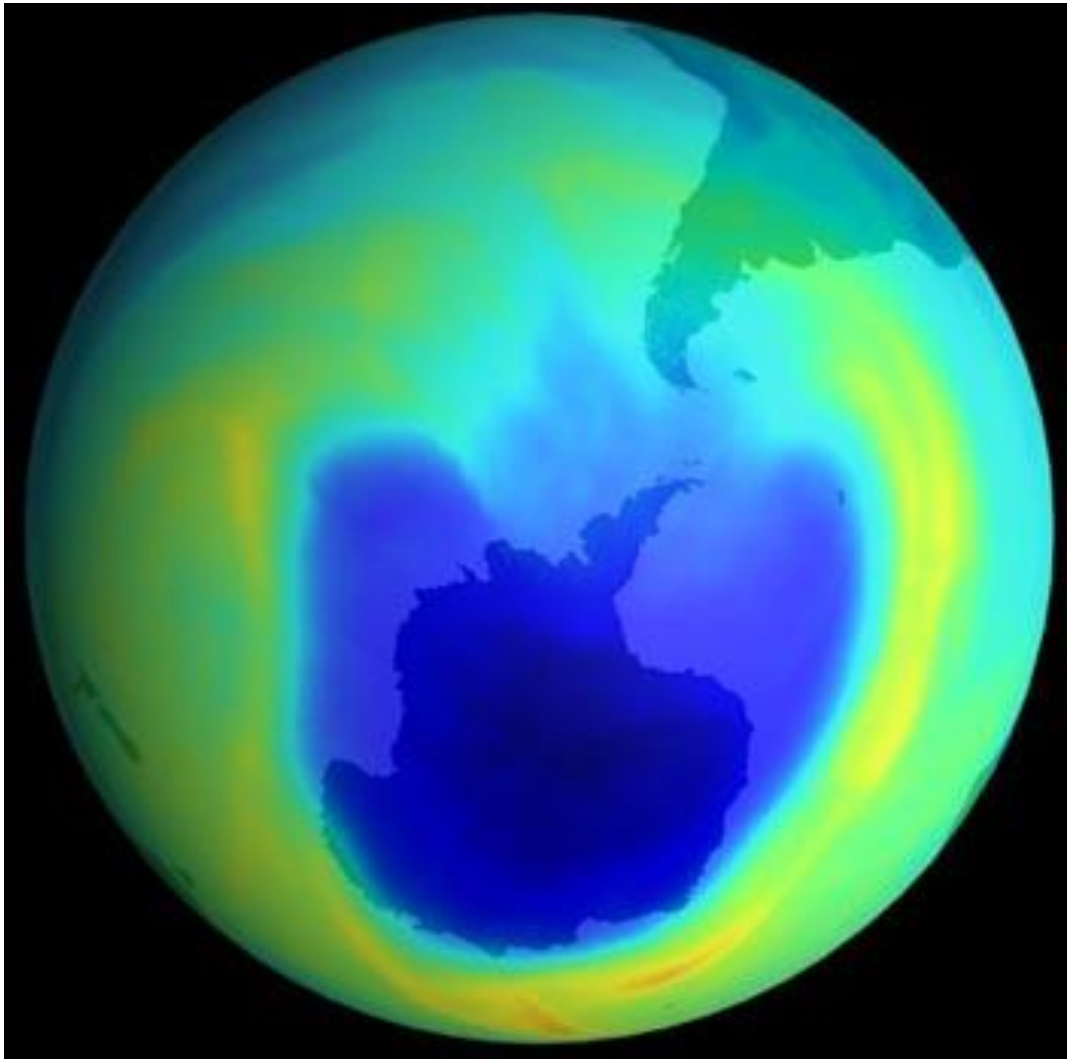
Chapter 1 Notes

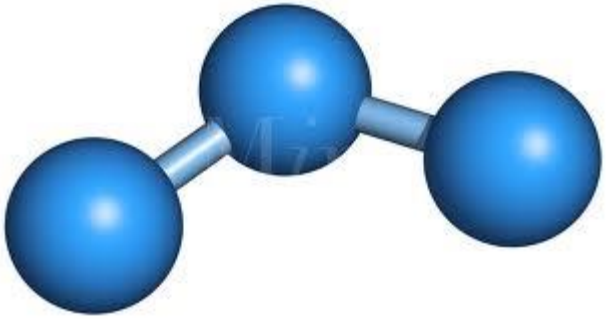
CHEM1450 S2016

Chemistry: Why am I here?

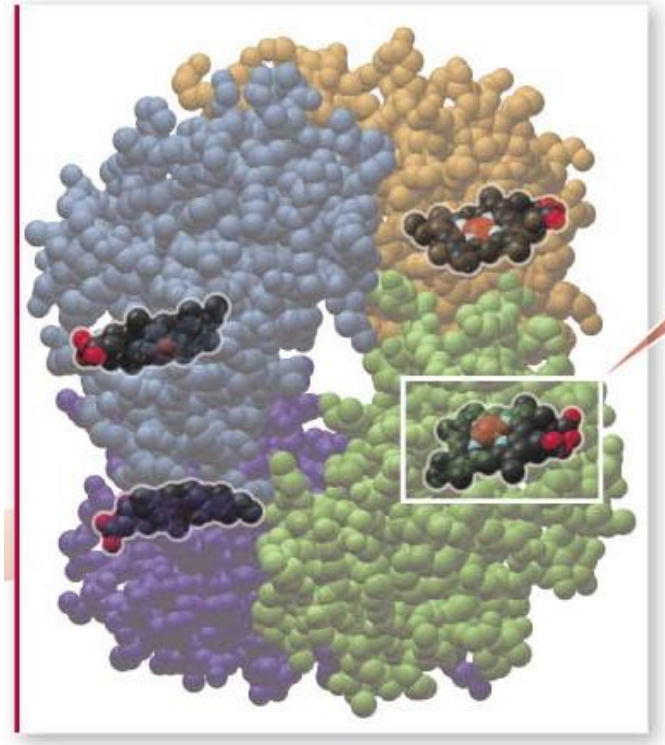
- Chemistry –
  - The science that seeks to understand the behavior of matter by studying the BEHAVIOR of atoms and molecules.
  - Not just a cause and effect… looks for the WHY and HOW
- One of my main objectives in this course is to help you KNOW atoms and molecules so that you can explain their behaviors.

