Chemistry: The Study of Change

Chapter 1

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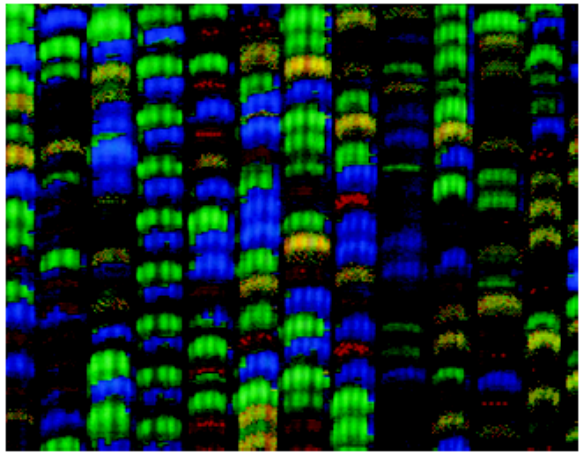
Chemistry: A Science for the 21st Century

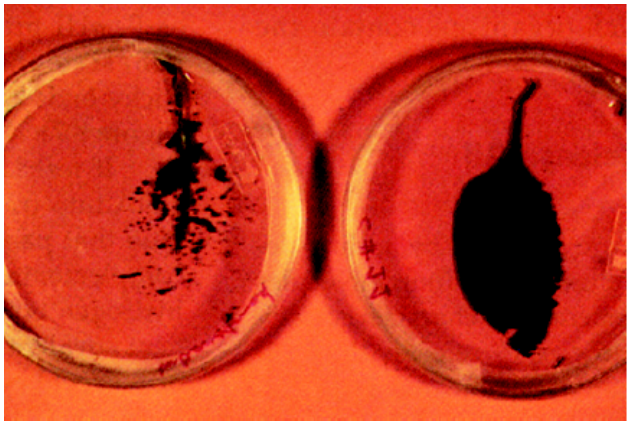
- Health and Medicine
  - Sanitation systems
  - Surgery with anesthesia
  - Vaccines and antibiotics
  - Gene therapy



- Energy and the Environment
  - Fossil fuels
  - Solar energy
  - Nuclear energy

Chemistry: A Science for the 21st Century

- Materials and Technology
  - Polymers, ceramics, liquid crystals
  - Room-temperature superconductors?
  - Molecular computing?

