

Chemistry: The Study of Change

change

化学

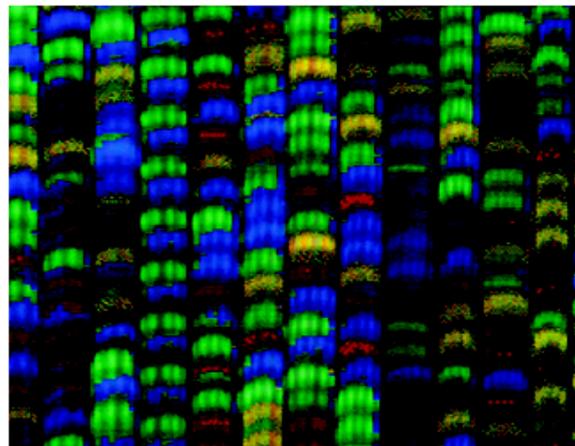
Chapter 1



Chemistry: A Science for the 21st Century

- Health and Medicine

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



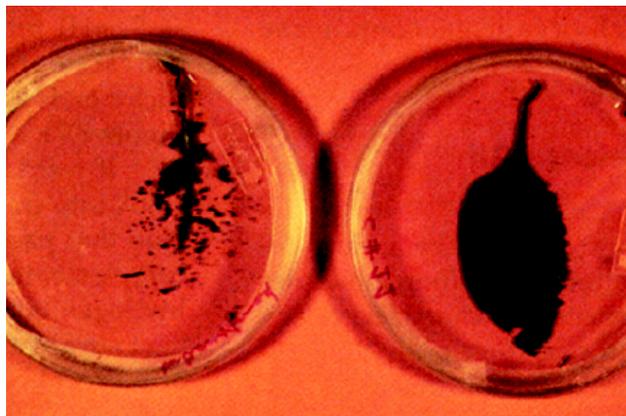
- Energy and the Environment

- 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

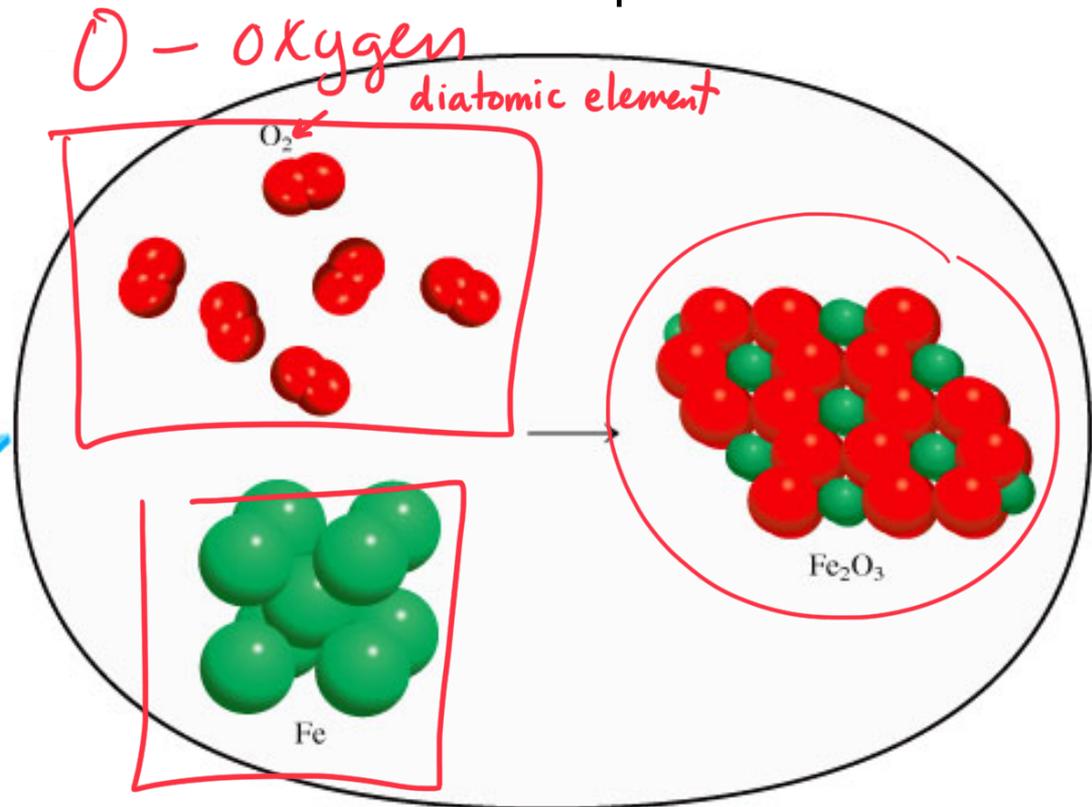
- Genetically modified crops
- “Natural” pesticides
- Specialized fertilizers