The Antarctic Ozone Hole

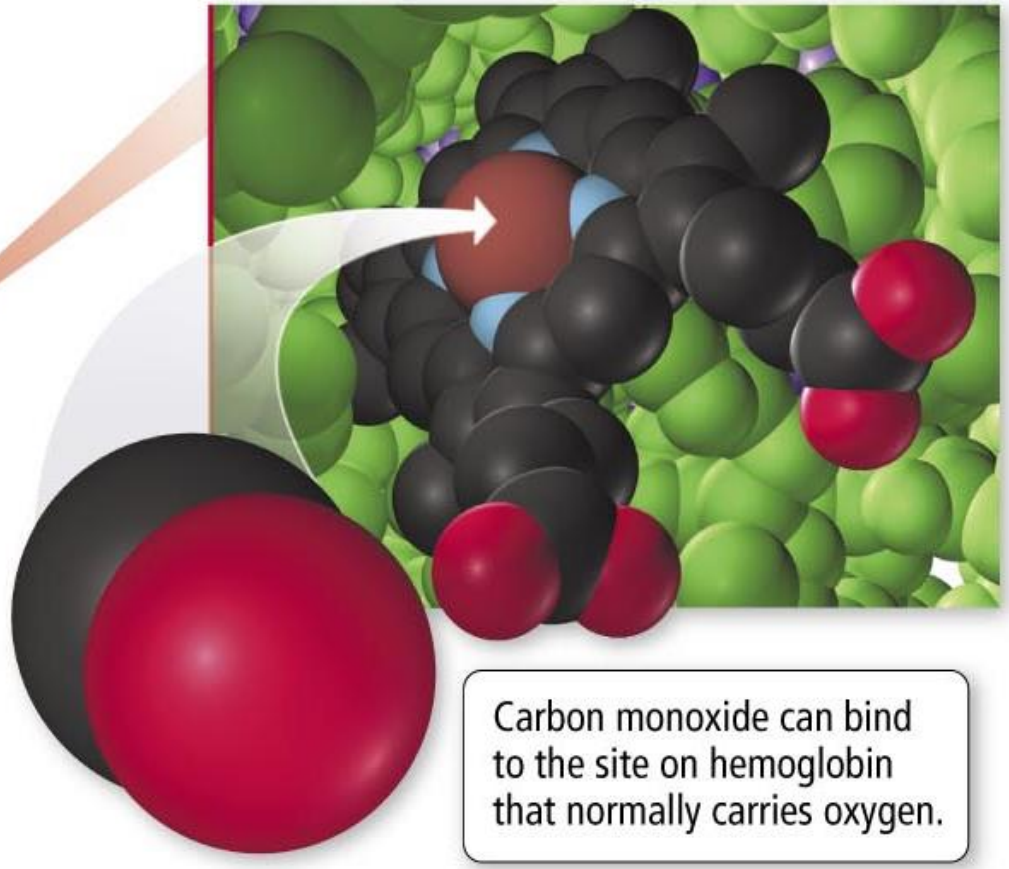




Hemoglobin and Carbon monoxide

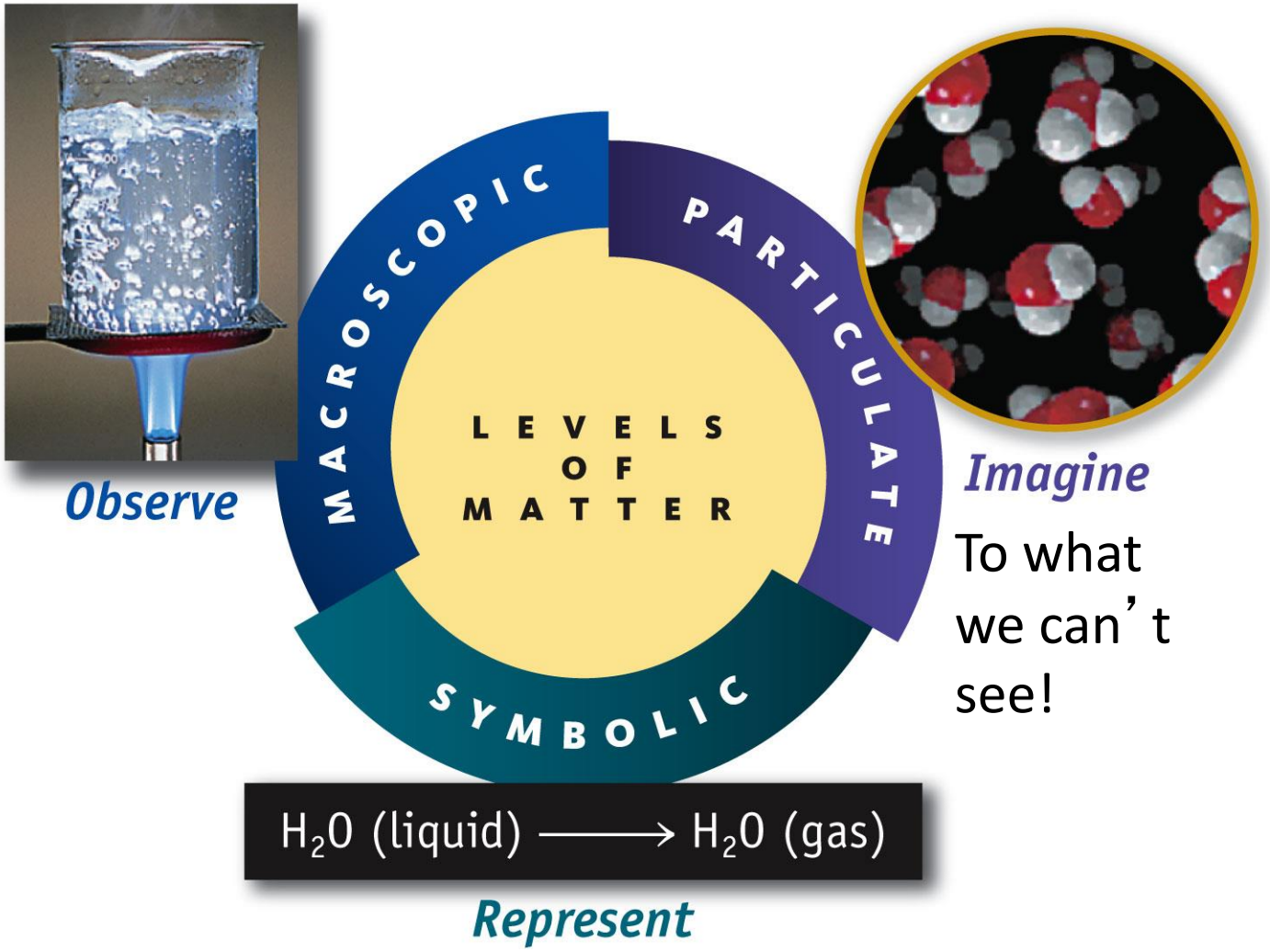


Hemoglobin, the oxygen-carrying molecule in red blood cells



Carbon monoxide can bind to the site on hemoglobin that normally carries oxygen.

