Substances vs. Mixtures

- **Pure substance** – a single kind of matter that cannot be separated into other kinds of matter by any physical means.
  - Examples: water or carbon dioxide
- **Mixture** – a physical combination of two or more pure substances in which each substance retains its own chemical identity.
  - Example: salt water

Pure Substances and Mixtures

Mixtures

- Have variable composition

Homogeneous Mixture:

- Contains only one visibly distinct phase (part), which has uniform properties throughout; solution

Heterogeneous Mixture:

- Contains visibly different phases (parts), each of which has different properties

Pure Substances and Mixtures

Homogeneous Mixtures

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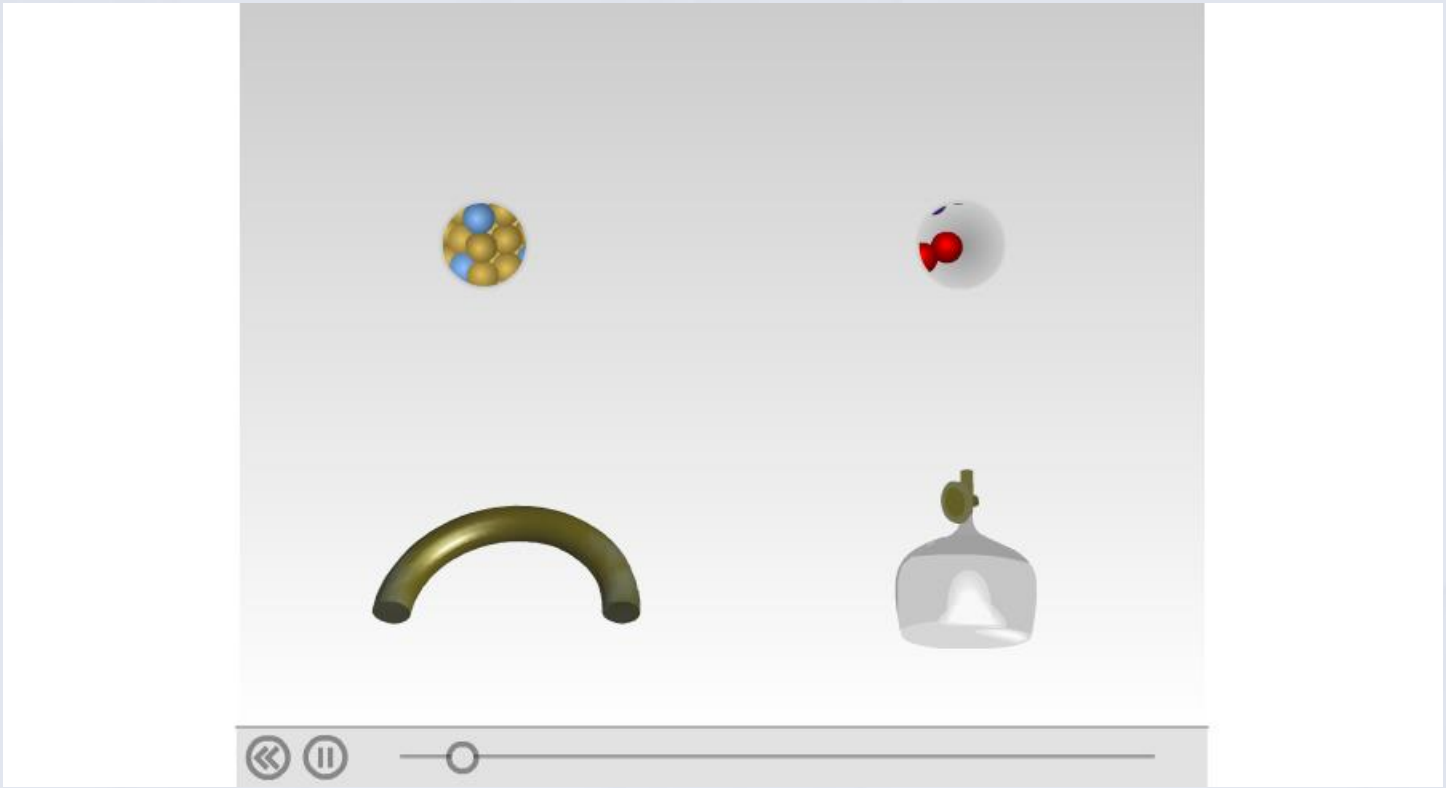
Pure Substances and Mixtures