The Study of Chemistry

Macroscopic

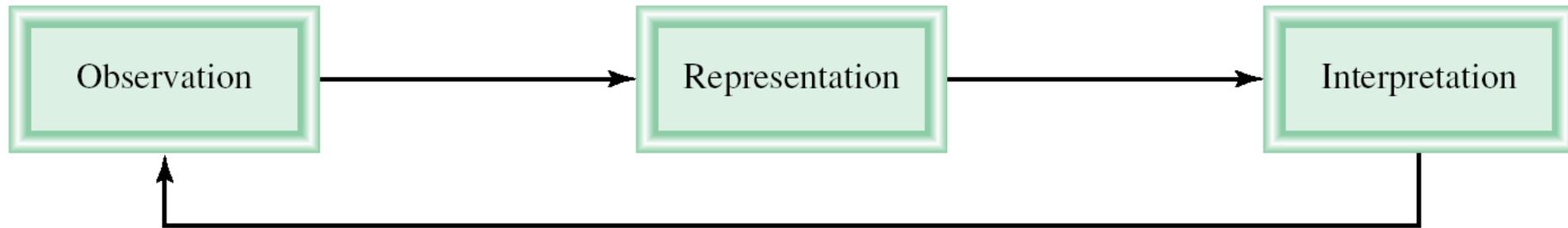


Microscopic



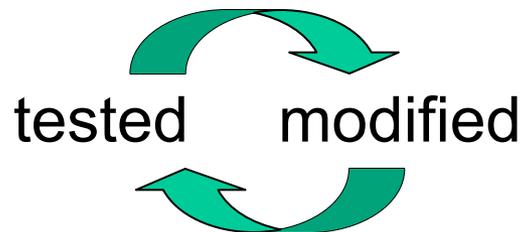
Fe → iron

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



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

educated guess
good hypothesis must be testable



Good scientist → attempts to prove themselves wrong

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

mathematical relationship

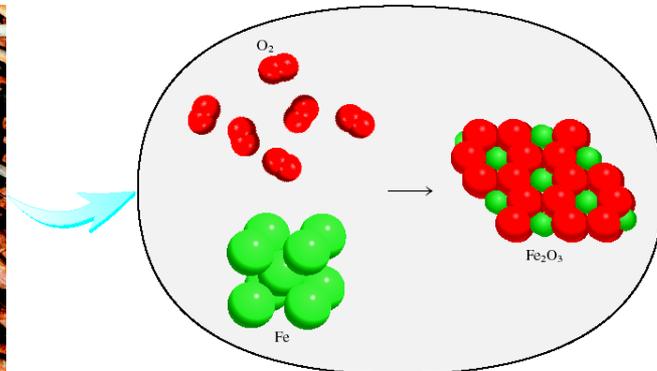
$$F_G = \frac{k m_1 m_2}{r^2}$$

Force = mass x acceleration
F = ma Newton's 2nd

over time if hypothesis remains reasonable

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

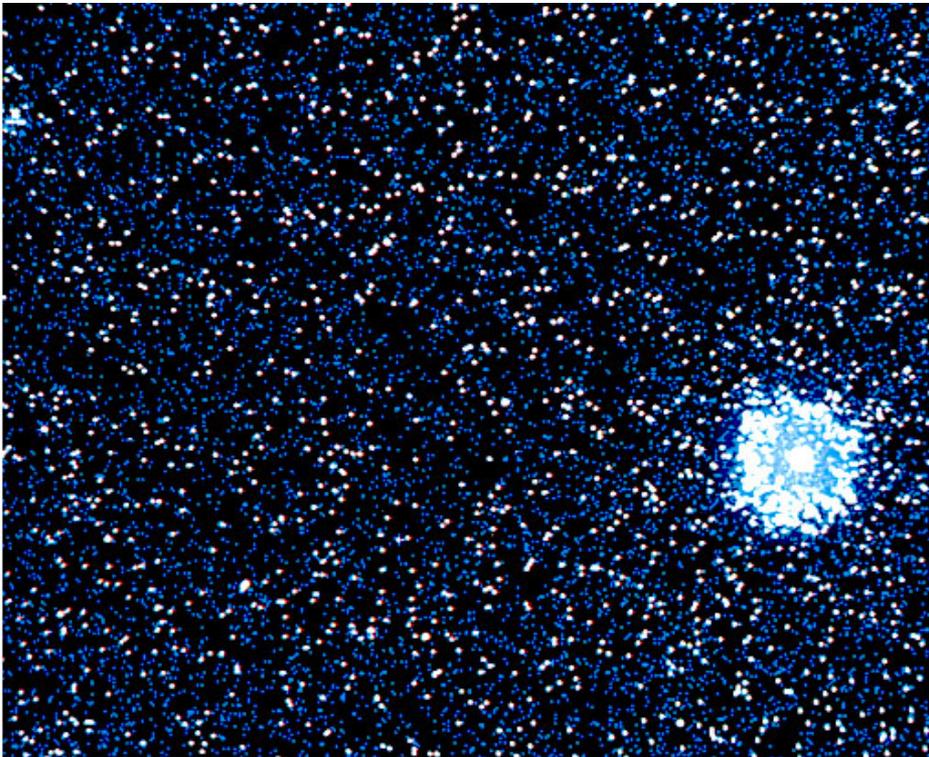
Atomic Theory



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.



