



# CHAPTER 1

## The Nature of Chemistry

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### Objectives

**You will be able to do the following.**

1. Describe how science in general is done.
2. Given a description of a property of a substance, identify the property as a chemical or physical property.
3. Given a description of a change for a substance, identify the change as a chemical or physical change.
4. Classify mixtures as heterogeneous or homogeneous.
5. Classify forms of matter as mixtures or substances.
6. Classify substances as elements or compounds
7. Write a description of matter in terms of the kinetic molecular theory.
8. Write a description of the relationship between temperature and motion.
9. Write a description of the similarities and differences between solids, liquids, and gases in terms of the kinetic molecular theory. Your description should include mention of the particle nature of matter, the degree of motion of the particles, and the degree of attraction between the particles.
10. Write an explanation for why solids usually expand when heated.
11. Write a description of the process of converting a solid into a liquid by heating. Your description should include mention of the changes in the solid when heat is added.
12. Write a description of the process by which a liquid evaporates to form a gas.
13. Convert between the names and symbols for the elements on Table 1.1.
14. Convert between the definition and the term for the following words or phrases.

### Chapter 1 Glossary

**Chemistry** The study of the structure and behavior of matter.

**Matter** Anything that has mass and occupies space.

**Hypothesis** An idea that is tentatively proposed as a explanation for some observation and provides a basis for experimentation.

**Qualitative** Information not involving numbers.

**Quantitative** Information obtained from measurements that produce numbers.

**Law** A statement that summarizes and explains a wide range of experimental results and has not been contradicted by experiments.

**Theory** A successful hypothesis...a unifying principle that explains a body of facts and the laws based on them.

**Model** A simplified approximation of reality.

**Physical properties** Characteristics that can be observed and measured without changing the composition of a substance.

**Physical changes** Changes in the physical properties of a substance.

**Chemical changes or reactions** Changes in which one or more substances are transformed into one or more different substances.

**Chemical properties** Descriptions of chemical reactions a substance undergoes.

**Mixture** A form of matter with two or more components and variable composition.

**Heterogeneous mixture** A mixture with two or more phases.

**Homogeneous mixture** A mixture with one phase.

**Solution** A homogeneous mixture.

**Substance** A form of matter with constant composition. Substances are either elements or compounds.

**Chemical elements** A substance that cannot be chemically converted into simpler substances; a substance in which all of the atoms have the same number of protons and therefore the same chemical characteristics.

**Chemical compounds** Substances that can be decomposed into simpler substances (elements).

**Macroscale** Large enough to be seen with the unaided eye.

**Microscale** Small enough to require a microscope to see.

**Nanoscale** On the order of the size of atoms.

**Solid** The state in which a substance has a definite shape and volume at a constant temperature.

**Liquid** The state in which a substance has a constant volume at a constant temperature but can change its shape.

**Gas** The state in which a substance can easily change shape and volume.

**Evaporation** or **vaporization** The conversion of a liquid to a gas.

**Metals** The elements that (1) have a metallic luster, (2) conduct heat and electric currents well, and (3) are malleable.

**Malleable** Capable of being extended or shaped by the blows of a hammer.

**Nonmetals** The elements that do not have the characteristics of metals. Some of the nonmetals are gases at room temperature and pressure, some are solids, and one is a liquid. Various colors and textures occur among the nonmetals.