Homogeneous vs. Heterogeneous Mixtures



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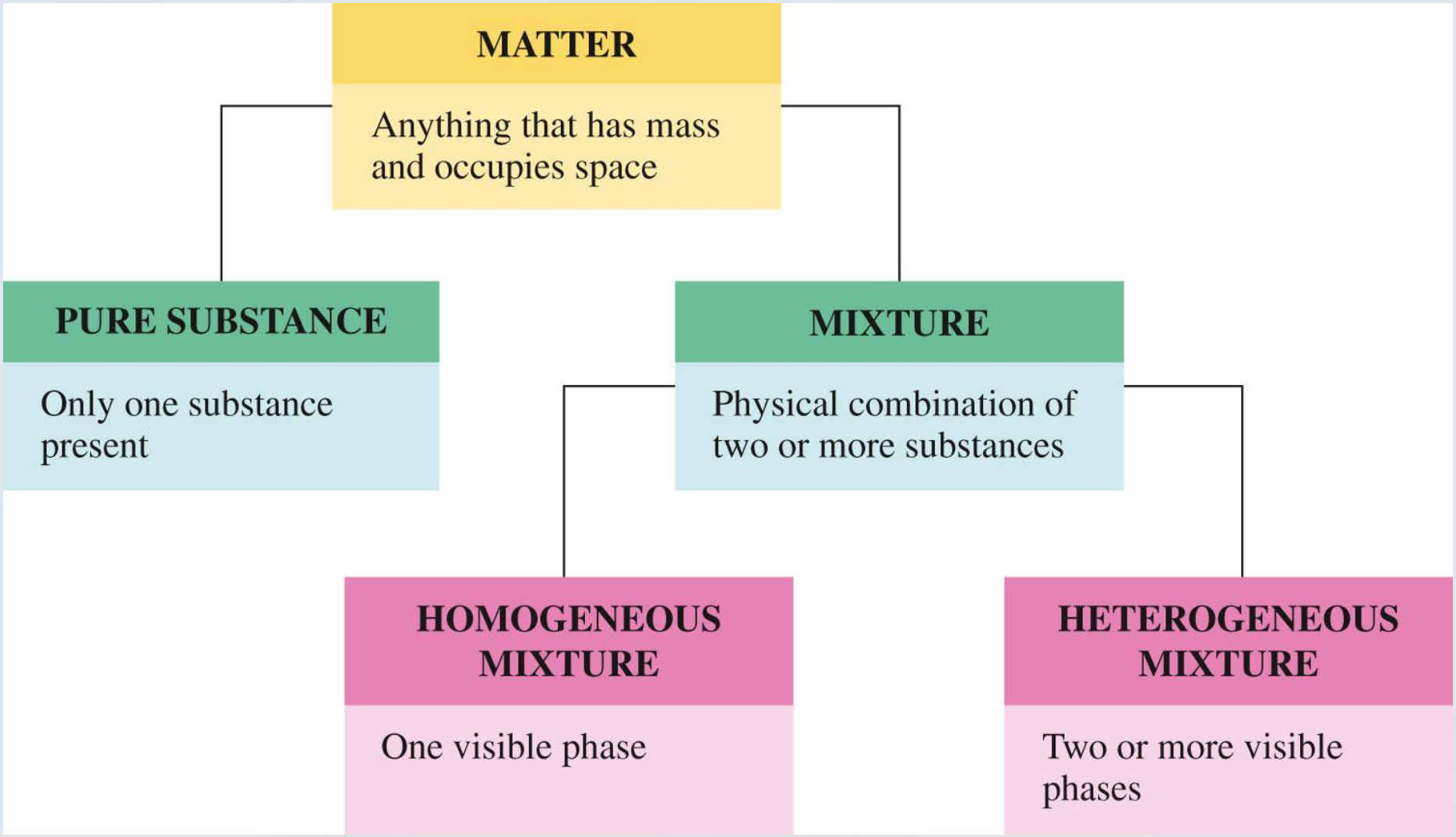
Pure Substances and Mixtures



Pure Substances and Mixtures

Concept Check

Which of the following is a homogeneous mixture?

