

Hewitt/Lyons/Suchocki/Yeh
**Conceptual Integrated
 Science**



Chapter 11
 INVESTIGATING MATTER

Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison Wesley

The Nature of Chemistry

Chemistry is . . .

- the study of matter and the transformations it can undergo.

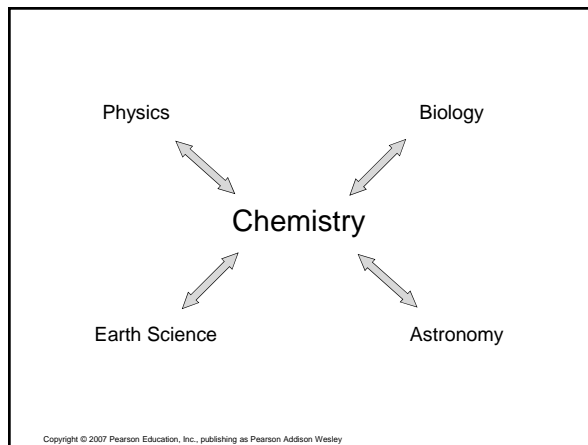
Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison Wesley

The Nature of Chemistry

Chemistry is . . .

- the study of matter and the transformations it can undergo.
- the “central” science.


Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison Wesley



The Nature of Chemistry


Chemistry is . . .

- the study of matter and the transformations it can undergo.
- the “central” science.
- a “materials” science.



Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison Wesley

Most of the material items in any modern house are shaped by some human-devised chemical process.



- Transparent matrix of processed silicon dioxide
- Chemically disinfected drinking water
- Caffeine solution
- Thermoset polymer
- Prescription medicines stored in refrigerator
- Chlorofluorocarbon-free refrigerating fluids

- Electrical energy from a fossil fuel or nuclear power plant
- Metal alloy
- Roasting carbohydrates, fats, proteins, and vitamins
- Natural gas laced with odoriferous sulfur compounds
- Fertilizer-grown vegetables

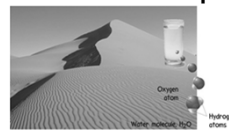
Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison Wesley

The Submicroscopic World

A single grain of sand contains about
125 million trillion atoms.

Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison Wesley

The Submicroscopic World



Roughly 250,000 dunes of this size contain about 125 million trillion grains of sand. Yet, that's how many atoms there are in a single grain of sand.

Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison Wesley

Phases of Matter

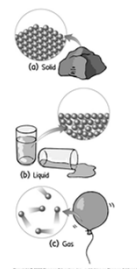
Solid : Occupies definite volume and shape

Liquid: Occupies definite volume, indefinite shape

Gas: Occupies indefinite volume and shape

Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison Wesley

Phases of Matter



Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison Wesley

Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison Wesley

Phases of Matter

Diffusion is the tendency of molecules to move from an area of high concentration to one of low concentration.



Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison Wesley

Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison Wesley

Changes of Phase

Melting: A change of phase from solid to liquid

Freezing: A change of phase from liquid to solid

Evaporation: A change of phase from liquid to gas

Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison Wesley

Changes of Phase (cont.)

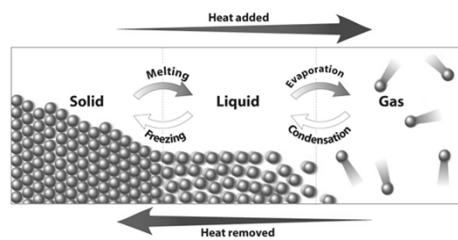
Sublimation: A change of phase from solid to gas

Boiling: Evaporation occurring beneath the liquid's surface

Condensation: A change of phase from gas to liquid

Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison Wesley

Change of Phase



Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison Wesley

Changes of Phase

Latent Heat is heat added or taken away from a substance without a change in temperature.

Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison Wesley

Integrated Science—Physics

How is it possible to add heat to water without an increase in temperature?

Increase the water's potential energy by pulling water molecules apart from one another, which is what happens when water changes phase.

Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison Wesley

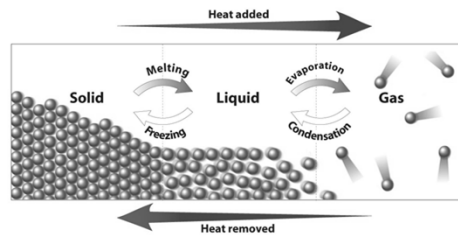
Changes of Phase

Latent Heat is heat added or taken away from a substance without a change in temperature.

Heat of Fusion is the heat energy needed to change a substance from solid to liquid (and vice versa).

Heat of Vaporization is the heat energy needed to change a substance from liquid to gas (and vice versa).

Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison Wesley



Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison Wesley

Notice how going from liquid to gas requires the complete separation among molecules.

Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison Wesley

Changes of Phase

Therefore, evaporation is a cooling process.
It follows that condensation is a warming process.

Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison-Wesley

Change of Phase

Evaporation is a cooling process.

- 1 Liquid water molecule having sufficient kinetic energy to overcome attractions to surrounding molecules approaches liquid surface.
- 2 Liquid water is cooled as it loses this high-speed water molecule.
- 3 Air is cooled as it collects slowly moving gaseous particles.

Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison-Wesley

Change of Phase

Condensation is a warming process.

Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison-Wesley

Physical and Chemical Properties

- A physical property describes the look or feel of a substance.