What we observe…



Chemical symbols allow us to connect…

The Periodic Table of the Elements

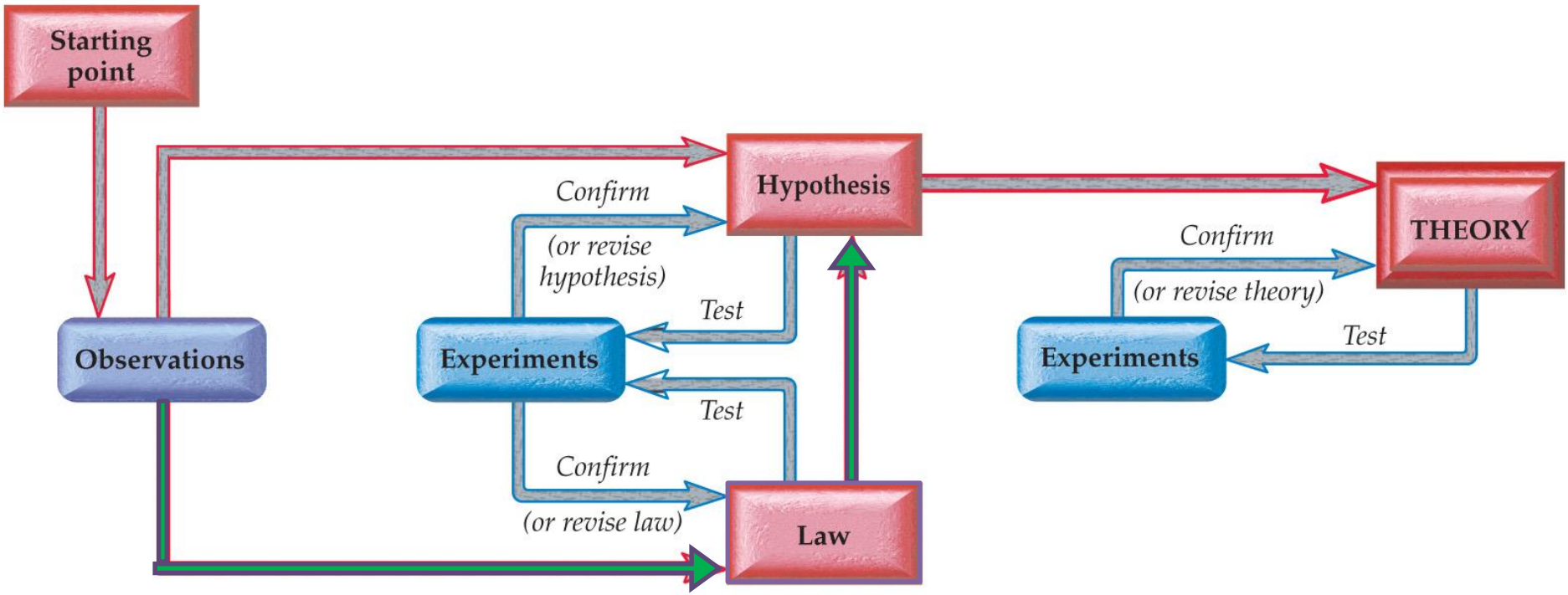
1 **H** Hydrogen 1.00794																	2 **He** Helium 4.003
3 **Li** Lithium 6.941	4 **Be** Beryllium 9.012182											5 **B** Boron 10.811	6 **C** Carbon 12.0107	7 **N** Nitrogen 14.00674	8 **O** Oxygen 15.9994	9 **F** Fluorine 18.9984032	10 **Ne** Neon 20.1797
11 **Na** Sodium 22.989770	12 **Mg** Magnesium 24.3050											13 **Al** Aluminum 26.981538	14 **Si** Silicon 28.0855	15 **P** Phosphorus 30.973761	16 **S** Sulfur 32.066	17 **Cl** Chlorine 35.4527	18 **Ar** Argon 39.948
19 **K** Potassium 39.0983	20 **Ca** Calcium 40.078	21 **Sc** Scandium 44.955910	22 **Ti** Titanium 47.867	23 **V** Vanadium 50.9415	24 **Cr** Chromium 51.9961	25 **Mn** Manganese 54.938049	26 **Fe** Iron 55.845	27 **Co** Cobalt 58.933200	28 **Ni** Nickel 58.6934	29 **Cu** Copper 63.546	30 **Zn** Zinc 65.39	31 **Ga** Gallium 69.723	32 **Ge** Germanium 72.61	33 **As** Arsenic 74.92160	34 **Se** Selenium 78.96	35 **Br** Bromine 79.904	36 **Kr** Krypton 83.80
37 **Rb** Rubidium 85.4678	38 **Sr** Strontium 87.62	39 **Y** Yttrium 88.90585	40 **Zr** Zirconium 91.224	41 **Nb** Niobium 92.90638	42 **Mo** Molybdenum 95.94	43 **Tc** Technetium (98)	44 **Ru** Ruthenium 101.07	45 **Rh** Rhodium 102.90550	46 **Pd** Palladium 106.42	47 **Ag** Silver 107.8682	48 **Cd** Cadmium 112.411	49 **In** Indium 114.818	50 **Sn** Tin 118.710	51 **Sb** Antimony 121.760	52 **Te** Tellurium 127.60	53 **I** Iodine 126.90447	54 **Xe** Xenon 131.29
55 **Cs** Cesium 132.90545	56 **Ba** Barium 137.327	57 **La** Lanthanum 138.9055	72 **Hf** Hafnium 178.49	73 **Ta** Tantalum 180.9479	74 **W** Tungsten 183.84	75 **Re** Rhenium 186.207	76 **Os** Osmium 190.23	77 **Ir** Iridium 192.217	78 **Pt** Platinum 195.078	79 **Au** Gold 196.96655	80 **Hg** Mercury 200.59	81 **Tl** Thallium 204.3833	82 **Pb** Lead 207.2	83 **Bi** Bismuth 208.98038	84 **Po** Polonium (209)	85 **At** Astatine (210)	86 **Rn** Radon (222)
87 **Fr** Francium (223)	88 **Ra** Radium (226)	89 **Ac** Actinium (227)	104 **Rf** Rutherfordium (261)	105 **Db** Dubnium (262)	106 **Sg** Seaborgium (263)	107 **Bh** Bohrium (262)	108 **Hs** Hassium (265)	109 **Mt** Meitnerium (266)	110 (269)	111 (272)	112 (277)	113	114				

58 **Ce** Cerium 140.116	59 **Pr** Praseodymium 140.90765	60 **Nd** Neodymium 144.24	61 **Pm** Promethium (145)	62 **Sm** Samarium 150.36	63 **Eu** Europium 151.964	64 **Gd** Gadolinium 157.25	65 **Tb** Terbium 158.92534	66 **Dy** Dysprosium 162.50	67 **Ho** Holmium 164.93032	68 **Er** Erbium 167.26	69 **Tm** Thulium 168.93421	70 **Yb** Ytterbium 173.04	71 **Lu** Lutetium 174.967
90 **Th** Thorium 232.0381	91 **Pa** Protactinium 231.03588	92 **U** Uranium 238.0289	93 **Np** Neptunium (237)	94 **Pu** Plutonium (244)	95 **Am** Americium (243)	96 **Cm** Curium (247)	97 **Bk** Berkelium (247)	98 **Cf** Californium (251)	99 **Es** Einsteinium (252)	100 **Fm** Fermium (257)	101 **Md** Mendelevium (258)	102 **No** Nobelium (259)	103 **Lr** Lawrencium (262)

The Scientific Method

- A process for trying to understand nature by observing nature and the way it behaves, and by conducting experiments to test our ideas.