- Pure water
- Gasoline
- Jar of jelly beans
- Soil
- Copper metal

Pure Substances and Mixtures

Concept Check

Which of the following is a homogeneous mixture?

- Pure water
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Elements and Compounds

Element

- **Element** – a pure substance that cannot be broken down into simpler pure substances by chemical means such as a chemical reaction, an electric current, heat, or a beam of light.
  - Examples: gold, silver, copper

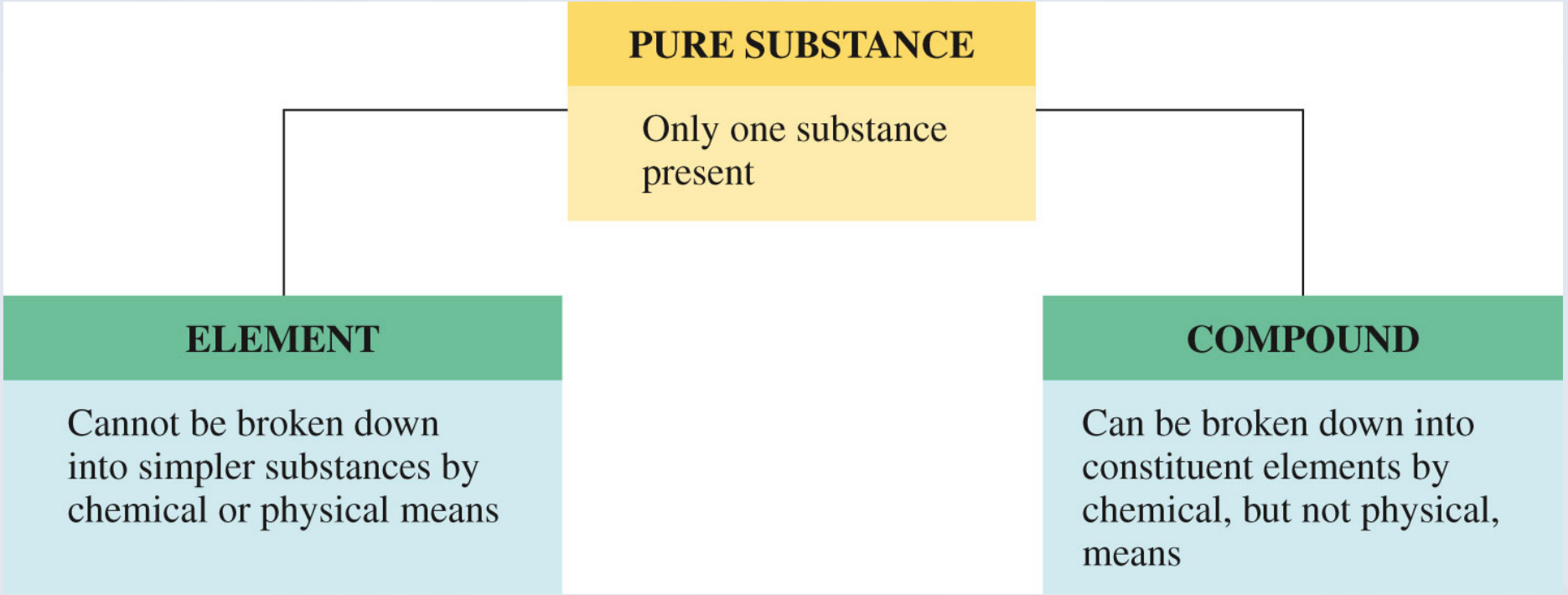
Elements and Compounds

Compound

- **Compound** – a pure substance that can be broken down into two or more simpler pure substances by chemical means.
  - Examples: water, carbon dioxide, ammonia