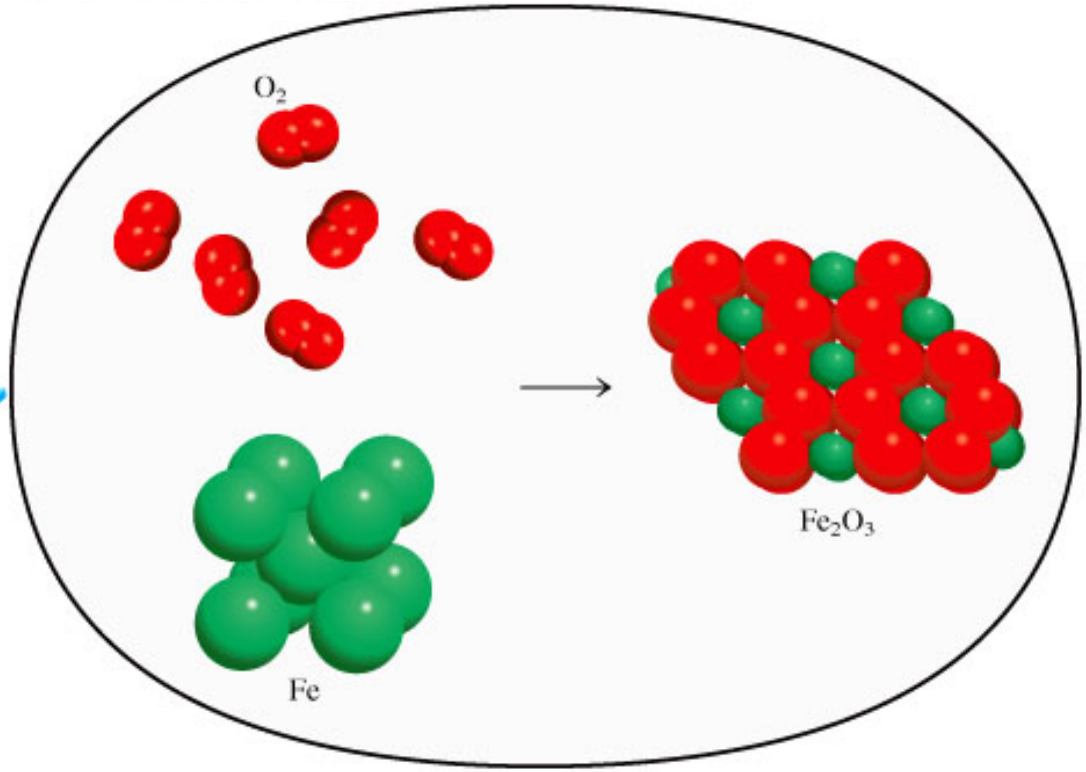


- Food and Agriculture
  - Genetically modified crops
  - “Natural” pesticides
  - Specialized fertilizers

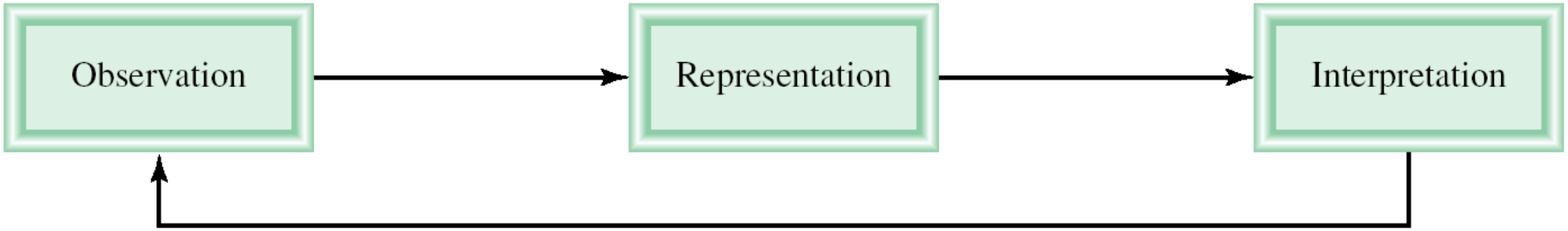
The Study of Chemistry

Macroscopic

Microscopic

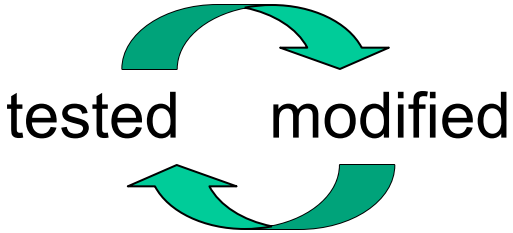


The ***scientific method*** is a systematic approach to research



A ***hypothesis*** is a tentative explanation for a set of observations

good hypothesis must be testable



mathematical

A ***law*** is a concise statement of a relationship between phenomena that is always the same under the same conditions.

$E = mc^2$

$F = ma$

Force = mass x acceleration

energy = (mass)(speed of light)^2

$3 * 10^8$

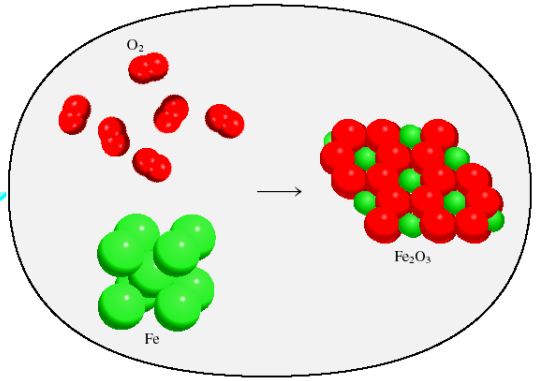
A ***theory*** is a unifying principle that explains a body of facts and/or those laws that are based on them.