Experimental Support

- expanding universe
- cosmic background radiation
- primordial helium

Chemistry is the study of matter and the changes it undergoes

$$E = mc^2$$

energy = (mass) (speed of light)²

Matter is anything that occupies space and has mass.



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



liquid nitrogen



gold ingots



silicon crystals

can separate by physical means

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

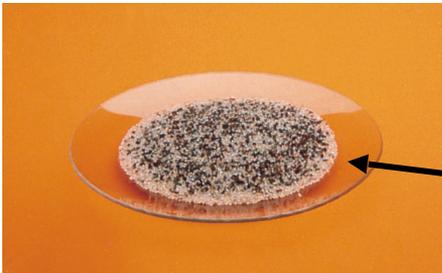
1. **Homogenous mixture** – composition of the mixture is the same throughout.

soft drink, milk, solder



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

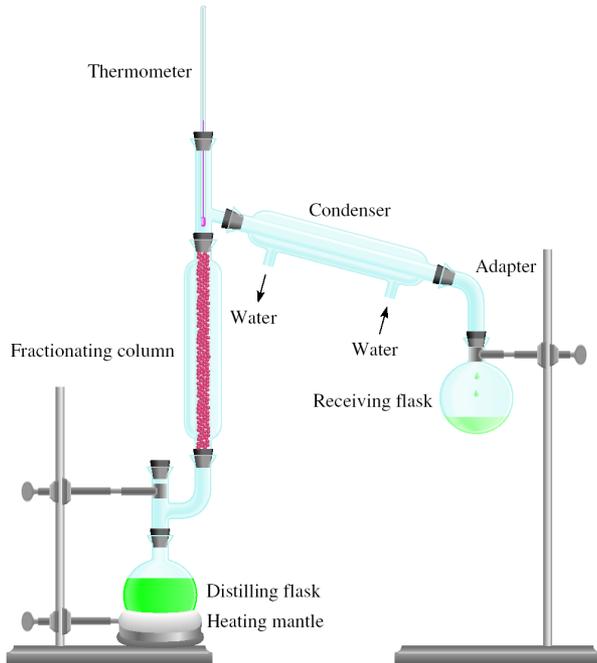
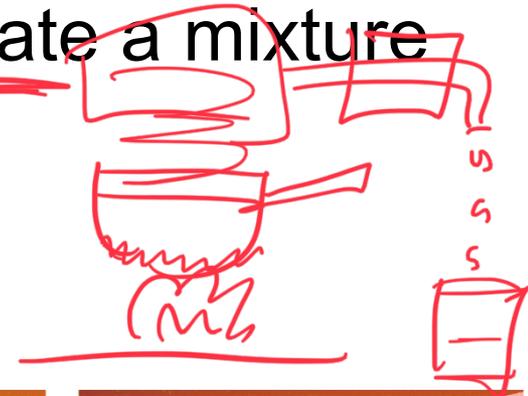
sand