The Scientific Method



What's the Difference Between an Observation and a Law?

- An **observation** tells you what happened in a single event.
- A **law** summarizes ***all*** the observations, effectively telling you what you will observe in future events.

The Law of Conservation of Matter

There is no observable change in the quantity of matter during a *chemical reaction or during a physical change*

The Law of Conservation of Energy

Energy cannot be created or destroyed in a *chemical reaction or in a physical change*. It can only be converted from one form to another.

Not defying COM!

Propane gas burning:

$$C_3H_8(g) + 5\,O_2(g) \longrightarrow 3\,CO_2(g) + 4\,H_2O(g)$$

Chemical composition altered

Chemical change

(c)

$CO_2(g)$, $H_2O(g)$
Carbon dioxide and water molecules

$C_3H_8(g)$
Propane molecules

What's the Difference Between a Hypothesis and a Theory?

- A **hypothesis** is an explanation of a single or small number of observations.
- A **theory** is an explanation that extends beyond individual observations to an understanding of the underlying causes for the way nature is or behaves.

What's the Difference Between a Law and a Theory?

- **Laws** answer the question "***What"*** will happen.
- **Theories** answer the question "***Why"*** does something happen.
  - This allows you to predict what will happen!

Relationships Between Pieces of the Scientific Method

	Applies to single or **small number** of events	Applies to **all** events
Describes ***what*** happens	observation	law
Explains ***why*** things happen	hypothesis	theory

Chemical and Physical Properties

Physical Properties: a property that a substance displays without changing its composition (*ex*. Color, melting point, boiling point)

Chemical Properties: a property only displayed when a change in composition occurs (ex: combustable, stable, explosive)

Which of the following is a chemical property?

a. squeezing oranges to make orange juice
b. melting butter for popcorn
c. separating sand from gravel
d. hydrogen peroxide decomposes to water and oxygen
e. ozone is a gas at room temperature

Chemical and Physical Properties

Extensive Properties: dependent on the amount of material present (*ex*. mass, volume)

Intensive Properties: independent on the amount of material present (*ex*. color, density)

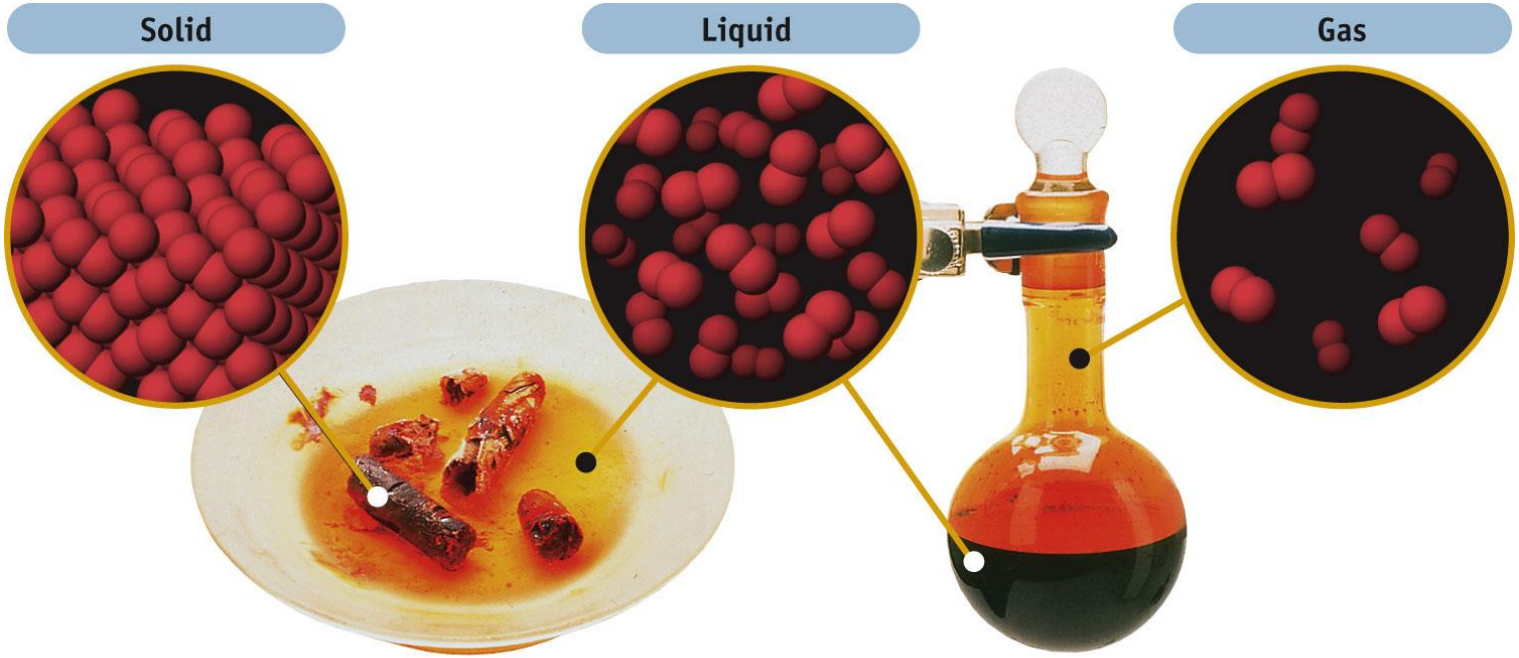
Which of the following would NOT be considered an *intensive property* describing an unknown sample?

- It is a solid at 25 ° C.
- It has a density of 1.38 g/ cm^3.
- It melts at 62.0 ° C.
- It has a volume of 0.52 cm^3.
- It is shiny.