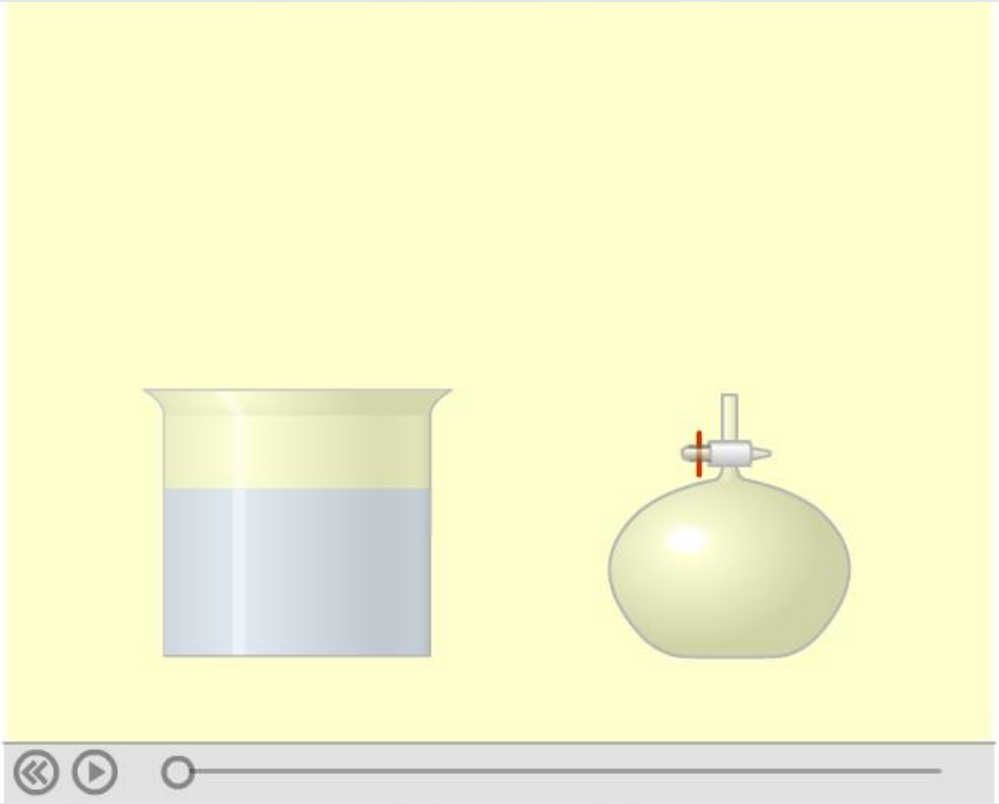
Elements and Compounds

A Pure Substance Can Be Either An Element or Compound



Elements and Compounds

Compound vs. Mixture



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Elements and Compounds

Distinguishing Between Compounds and Mixtures

1) Compounds have properties distinctly different from those of the substances that combined to form the compound. The components of mixtures retain their individual properties.

Elements and Compounds

Distinguishing Between Compounds and Mixtures

2) Compounds have a definite chemical composition. Mixtures have a variable chemical composition.

Elements and Compounds

Distinguishing Between Compounds and Mixtures

3) Physical methods are sufficient to separate the components of a mixture. The components of a compound cannot be separated by physical methods; chemical methods are required.