not a hypothesis

not a guess

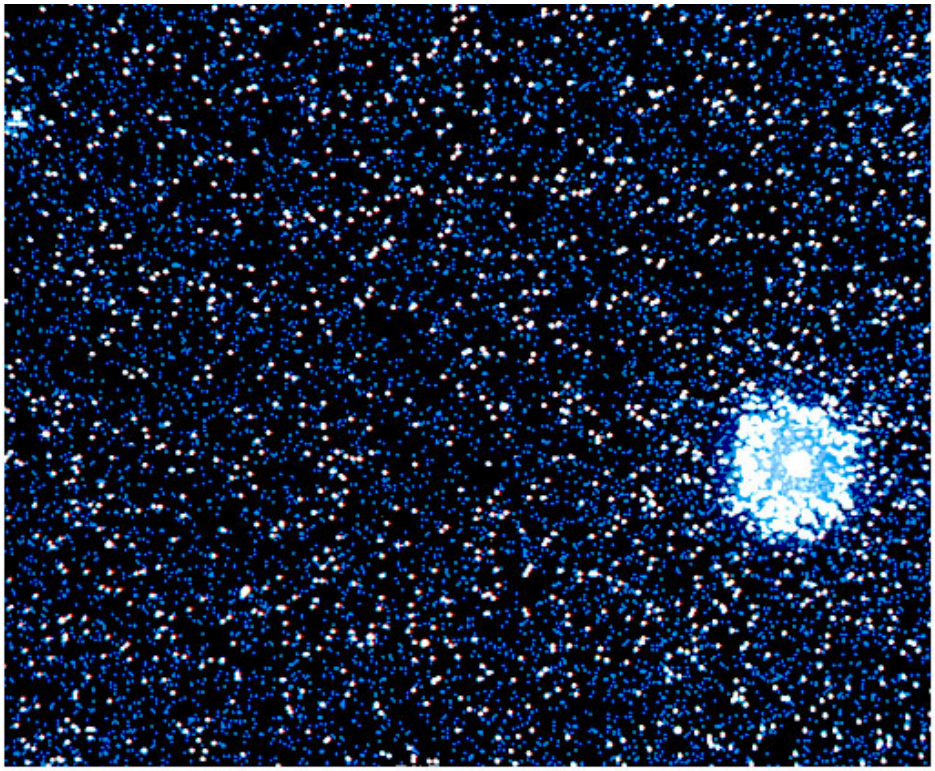
Atomic Theory

based on countless experiments from many scientists



Chemistry In Action:
Primordial Helium and the Big Bang Theory

In 1940 George Gamow ***hypothesized*** that the universe began with a gigantic explosion or big bang.



<u>Experimental Support</u>

- expanding universe
- cosmic background radiation
- primordial helium

Chemistry is the study of matter and the changes it undergoes

Matter is anything that occupies space and has mass.

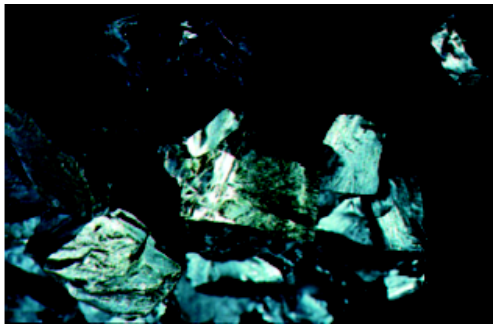
water H_2O

element, compound

A ***substance*** is a form of matter that has a definite composition and distinct properties.

liquid nitrogen

gold ingots



silicon crystals

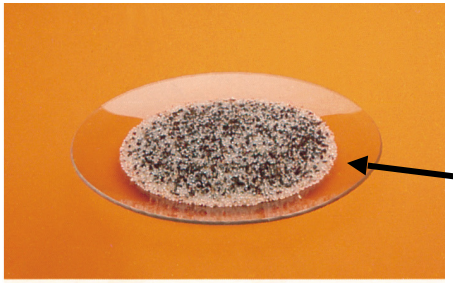
A ***mixture*** is a combination of two or more substances in which the substances retain their distinct identities.

can be separated by physical means

1. ***Homogenous mixture*** – composition of the mixture is the same throughout.