States of Matter (Physical Property)

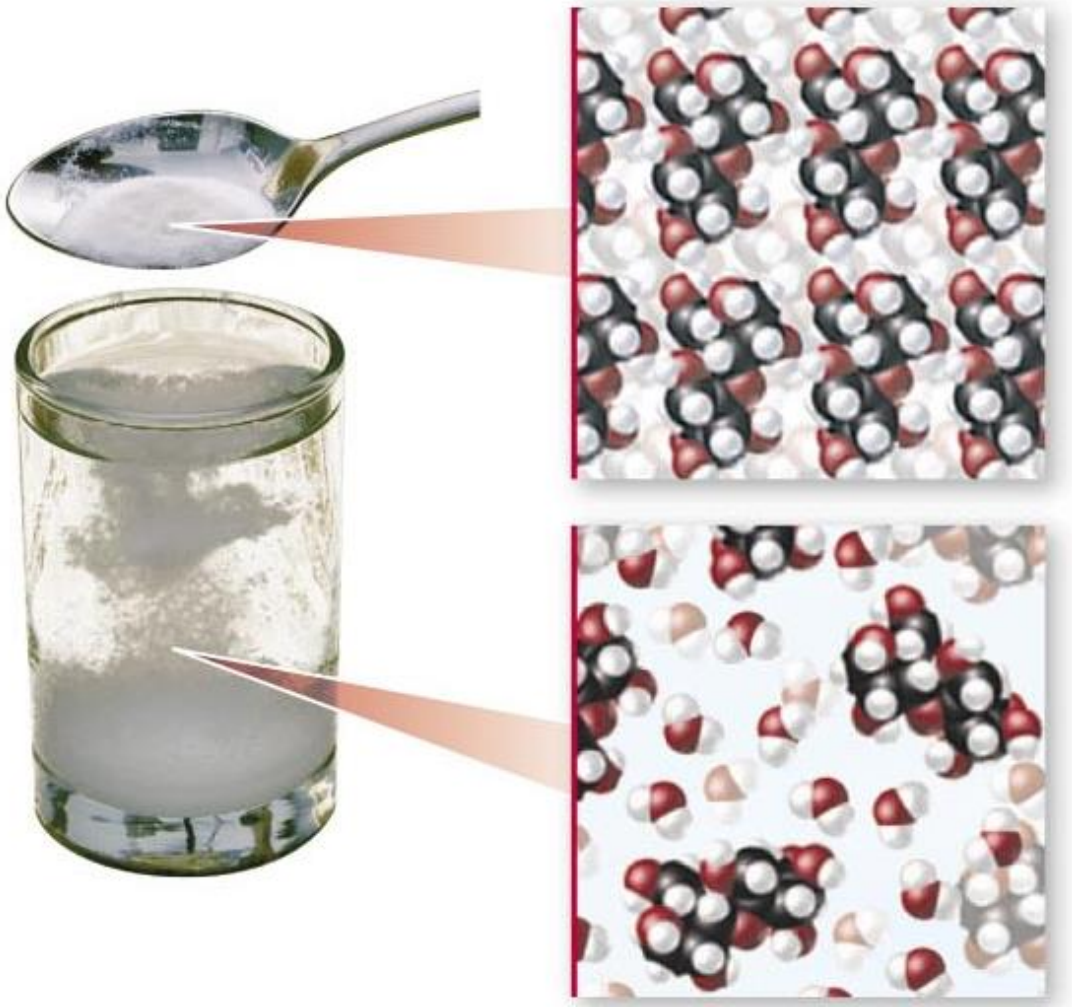
- Solid
- Liquid
- Gas

Br_2



States of Matter (Physical Property)

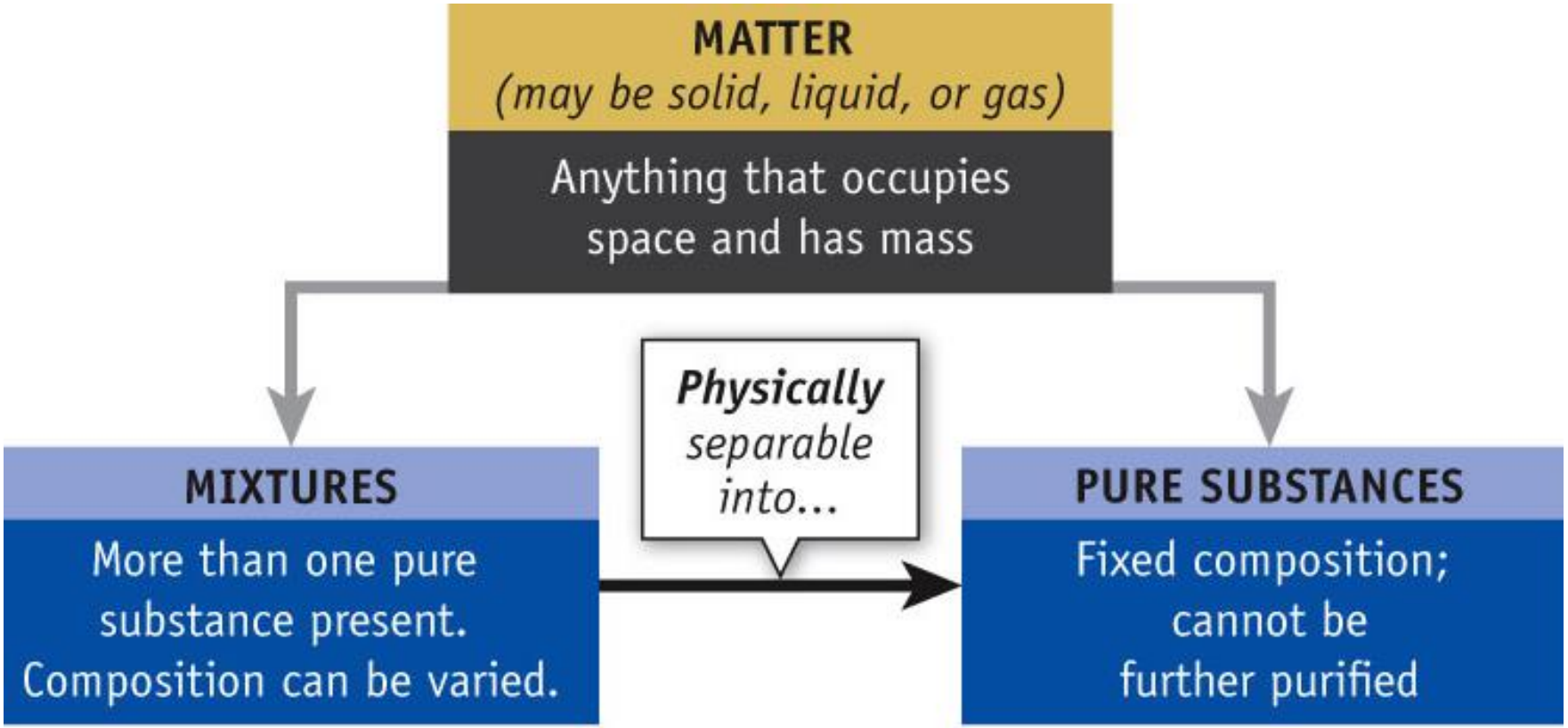
- Aqueous (aq) -dissolved in water



$C_{12}H_{22}O_{11}(s)$
Solid sugar

$C_{12}H_{22}O_{11}(aq)$
Dissolved sugar molecules

Classifying Matter



Pure Substances

A pure substance has well defined physical and chemical properties.

