An Introduction to Chemistry

The vibrant colors of the aurora borealis are the result of chemistry in our atmosphere.

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1.1 The Nature of Chemistry

A. Thinking Like a Chemist

1.2 A Scientific Approach to Problem Solving

A. The Scientific Method

1.3 The Particulate Nature of Matter

A. Physical States of Matter

1.4 Classifying Matter

A. Distinguishing Mixtures from Pure Substances

Chapter Outline

Chemistry is the science of matter.

Chemistry deals with the composition, structure, properties, reactions and energetics of matter.

Chemists devise experiments, interpret data and synthesize new substances.

The Nature of Chemistry

Chemistry is the science of matter.

Matter is any object that has mass and occupies space.

Chemistry deals with the composition, structure, properties, reactions and energetics of matter.

Chemists devise experiments, interpret data and synthesize new substances.

Thinking Like a Chemist

Chemists try to understand how and why chemical changes occur in nature and the human body. Chemists try to explain the macroscopic world, which is observable to the eye...

…and the microscopic world, which is made up of objects too small to see, like atoms and molecules.

A Microscopic View of Water

Imagine holding one molecule of water in your hand. What does it look like?

Water (H₂O) is composed of two hydrogen atoms and one oxygen atom.

The atoms must connect in a specific arrangement, in this case forming two O-H bonds.

A Scientific Approach to Problem Solving

Scientists use a logical process to explain the world around them.

This process is called the Scientific Method.
The Scientific Method

1. Collect the facts and data relevant to your question. Perform an experiment, then analyze the resulting data to look for trends that relate to the question.
2. Formulate a hypothesis. A hypothesis is a tentative explanation of the data that requires further experimentation to be validated.
3. Plan and perform additional experiments to test the hypothesis.
4. Modify the hypothesis. A useful hypothesis must explain all of the data.

A well-established hypothesis is often called a theory. A theory summarizes a hypothesis that has been supported by repeated experimentation. A theory is valid as long as there is no evidence to disprove it.

A scientific law is a statement of natural phenomenon where no exceptions are known under the given conditions.

Matter appears in many forms, both big and small. On the microscopic level, all matter is composed of discrete, tiny fundamental particles called atoms.

Using a scanning tunneling microscope, individual atoms can be configured into specific arrangements.

Matter exists as three physical states: solid, liquid and gas.

A solid has definite shape and volume which can be independent of its container.
The most common solids are crystalline and have regular, repeating three-dimensional geometric patterns.

Solid water molecules are held together rigidly and are very close to each other.

A liquid has definite volume but not a definite shape. Liquid particles are held together by strong attractive forces and are able to move freely.

Liquids are fluid which allows them to take the shape of the container.

Liquid water molecules are close together but are free to move around and slide over each other.
A gas has indefinite volume and no fixed shape. Gas particles move independently and are relatively far apart, which allows them to completely fill a container. Gases can be compressed or expanded almost indefinitely.

Gaseous water molecules are far apart and move freely and randomly.

Although matter is separated into discrete units, attractive forces hold the particles together and give matter its appearance of continuity. Attractive forces are strongest in solids, giving them rigidity; weaker in liquids but strong enough to maintain definite volumes; and weakest in gases which allows them to behave nearly independently.

Physical States of Matter

Classifying Matter

Matter can be subdivided into specific categories. A pure substance has a definite, fixed composition and is either an element or a compound. The sugar on the spoon and the water in the beaker are each a pure substance – both are compounds.

Mixtures

A mixture is a combination of two or more pure substances and can be homo- or heterogeneous. Sugar dissolved in water is a homogeneous mixture. The proportion of sugar and water can be varied but the composition will be the same throughout.
The components of a mixture do not lose their identities and may be separated by physical means such as: boiling, filtration, floatation, magnetism. Sulfur and iron can be separated using a magnet.

Which of the following is a heterogeneous mixture?

a. baking soda  
b. gasoline  
c. grape juice  
d. copper metal  
e. soil

Filtration is a common method to separate components of what type of mixture?

a. homogeneous mixture of 2 liquids  
b. heterogeneous mixture of 2 liquids  
c. heterogeneous mixture of solid in liquid  
d. homogeneous mixture of solid in liquid