cement,
iron filings in sand

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

salt water → mixture



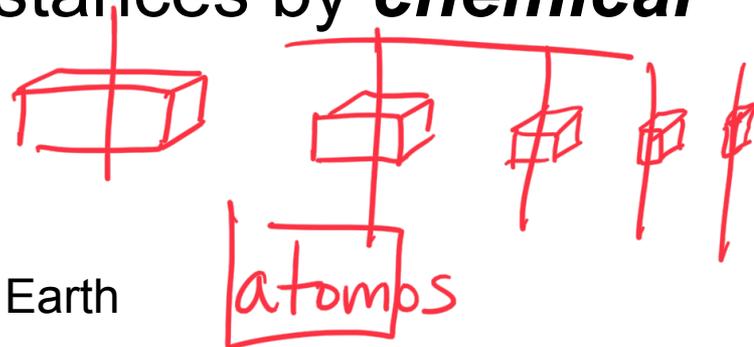
distillation



magnet

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

Democritus



- ~~118~~ elements have been identified
 - 82 elements occur naturally on Earth
gold, aluminum, lead, oxygen, carbon, sulfur

- 32 elements have been synthesized by scientists
technetium, americium, seaborgium



Manganese ~~Mn~~ Mn

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

All have a different number of protons.

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

different

H_2O
compound

O_2
element

N_2
element

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



lithium fluoride

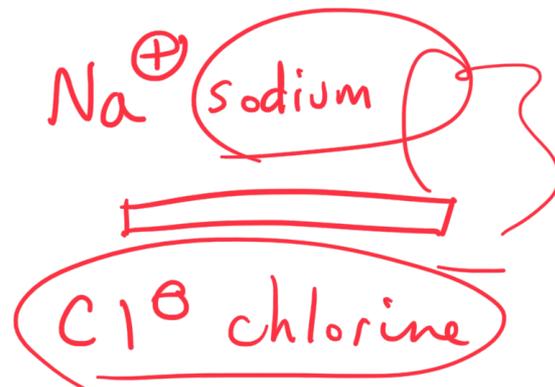
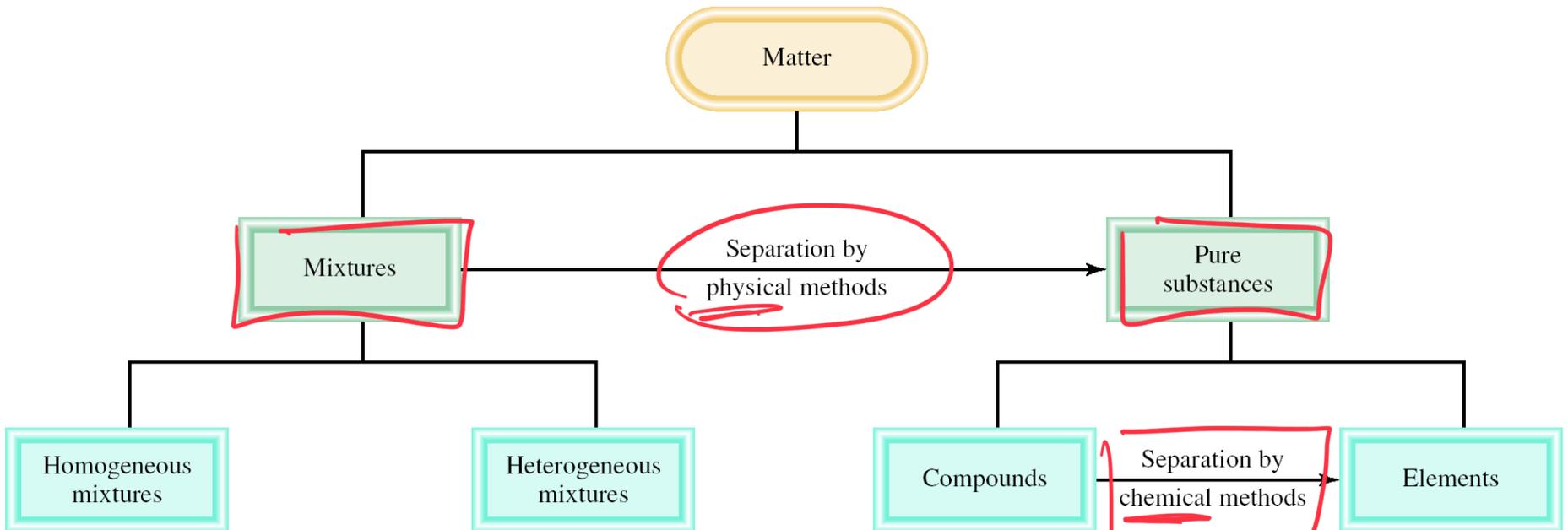


