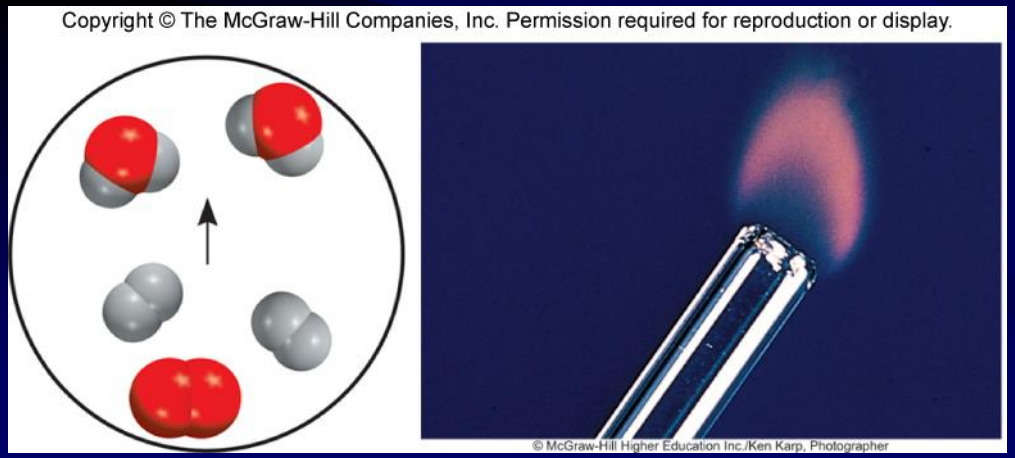
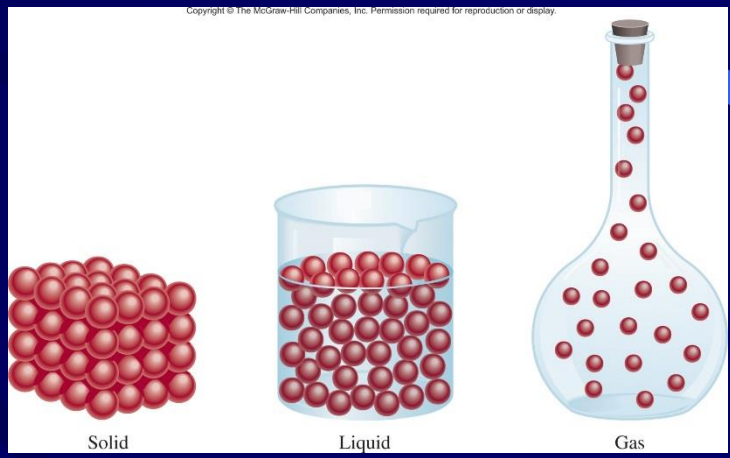
Chemistry 151 - Kolack