Pure substances can be classified as *elements* or *compounds*.

The only way to further separate a pure substance is through chemical means.

Elements

The Periodic Table of the Elements

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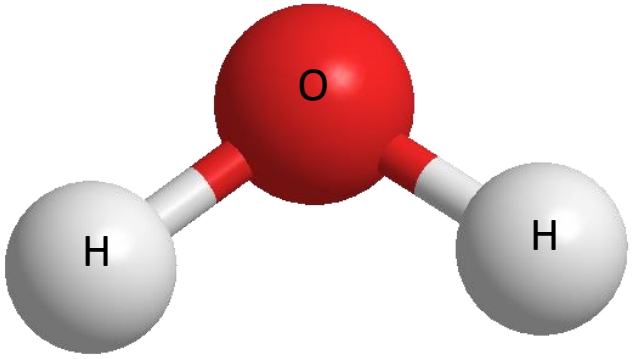
Compounds

Chemical compounds are composed of two or more atoms.



Water Molecule

H_2O

Chemical Formula

A molecule is the smallest unit of a compound that retains the chemical characteristics of the compound.

Mixtures: Homogeneous and Heterogeneous

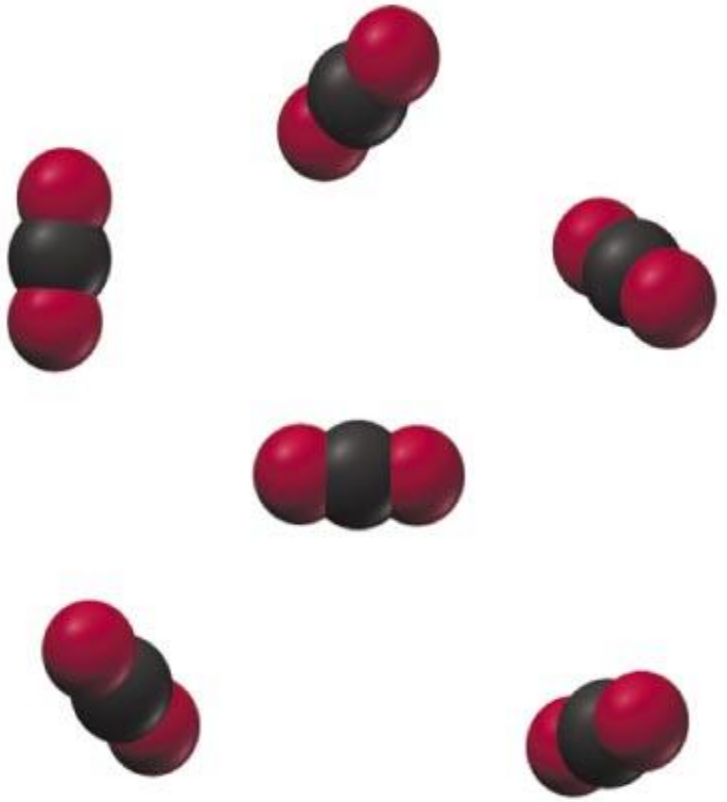
A homogeneous mixture consists of two or more substances in the same phase. No amount of optical magnification will reveal a homogeneous mixture to have different properties in different regions.

A heterogeneous mixture does not have uniform composition. Its components are easily visually distinguishable.

When separated, the components of both types of mixtures yield pure substances.

Which of the following is correct for the material pictured?

- a gaseous pure substance
- a liquid pure substance
- a gaseous mixture
- a solid mixture
- none of the above



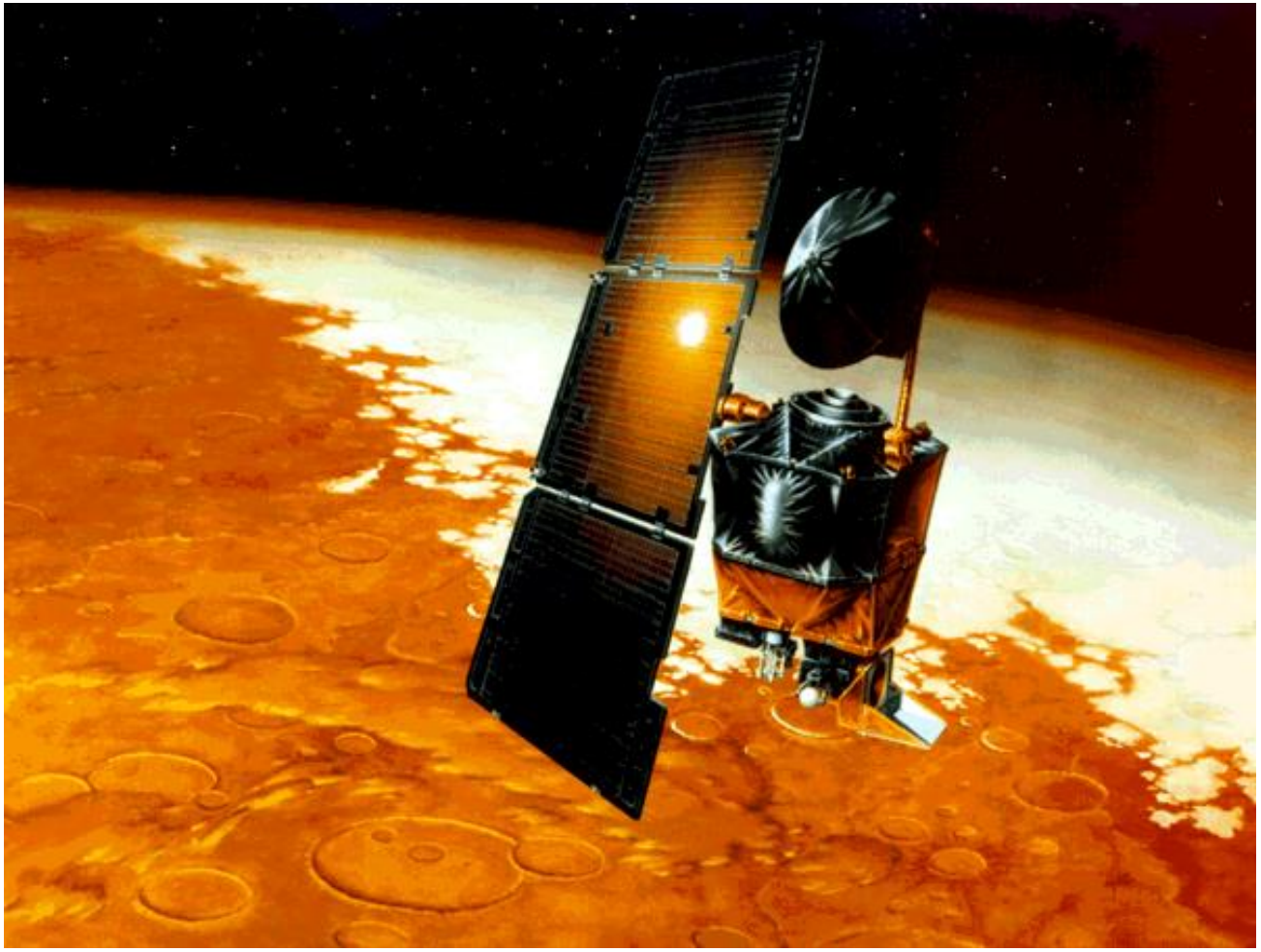
Which of the following is a pure substance?