Elements and Compounds

To Classify a Sample of Matter

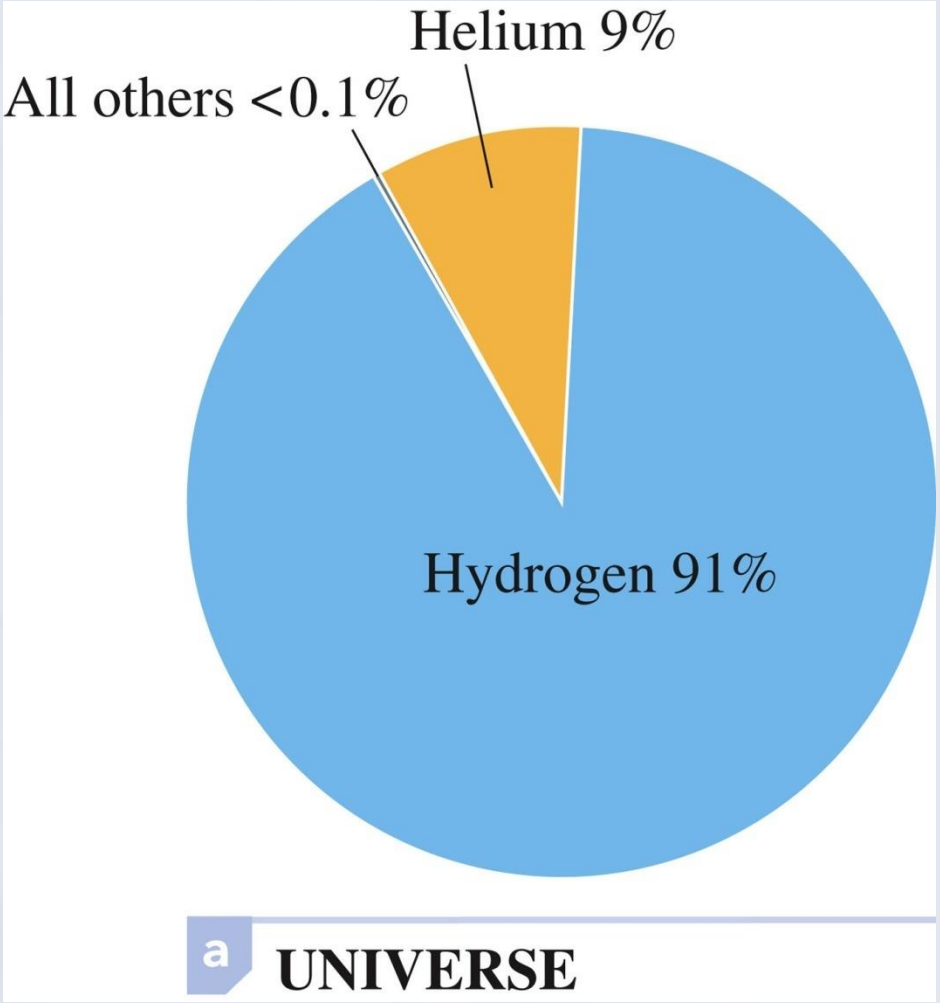
1) Does the sample of matter have the same properties throughout?
2) Are two or more different substances present?
3) Can the pure substance be broken down into simpler substances?

Discovery and Abundance of the Elements

- 118 known elements:
  - 88 of the elements occur naturally
  - 30 of the elements have been synthesized