**Metalloids** or **semimetals** The elements that have some but not all of the characteristics of metals.

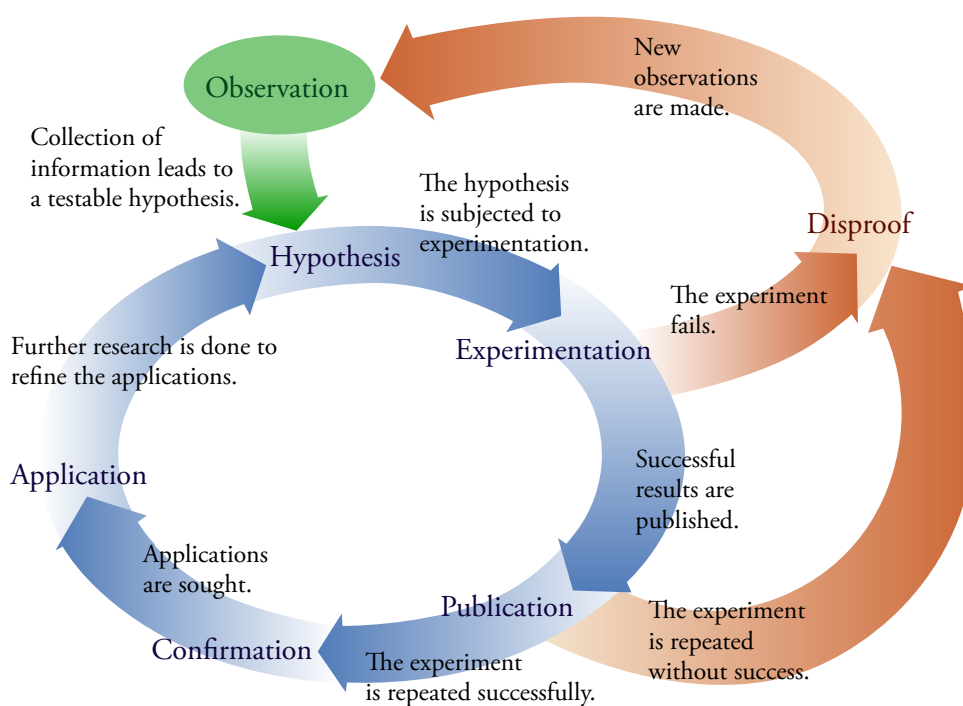
**Molecule** An uncharged collection of atoms held together with covalent bonds.

**Chemical formula** Uses symbols for the elements and subscripts for these symbols to represent the atomic composition of a substance.

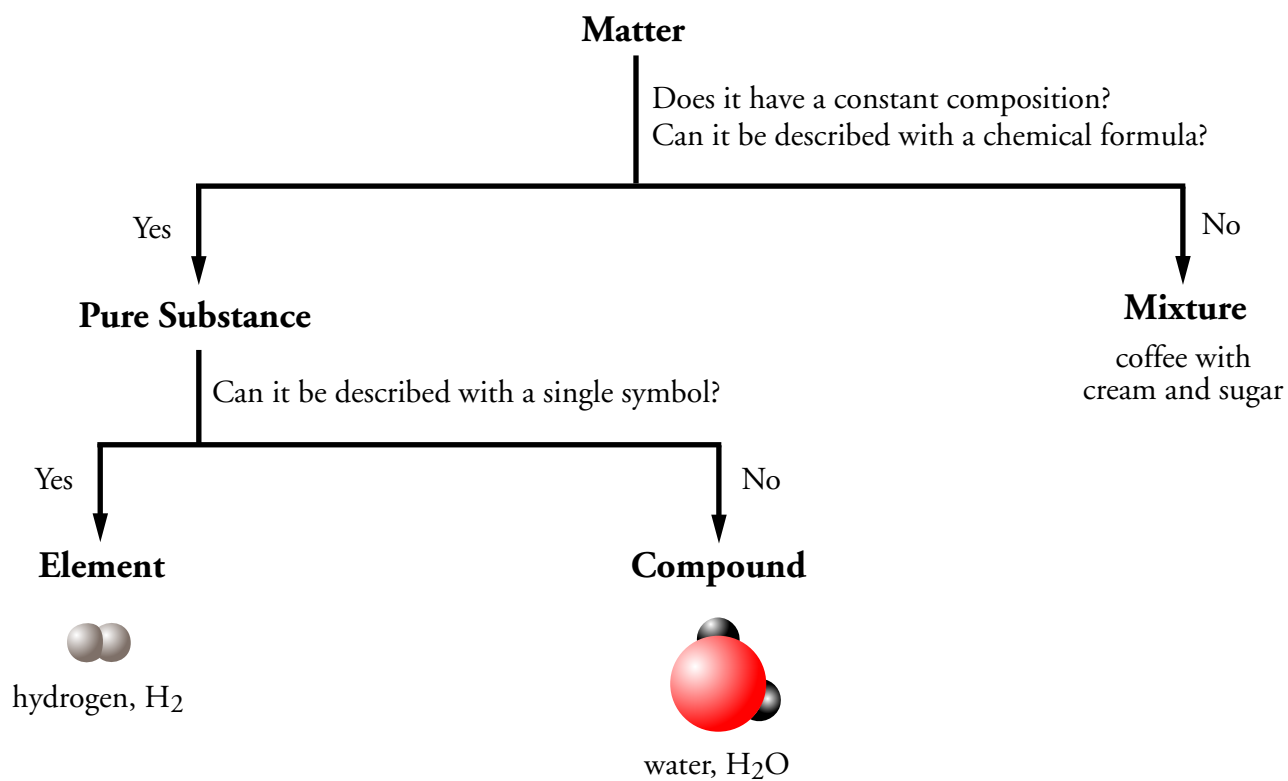
**Diatomic** Composed of paired atoms. The diatomic elements are H<sub>2</sub>, N<sub>2</sub>, O<sub>2</sub>, F<sub>2</sub>, Cl<sub>2</sub>, Br<sub>2</sub>, and I<sub>2</sub>.