quartz



dry ice – carbon dioxide

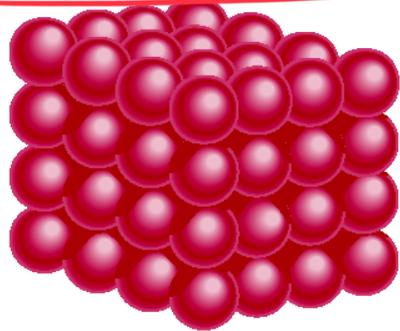
Classifications of Matter



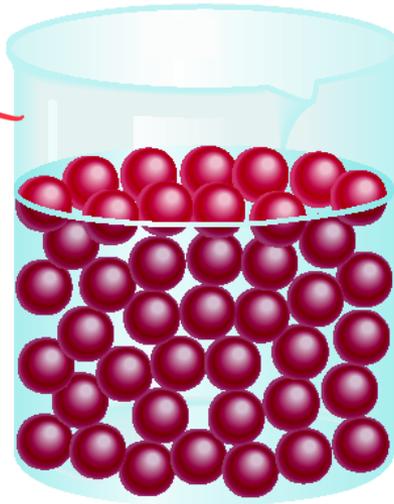
NaCl → different properties
ionic compound

A Comparison: The Three States of Matter

Fixed - volume
particles only vibrational
motion.
particles close - most dense
low energy