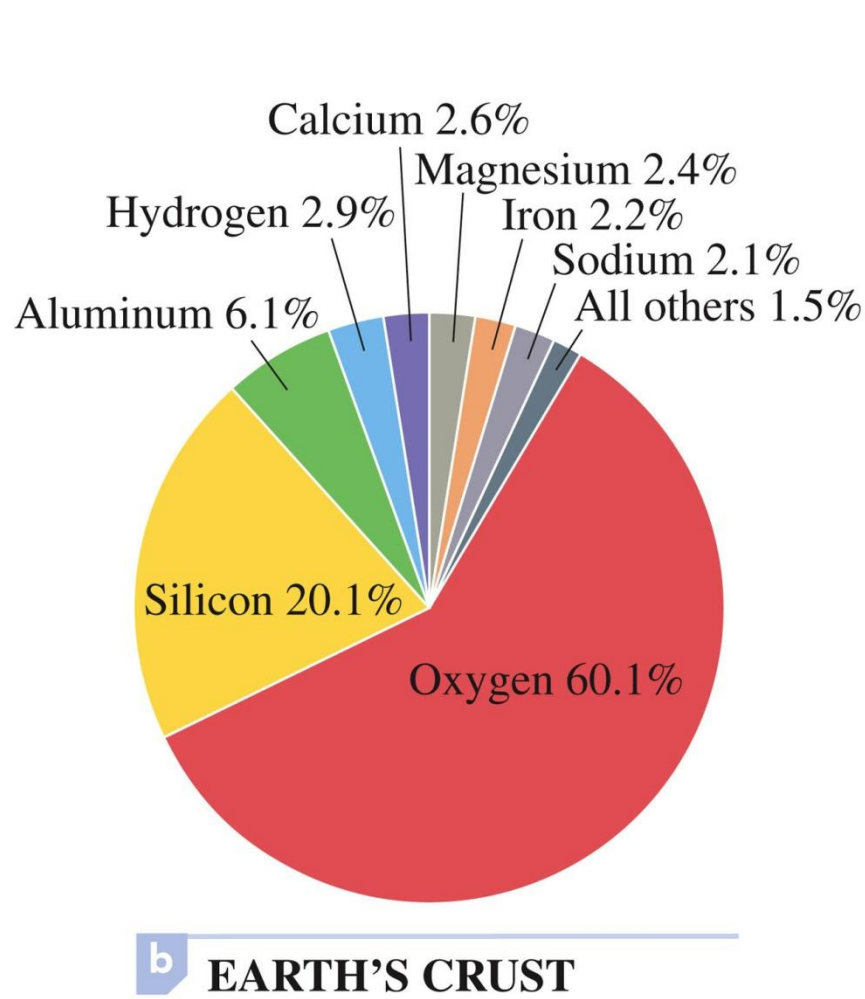
Discovery and Abundance of the Elements

Abundance of Elements (in Atom Percent) in the Universe



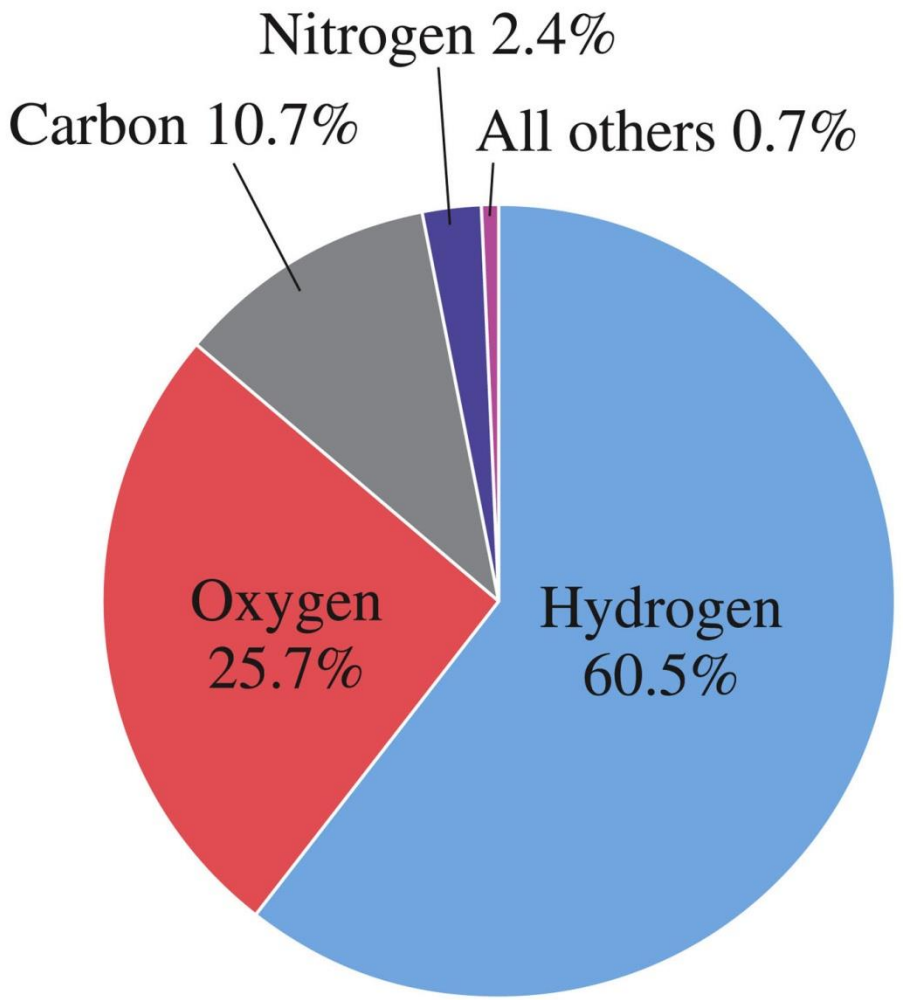
Discovery and Abundance of the Elements

Abundance of Elements (in Atom Percent) in the Earth's Crust



Discovery and Abundance of the Elements

Elemental Composition of the Human Body (in Atom Percent)



Names and Chemical Symbols of the Elements

Chemical Symbol

- One- or two-letter designation for an element derived from the element's name.
- Two letter symbols are often, but not always, the first two letters of the element's name.