a. sweat
b. beef stew
c. coffee
d. apple juice
e. ice

Which of the following is a heterogeneous mixture?

a. seawater
b. chicken soup
c. coffee
d. hydrogen peroxide
e. ice

The Importance of Units



Sept 30th 1999

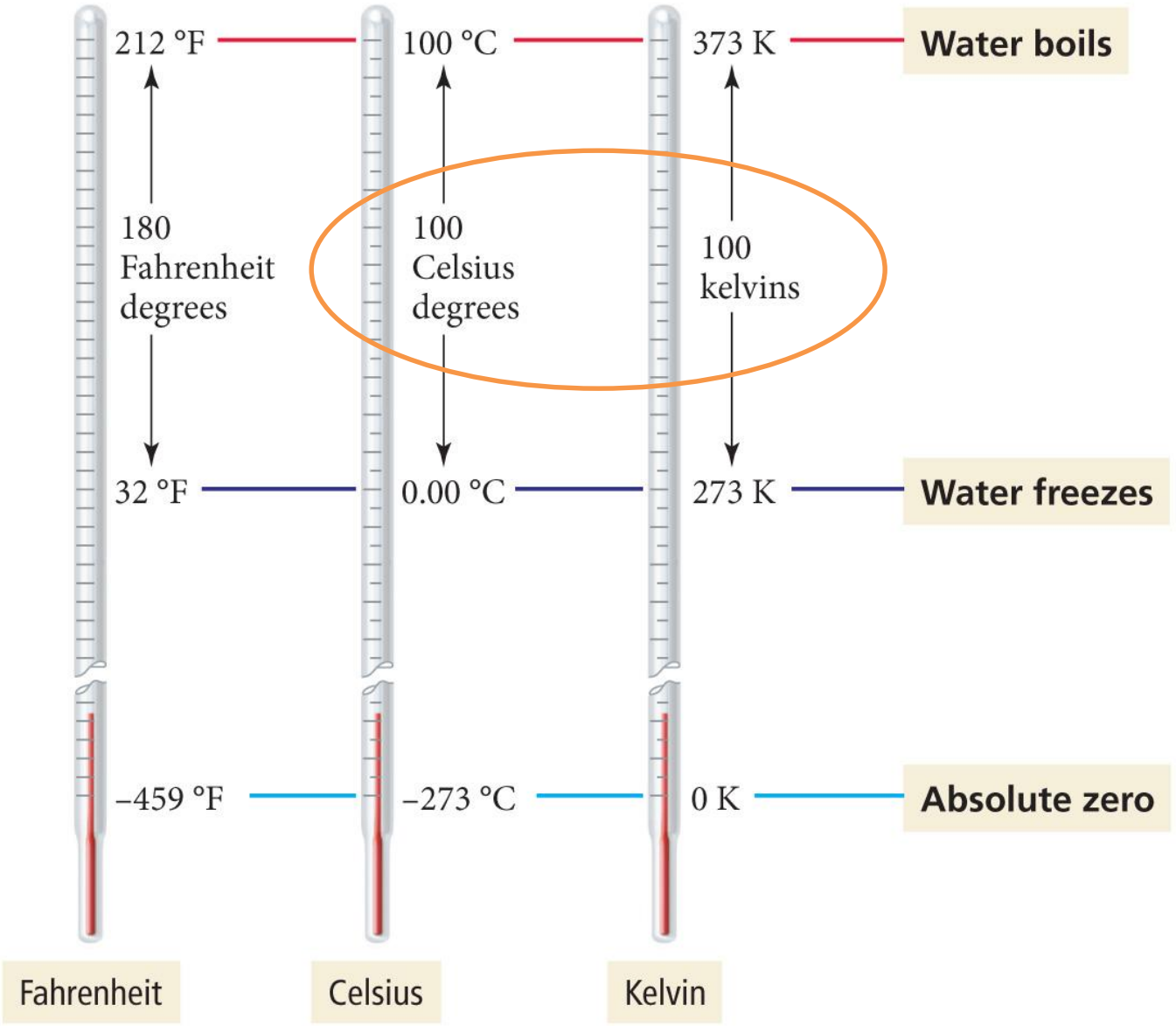
CNN

"NASA lost a 125 million dollar Mars orbiter because one engineering team used metric units while another used English units for a key spacecraft operation, according to a review finding released Thursday"

TABLE 1.1 SI Base Units

Quantity	Unit	Symbol
Length	Meter	m
Mass	Kilogram	kg
Time	Second	s
Temperature	Kelvin	K
Amount of substance	Mole	mol
Electric current	Ampere	A
Luminous intensity	Candela	cd

Temperature Scales



Chlorine vaporizes at –34.4 ˚C. What is this temperature in degrees Fahrenheit?