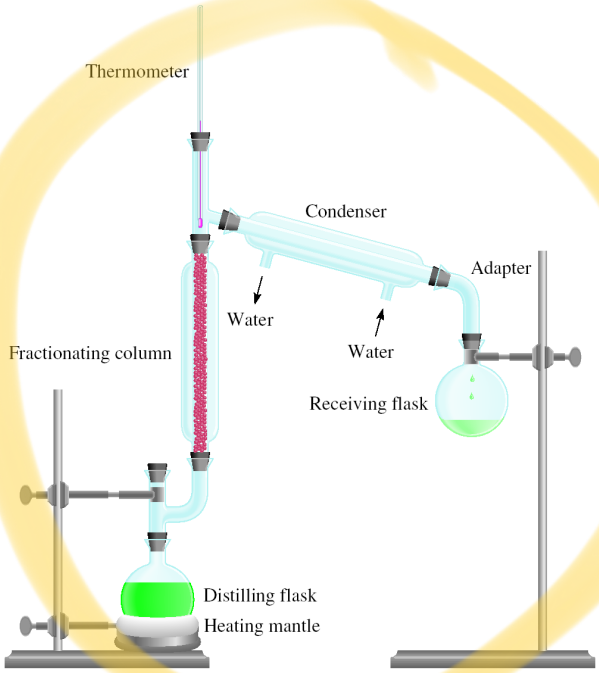
soft drink, milk, solder

2. ***Heterogeneous mixture*** – composition is not uniform throughout.



cement,
iron filings in sand

Physical means can be used to separate a mixture into its pure components.

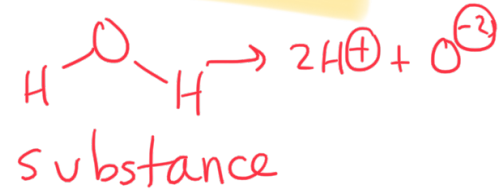


distillation

magnet

An ***element*** is a substance that cannot be separated into simpler substances by ***chemical means***.

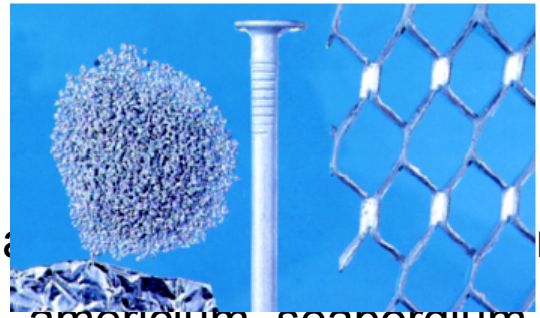
H_2O



≈118

- 114 elements have been identified
  - 82 elements occur naturally on Earth

    gold, aluminum, lead, oxygen, carbon, sulfur



  - 32 elements ha ntists

    technetium, americium, seaborgium

TABLE 1.1 Some Common Elements and Their Symbols

Name	Symbol	Name	Symbol	Name	Symbol
Aluminum	Al	Fluorine	F	Oxygen	O
Arsenic	As	Gold	Au	Phosphorus	P
Barium	Ba	Hydrogen	H	Platinum	Pt
Bismuth	Bi	Iodine	I	Potassium	K
Bromine	Br	Iron	Fe	Silicon	Si
Calcium	Ca	Lead	Pb	Silver	Ag
Carbon	C	Magnesium	Mg	Sodium	Na
Chlorine	Cl	Manganese	Mn	Sulfur	S
Chromium	Cr	Mercury	Hg	Tin	Sn
Cobalt	Co	Nickel	Ni	Tungsten	W
Copper	Cu	Nitrogen	N	Zinc	Zn

(molecule)

A ***compound*** is a substance composed of atoms of two or more elements chemically united in fixed proportions.

different

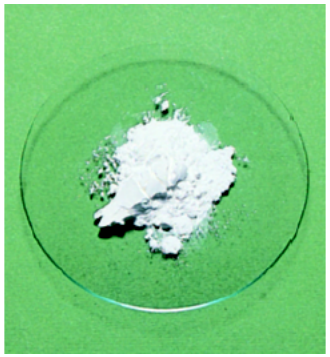
compound

O_2 not compound

diatomic element

Compounds can only be separated into their pure components (elements) by ***chemical*** means.