Gold
Opacity: opaque
Color: yellowish
Phase at 25 °C: solid
Density: 19.3 g/mL

Diamond
Opacity: transparent
Color: colorless
Phase at 25 °C: solid
Density: 3.5 g/mL

Water
Opacity: transparent
Color: colorless
Phase at 25 °C: liquid
Density: 1.0 g/mL

Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison-Wesley

Physical and Chemical Properties

A change in phase is a physical change.

Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison-Wesley

Physical and Chemical Properties

- A chemical property describes the tendency of a substance to transform into a new substance.

It is a chemical property of iron to transform into rust.

Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison-Wesley

Physical and Chemical Properties

- The transformation of one or more substances into others is a chemical change.



Methane
Reacts with oxygen to form carbon dioxide and water, giving off lots of heat during the reaction.



Baking soda
Reacts with vinegar to form carbon dioxide and water, absorbing heat during the reaction.



Copper
Reacts with carbon dioxide and water to form the greenish-blue substance called patina.

Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison Wesley

Physical and Chemical Properties

A substance is identified not only by the kinds of atoms it contains but also by how those atoms are connected to one another.

During a chemical change, a new substance is formed as atoms rearrange themselves into new configurations.

Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison Wesley

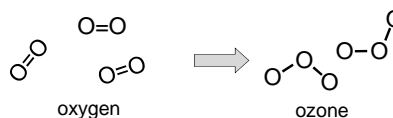
Physical and Chemical Properties



Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison Wesley

Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison Wesley

The transformation of oxygen, O₂, into ozone, O₃, is an example of

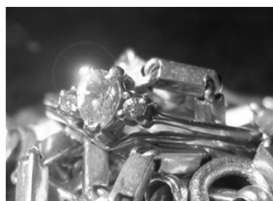


- A. a physical change.
- B. a chemical change.
- C. both a physical and chemical change.
- D. neither a physical nor chemical change.

✓ [Default]

Elements

Element: A material made of only one kind of atom.



Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison Wesley

Elements

- Element: A material made of only one kind of atom.
- Atom: The fundamental unit of an element.



Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison Wesley

The Periodic Table

- The Periodic Table is a listing of all the known elements.

The periodic table is organized into 18 groups (vertical columns) and 7 periods (horizontal rows). The elements are arranged in order of increasing atomic number. The 6th and 7th periods include lanthanide and actinide series, respectively.

Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison Wesley

The Periodic Table

Examples of element properties and uses:

- Ag (Silver):** If this silver mug were filled with boiling water, the handle would quickly become too hot to handle because silver is one of the best conductors of heat.
- Ti (Titanium):** About 50,000 pounds of synthetic diamonds are produced from carbon each year.
- Si (Silicon):** Chips of 99.9999% pure silicon are sliced into wafers for the manufacture of integrated circuits.
- He (Helium):** Helium is formed underground as a byproduct of radioactive decay.
- Zn (Zinc):** Zinc has a low melting point and is commonly used in making coins.
- Hg (Mercury):** Mercury freezes at -38°C and is a liquid at room temperature.
- Br (Bromine):** Bromine is a dark orange liquid that readily vaporizes at room temperature.

Legend: Metal Metalloid Nonmetal

Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison Wesley

The Periodic Table

- The elements are highly organized within the Periodic Table.
- Each vertical column is called a "group."
- Each horizontal row is called a "period."

Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison Wesley

The Periodic Table

The periodic table is organized into 18 groups (vertical columns) and 7 periods (horizontal rows). The elements are arranged in order of increasing atomic number. The 6th and 7th periods include lanthanide and actinide series, respectively.

Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison Wesley

The Periodic Table

Sizes of the different atoms; size decreases to the right and upwards.

Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison Wesley

The Periodic Table

Elements are grouped naturally by type.

- 1: Alkali metals
- 2: Alkaline-earth metals
- 3-12: Transition metals
- 13-17: Common names (Al, Si, P, S, Cl, Br, I, At)
- 13-17: Chalcogens
- 16-17: Halogens
- 18: Noble gases

Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison Wesley

The Periodic Table

The Inner Transition Elements are special.

Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison Wesley

Chemical Compounds

- **Compound:** A substance consisting of atoms of different elements.

Sodium atom
Chlorine atom
Sodium chloride, NaCl
Hydrogen atom
Nitrogen atom
Ammonia, NH₃

Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison Wesley

Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison Wesley

Chemical Compounds

- Compounds have properties uniquely different from the elements from which they are made.

Sodium metal and chlorine gas react to form sodium chloride

Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison Wesley

Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison Wesley

Chemical Compounds

- **Chemical formula:** Used to show the proportion by which elements combine to form a compound.

Compound	Formula
Sodium chloride	NaCl
Ammonia	NH ₃
Water	H ₂ O

Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison Wesley

Elements

- **Elemental formula:** Used to show the proportion by which atoms combine to form an element.

Compound	Formula
Oxygen	O ₂
Ozone	O ₃
Sulfur	S ₈
Gold	Au

Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison Wesley

Naming Compounds

Guideline 1

- Start with the element farthest to the left in the periodic table.
- For the element to the right, add the suffix *-ide*.

Example:

NaCl = "Sodium Chloride"

Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison Wesley

Naming Compounds

Guideline 3

- Common names are sometimes used for convenience.

H_2O "Water"

H_2O_2 "Hydrogen peroxide"

Copyright © 2007 Pearson Education, Inc., publishing as Pearson Addison Wesley