- –34.4 ˚F
- –29.9 ˚F
- 238.75 ˚F
- 307.55 ˚F
- 273.15 ˚F

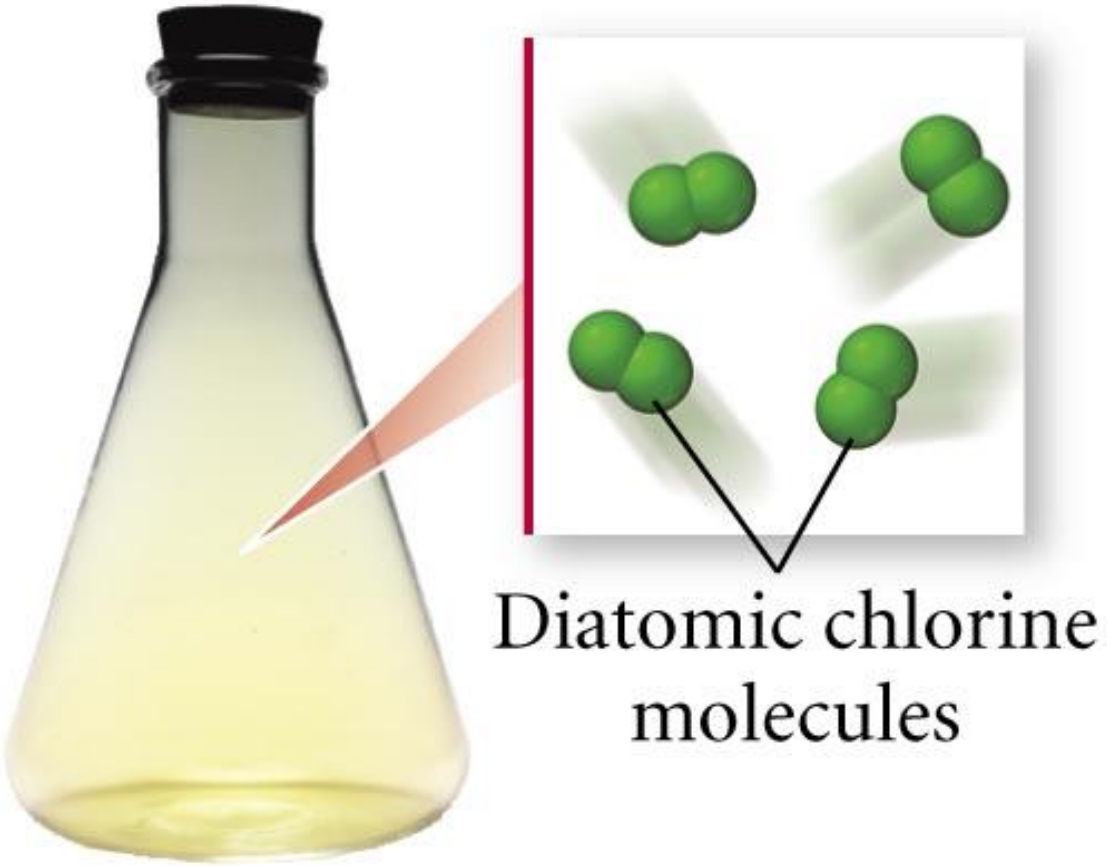
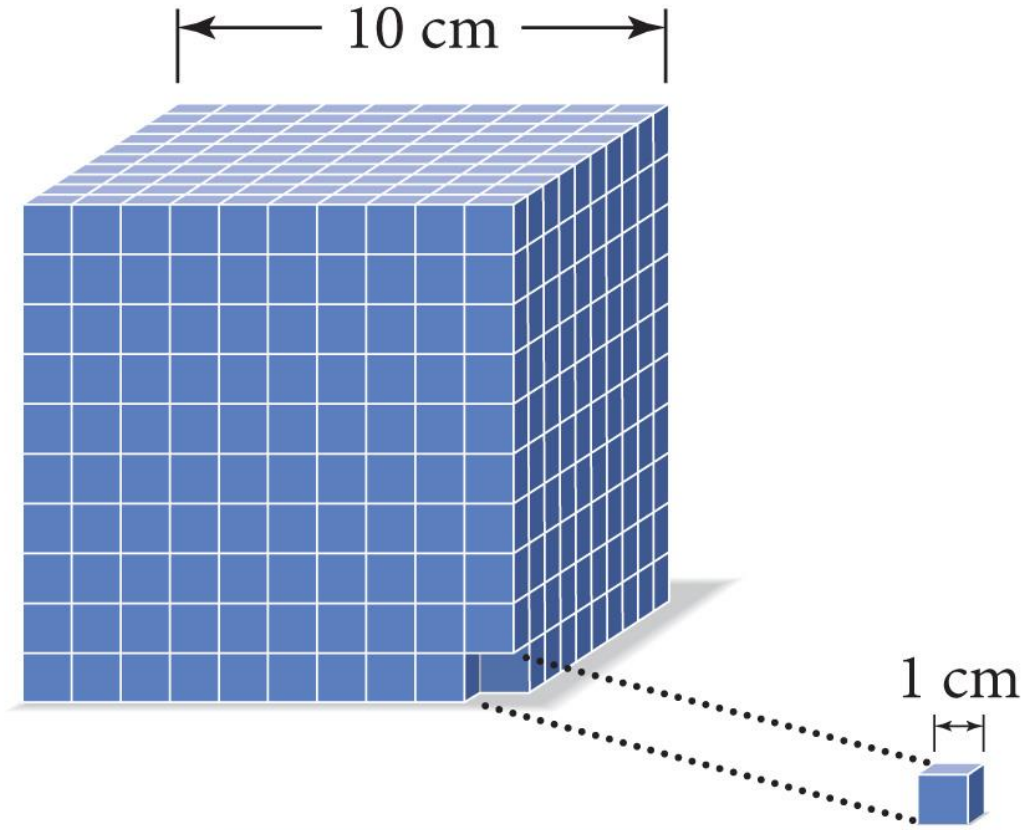


TABLE 1.2 SI Prefix Multipliers

Prefix	Symbol	Multiplier	
exa	E	1,000,000,000,000,000,000	(10^{18})
peta	P	1,000,000,000,000,000	(10^{15})
tera	T	1,000,000,000,000	(10^{12})
giga	G	1,000,000,000	(10^{9})
mega	M	1,000,000	(10^{6})
kilo	k	1000	(10^{3})
deci	d	0.1	(10^{-1})
centi	c	0.01	(10^{-2})
milli	m	0.001	(10^{-3})
micro	μ	0.000001	(10^{-6})
nano	n	0.000000001	(10^{-9})
pico	p	0.000000000001	(10^{-12})
femto	f	0.000000000000001	(10^{-15})
atto	a	0.000000000000000001	(10^{-18})

Relationship between Length and Volume



A 10-cm cube contains 1000 1-cm cubes.

Sig Fig Rules:

1. All nonzero digits ARE significant.
2. Zeroes
   a) Interior zeroes ARE significant.
   b) Leading zeroes ARE NOT significant.
   c) Trailing zeroes ARE significant IF they are after a decimal point.
3. Exact numbers (counted, or integral numbers used in an equation) have infinite sig figs.

- Sig Fig Math

1. In Multiplication or Division, the result carries the same number of sig figs as the factor with the least.
2. In add/subtract, the result carries the same number of decimal places as the quantity with the fewest decimal places.

- Rounding

1. When rounding, round up if the digit dropped is 5 or more.
2. Avoid rounding errors by rounding only the final answer.