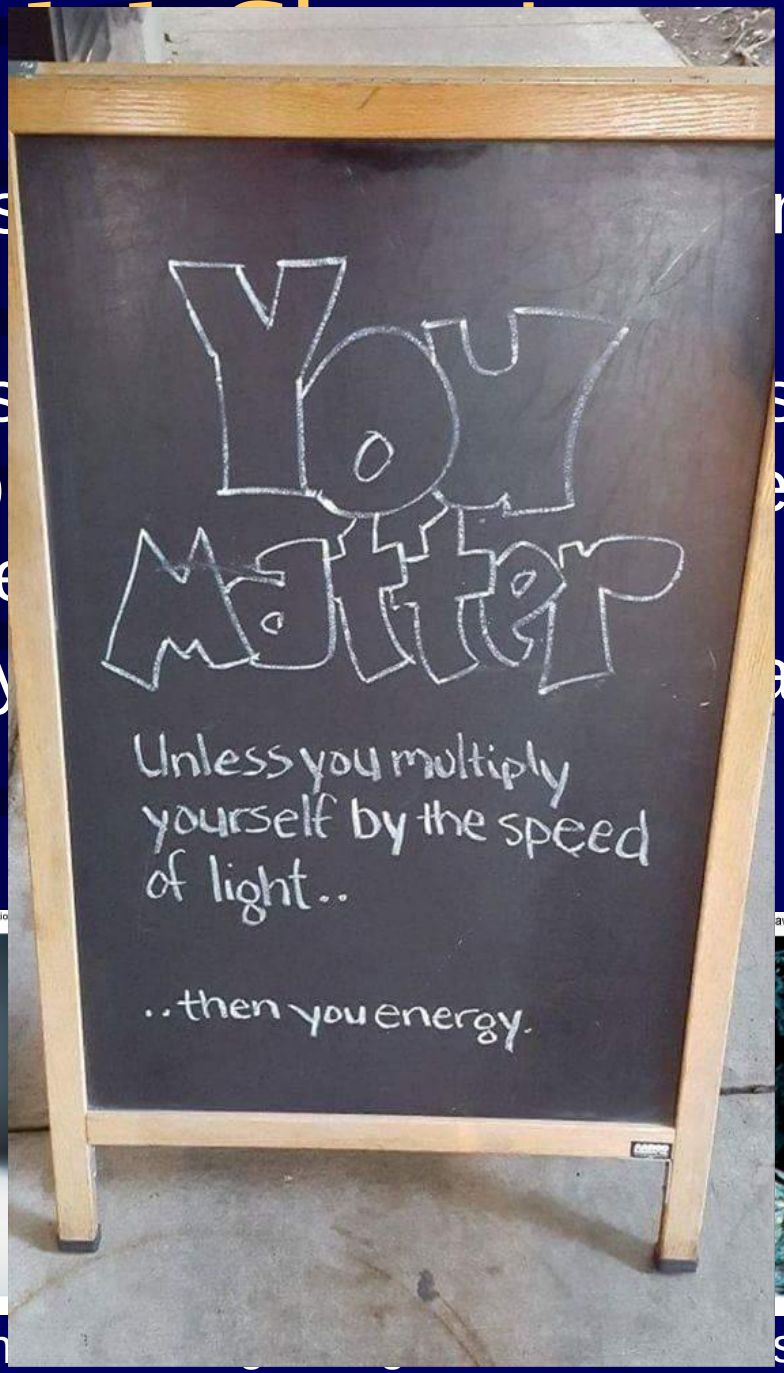
Chapter 1

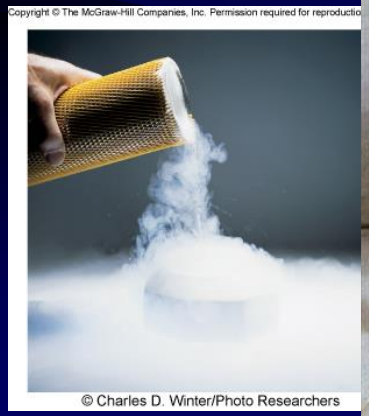
Sections 1.1-1.3





- The Universe is [illegible] nd <u>energy</u> (and empty space).
- CHEMISTRY is [illegible] s composition, structure and p[illegible] e changes of matter from one
- MATTER is any[illegible] ace and has mass.