**Allotropes** Different forms of an element in the same physical state at the same temperature and pressure.

**Figure 1.1**  
The Scientific Method



**Figure 1.2**  
Classification of Matter



## Sample Study Sheet 1.1 Classification of Matter

**TIP-OFF** You are asked to classify a sample of matter as a pure substance or a mixture; or you are asked to classify a pure substance as an element or a compound.

**GENERAL STEPS** The following general procedure is summarized in Figure 1.2.

- To classify a sample of matter as a pure substance or a mixture, ask one or both of the following questions:

*Does it have a constant composition?* If it does, it is a pure substance. If it has variable composition, it is a mixture.

*Can the sample as a whole be described with a chemical formula?* If it can, it is a pure substance. If it cannot, it is a mixture.

- To classify a pure substance as an element or a compound, ask the following question:

*Can it be described with a single symbol?* If it can, it is an element. If its chemical formula contains two or more different element symbols, it is a compound.

### EXERCISE 1.1 - Classification of Matter

The label on a container of double-acting baking powder tells us that it contains cornstarch, bicarbonate of soda (also called sodium hydrogen carbonate,  $\text{NaHCO}_3$ ), sodium aluminum sulfate, and acid phosphate of calcium (which chemists call calcium dihydrogen phosphate,  $\text{Ca}(\text{H}_2\text{PO}_4)_2$ ). Classify each of the following as a pure substance or a mixture. If it is a pure substance, is it an element or a compound?