Names and Chemical Symbols of the Elements

Chemical Symbol

- First letter of a chemical symbol is always capitalized and the second is not:
  - H – hydrogen
  - Ba – barium
  - Co – cobalt
  - Pb – lead
  - Ag – silver

Names and Chemical Symbols of the Elements

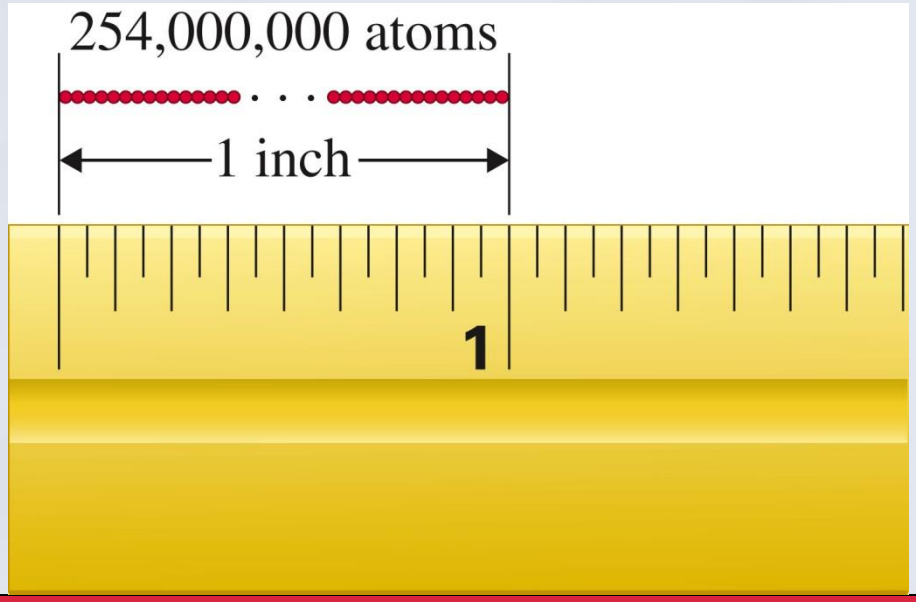
Latin Names

- For some elements, the symbol is derived from the Latin name of the element:
  - Ag – silver
  - Au – gold
  - Fe – iron
  - Pb – lead
  - Cu – copper

Atoms and Molecules

Atom

- The smallest particle of an element that can exist and still have the properties of the element.
- The limit of chemical subdivision.
- Atoms are extremely small particles.



Atoms and Molecules

Molecule

- Group of two or more atoms that functions as a unit because the atoms are tightly bound together.
- The limit of physical subdivision.
- Behaves in many ways as a single, distinct particle would.
- Diatomic molecule – contains two atoms
- Triatomic molecule – contains three atoms
- Tetraatomic, pentatomic, etc.