© Charles D. Winter/Photo Researchers

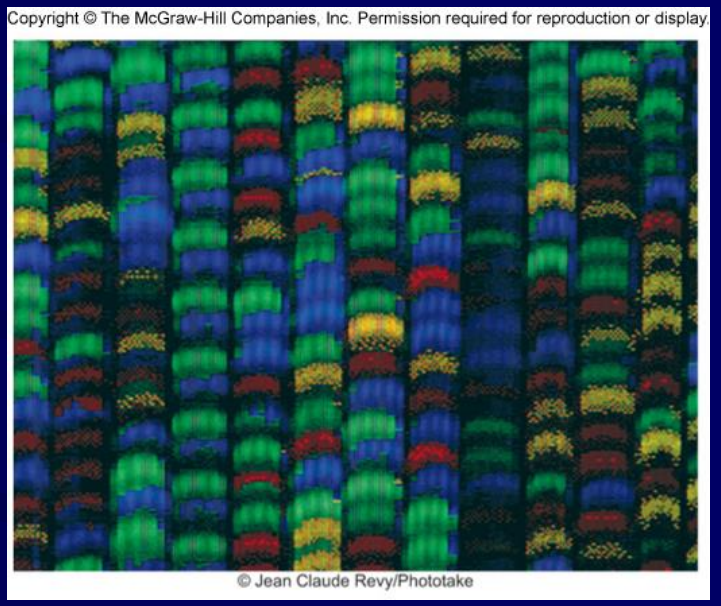
liquid nitrogen

© Frank Wing/Stock Boston

silicon crystals

Chemistry: a 21st century science

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



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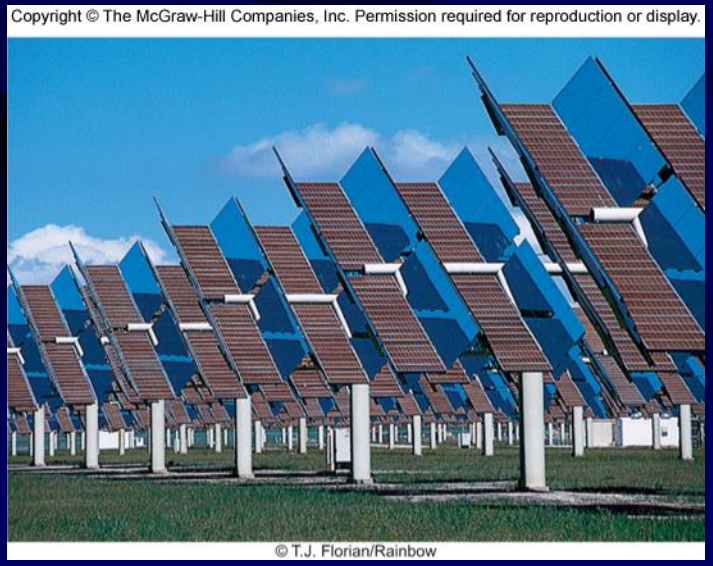

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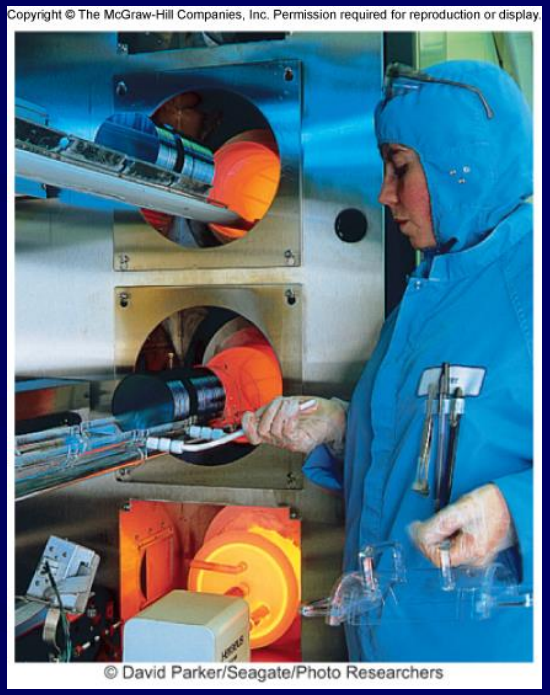
- Energy and the environment
  - Fossil fuels
  - Solar energy
  - Nuclear energy

Chemistry: a 21st century science

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



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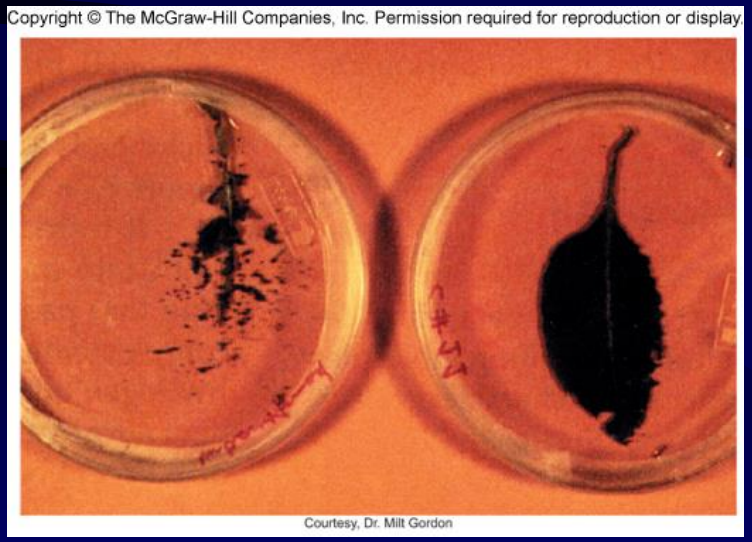