NaCl table salt

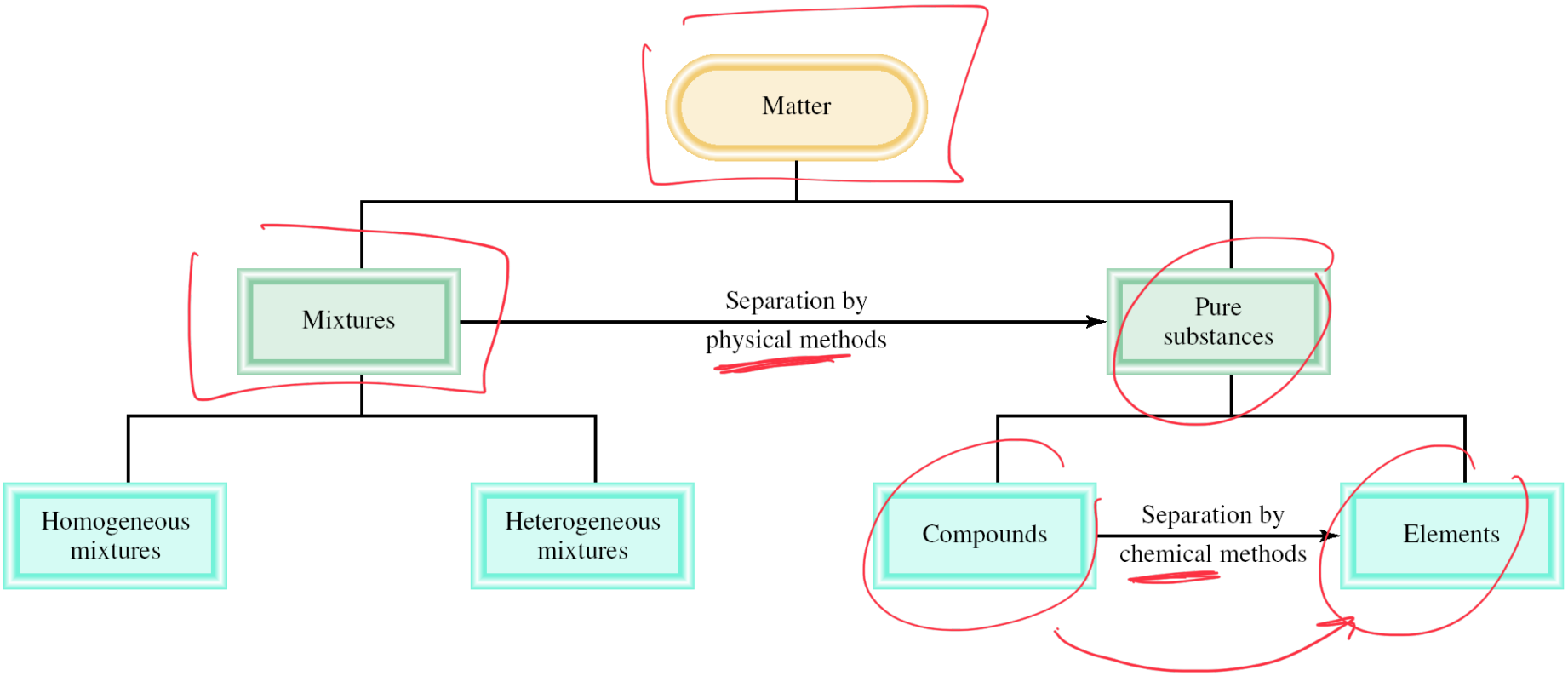


lithium fluoride

quartz

dry ice – carbon dioxide

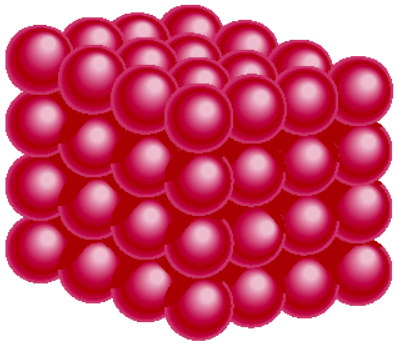
Classifications of Matter



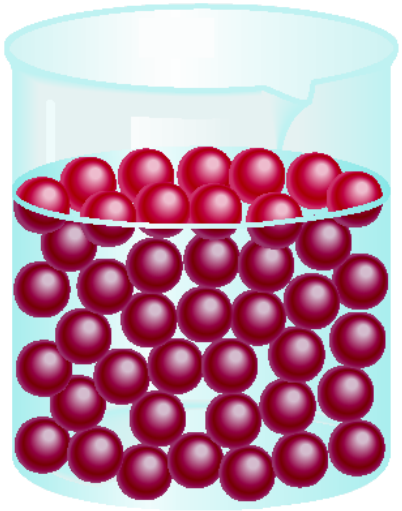
A Comparison: The Three States of Matter