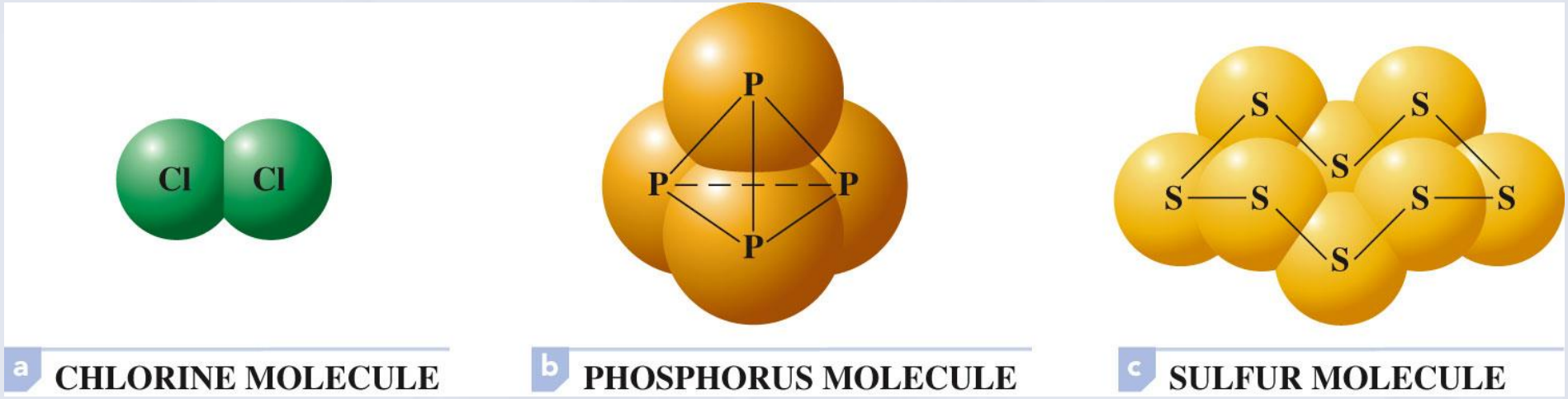
Atoms and Molecules

Homoatomic Molecule

- Molecule in which all atoms present are of the same kind.
- Substance containing homoatomic molecules must be an element.
  - Examples: H_2, O_2, N_2, Cl_2, P_4, S_8

Atoms and Molecules

Homoatomic Molecules



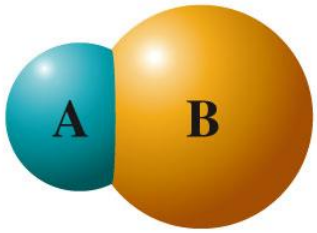
Atoms and Molecules

Heteroatomic Molecule

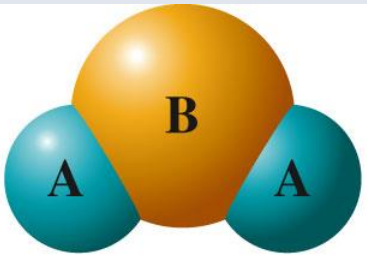
- Molecule in which two or more kinds of atoms are present.
- Substance containing heteroatomic molecules must be compounds.
  - Examples: H_2O, CO_2, N_2O_4, $C_{12}H_{22}O_{11}$

Atoms and Molecules

Heteroatomic Molecules

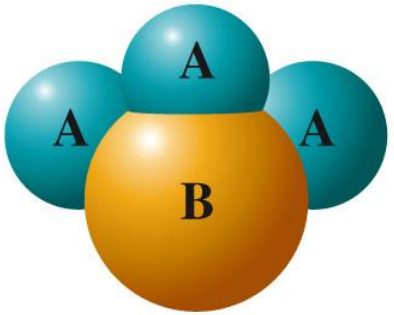


a A diatomic molecule containing one atom of A and one atom of B



b A triatomic molecule containing two atoms of A and one atom of B

c A tetraatomic molecule containing two atoms of A and two atoms of B



d A tetraatomic molecule containing three atoms of A and one atom of B

Concept Check

Classify XeF_4 as:

1) diatomic, triatomic, etc.

2) homoatomic or heteroatomic

3) element or compound

Atoms and Molecules

Concept Check

Classify XeF_4 as:

1) diatomic, triatomic, etc.

pentatomic

2) homoatomic or heteroatomic

heteroatomic

3) element or compound

compound

Chemical Formulas

- A notation made up of the chemical symbols of the elements present in a compound and numerical subscripts (located to the right of each chemical symbol) that indicate the number of atoms of each element present in a molecule of the compound.
  - Examples:
    - H_2O – two atoms of hydrogen, one atom of oxygen
    - $Ca_3(PO_4)_2$ – three atoms of calcium, two atoms of phosphorus, eight atoms of oxygen

Chemical Formulas

Exercise

For each of the following chemical formulas, determine how many atoms of each element are present:

a) H_2SO_4

b) $Fe_2(CO_3)_3$

Chemical Formulas

Exercise

For each of the following chemical formulas, determine how many atoms of each element are present:

a) H_2SO_4

two hydrogen; one sulfur; four oxygen

b) $Fe_2(CO_3)_3$

two iron; three carbon; nine oxygen