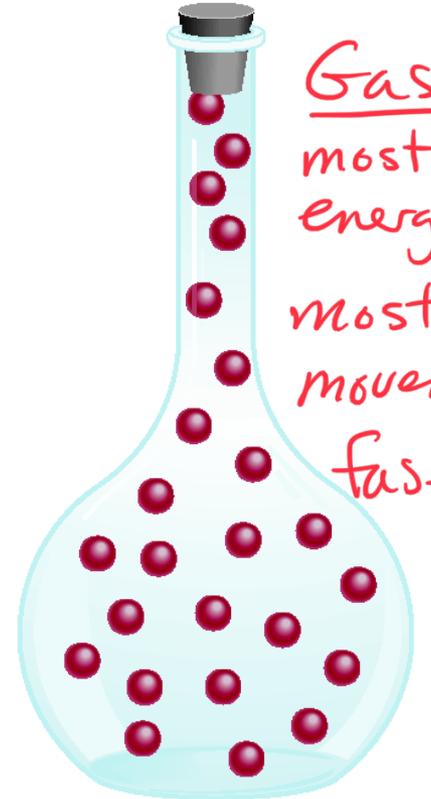
Solid



Liquid

Fluids

Adapt to their containers



Gas
most energy
most movement
fastest

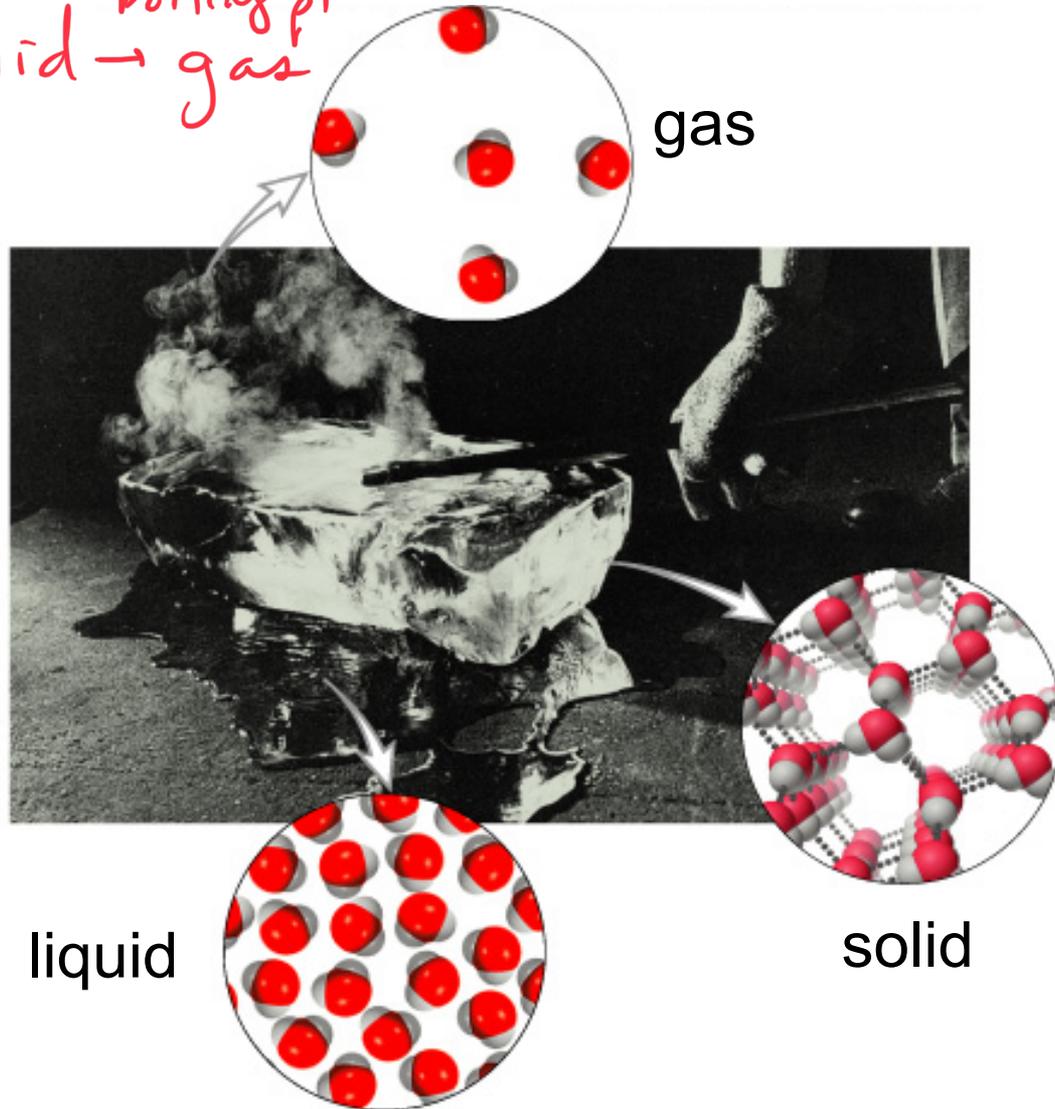
Gas

particles further
spaced - more movement
translational $\frac{1}{3}$ vibrational
more energy

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

melting pt
solid \rightarrow liquid \rightarrow gas
boiling pt

introduce
energy in
form of
heat



Types of Changes

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

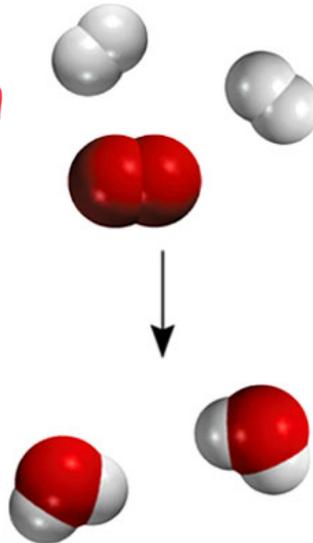
ice melting

sugar dissolving
in water

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

*involves a
chemical reaction*

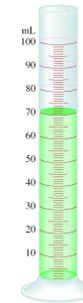
hydrogen burns in
air to form water



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