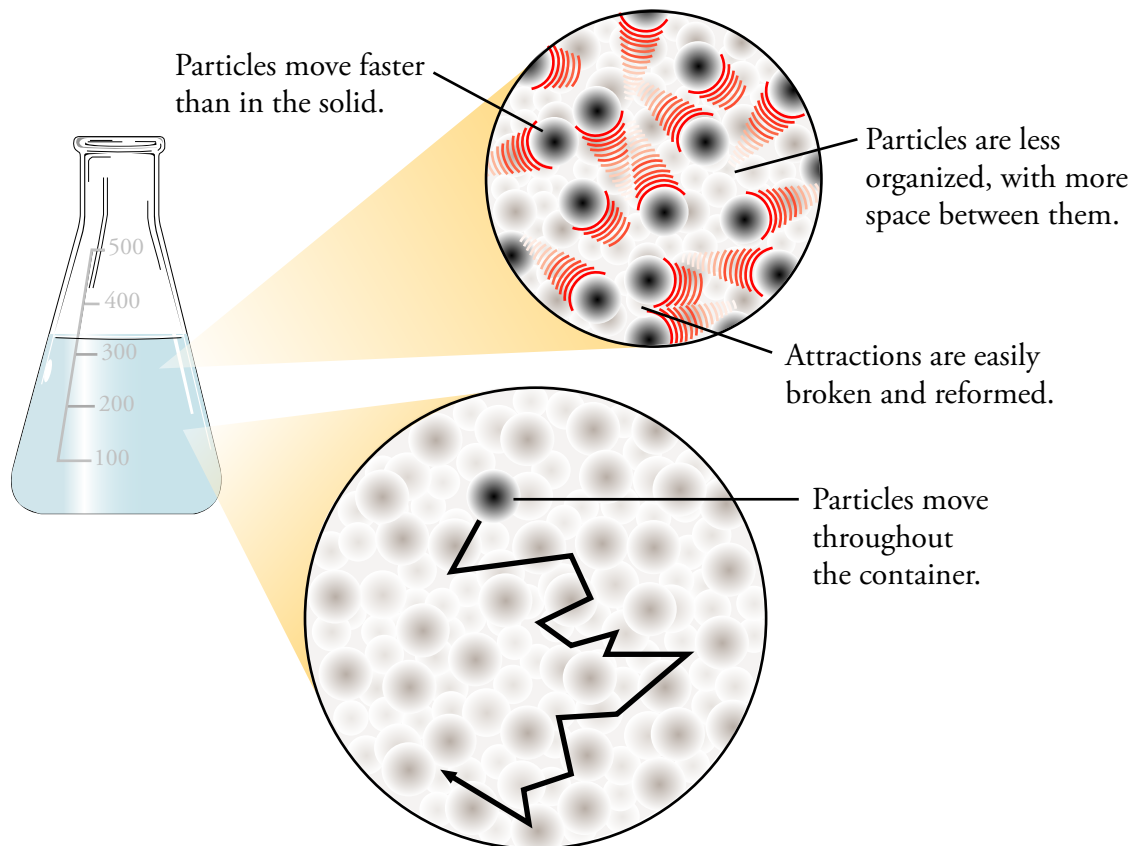
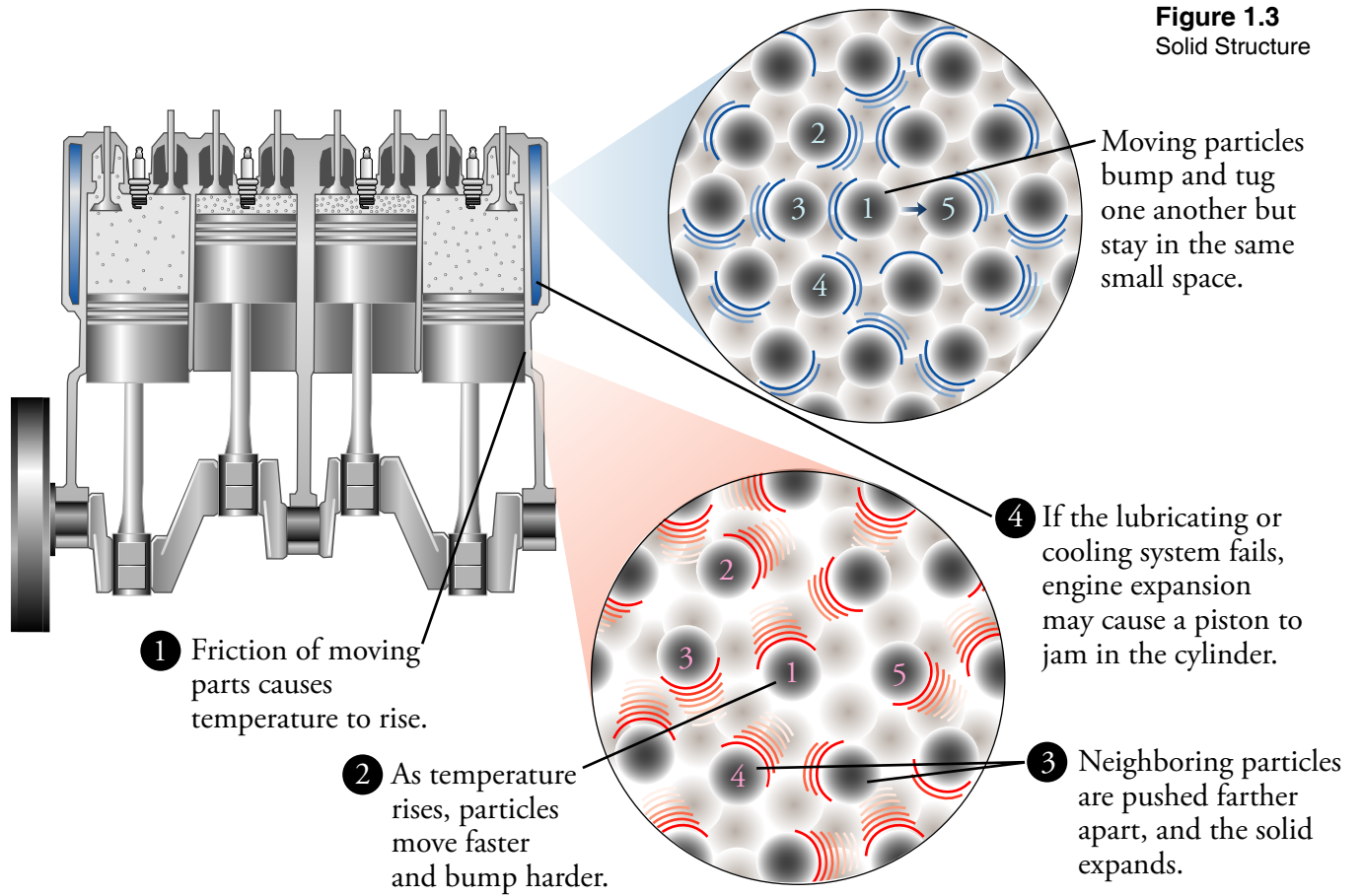
- a. calcium
- b. calcium dihydrogen phosphate
- c. double-acting baking powder