Distance and motion

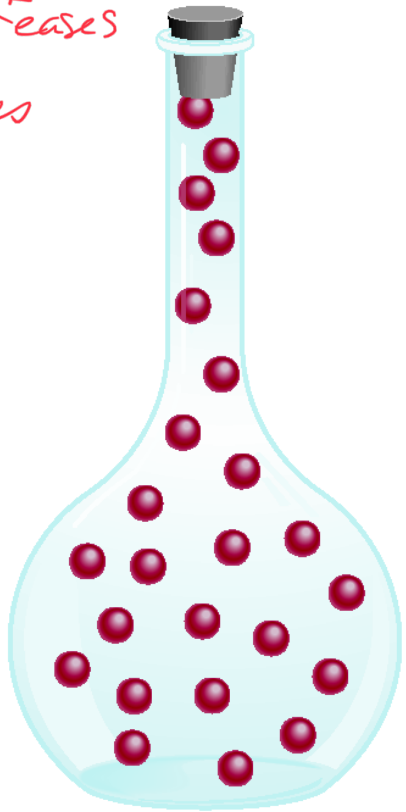
distance between atoms increases
relative motion of atoms increases



Solid

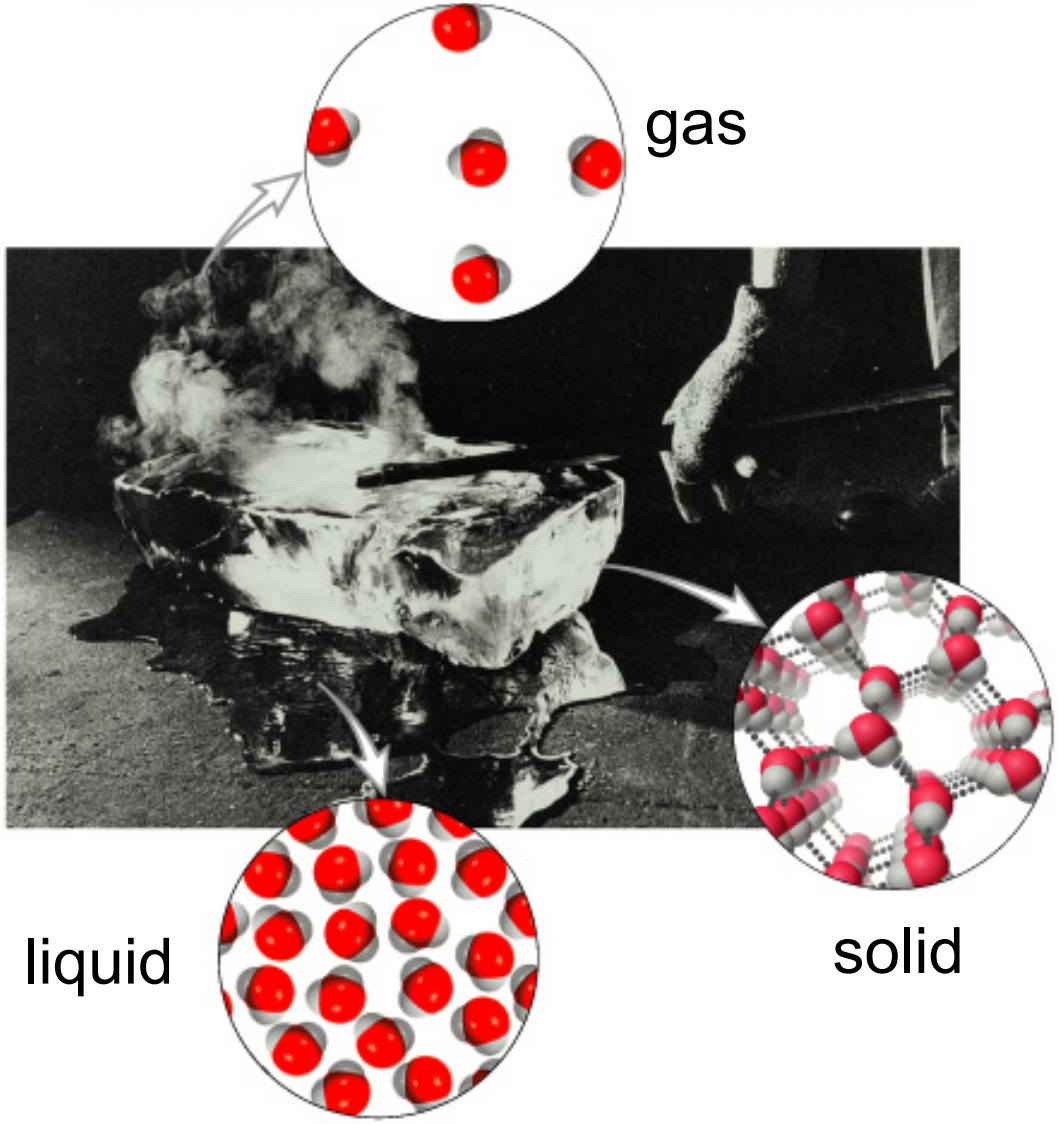


Liquid



Gas

The Three States of Matter: Effect of a Hot Poker on a Block of Ice



Types of Changes

A ***physical change*** does not alter the composition or identity of a substance.

phase change

ice melting

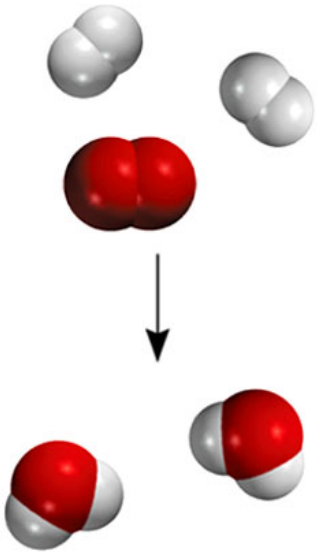
sugar dissolving in water

A ***chemical change*** alters the composition or identity of the substance(s) involved.

involves forming/breaking of chemical bonds

combustion

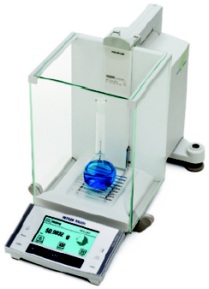
hydrogen burns in air to form water

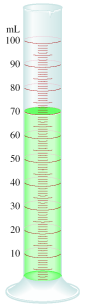