The kinetic molecular theory provides a simple model of the nature of matter. It has the following components.

- ◆ All matter is composed of tiny particles.
- ◆ These particles are in constant motion. The amount of motion is proportional to temperature. Increased temperature means increased motion.
- ◆ Solids, gases, and liquids differ in the degree of motion of their particles and the extent to which the particles interact.

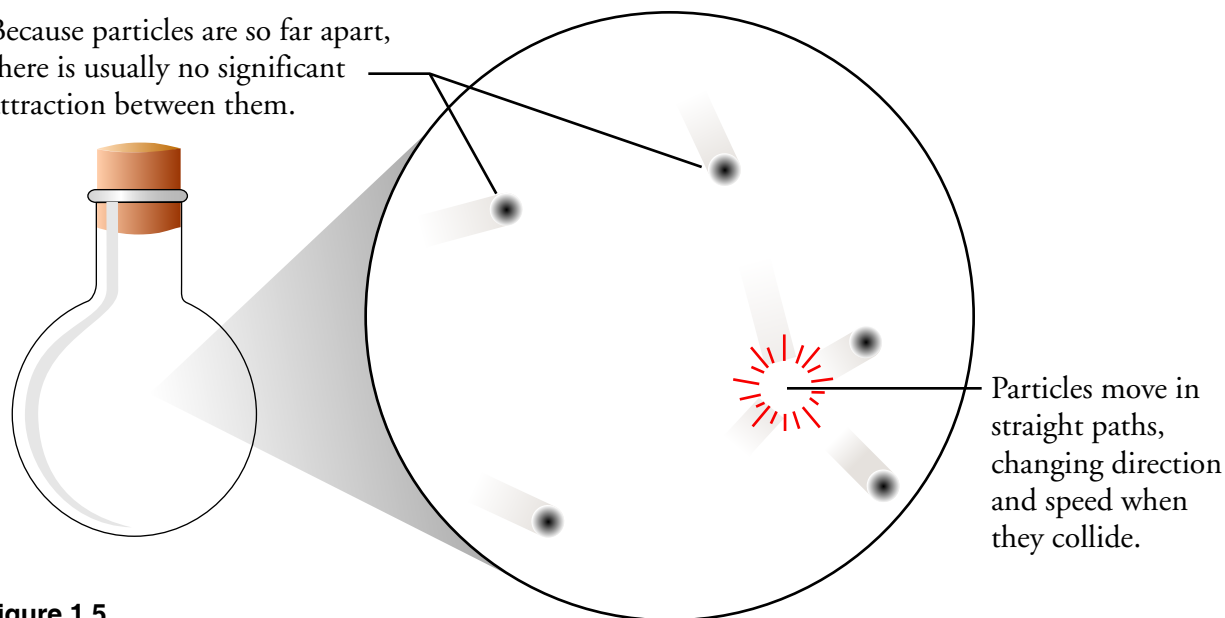
There is a Shockwave animation that shows the particle nature of solids, liquids, and gases at the following Web address:

**[http://www.mpcfaculty.net/mark\\_bishop/KMT.htm](http://www.mpcfaculty.net/mark_bishop/KMT.htm)**



**Figure 1.4**  
Liquid Structure

Because particles are so far apart, there is usually no significant attraction between them.



**Figure 1.5**  
Gas Structure

**Table 1.1** Common Elements

Element	Symbol	Element	Symbol	Element	Symbol
<b>aluminum</b>	<b>Al</b>	<b>gold</b>	<b>Au</b>	<b>potassium</b>	<b>K</b>
antimony	Sb	<b>helium</b>	<b>He</b>	radium	Ra
<b>argon</b>	<b>Ar</b>	<b>hydrogen</b>	<b>H</b>	radon	Rn
arsenic	As	<b>iodine</b>	<b>I</b>	rubidium	Rb
barium	Ba	<b>iron</b>	<b>Fe</b>	scandium	Sc
beryllium	Be	krypton	Kr	selenium	Se
bismuth	Bi	<b>lead</b>	<b>Pb</b>	<b>silicon</b>	<b>Si</b>
<b>boron</b>	<b>B</b>	<b>lithium</b>	<b>Li</b>	<b>silver</b>	<b>Ag</b>
<b>bromine</b>	<b>Br</b>	<b>magnesium</b>	<b>Mg</b>	<b>sodium</b>	<b>Na</b>
cadmium	Cd	<b>manganese</b>	<b>Mn</b>	strontium	Sr
<b>calcium</b>	<b>Ca</b>	<b>mercury</b>	<b>Hg</b>	<b>sulfur</b>	<b>S</b>
<b>carbon</b>	<b>C</b>	molybdenum	Mo	tellurium	Te
cesium	Cs	<b>neon</b>	<b>Ne</b>	thallium	Tl
<b>chlorine</b>	<b>Cl</b>	<b>nickel</b>	<b>Ni</b>	<b>tin</b>	<b>Sn</b>
<b>chromium</b>	<b>Cr</b>	<b>nitrogen</b>	<b>N</b>	<b>titanium</b>	<b>Ti</b>
<b>cobalt</b>	<b>Co</b>	<b>oxygen</b>	<b>O</b>	tungsten	W
<b>copper</b>	<b>Cu</b>	palladium	Pd	<b>uranium</b>	<b>U</b>
<b>fluorine</b>	<b>F</b>	<b>phosphorus</b>	<b>P</b>	vanadium	V
gallium	Ga	<b>platinum</b>	<b>Pt</b>	xenon	Xe
germanium	Ge	plutonium	Pu	<b>zinc</b>	<b>Zn</b>