Extensive and Intensive Properties

An ***extensive property*** of a material depends upon how much matter is is being considered.

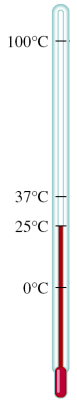
- mass
- length
- volume





An ***intensive property*** of a material does not depend upon how much matter is is being considered.

- density
- temperature
- color



melting/boiling point

Matter - anything that occupies space and has ***mass***.

mass – measure of the quantity of matter

SI unit of mass is the ***kilogram*** (kg)

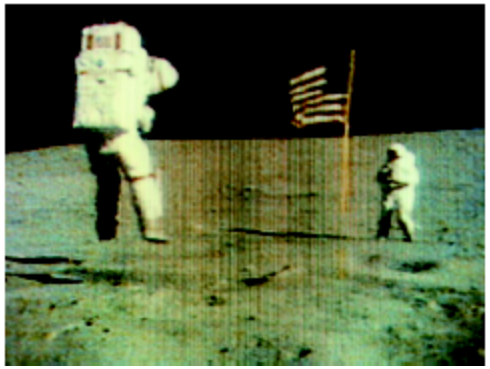
1 kg = 1000 g = 1 x 10^3 g

weight – force that gravity exerts on an object

weight = *c* x mass

on earth, *c* = 1.0

on moon, *c* ~ 0.1



A 1 kg bar will weigh

1 kg on earth

0.1 kg on moon