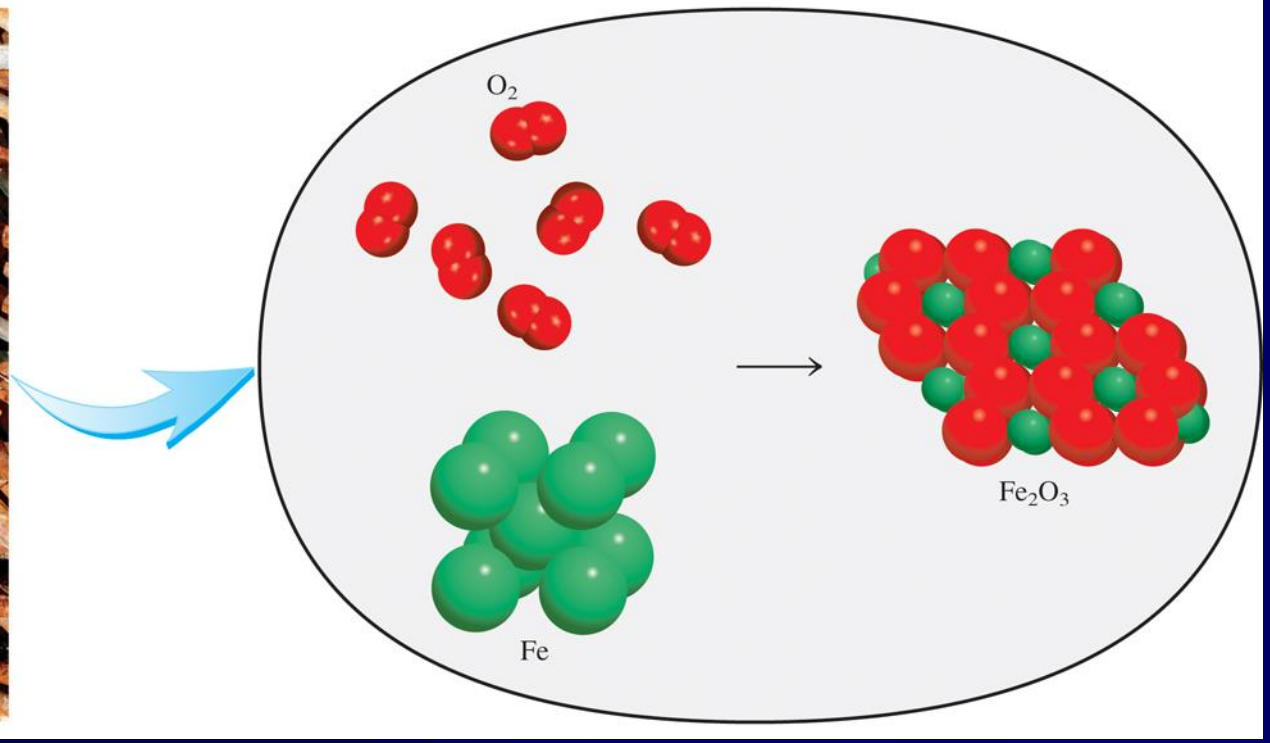
Courtesy, Dr. Milt Gordon

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

1.2 The study of chemistry

Macroscopic

Microscopic

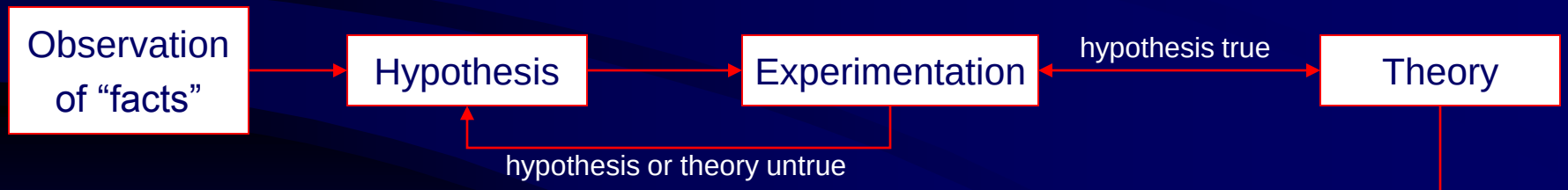


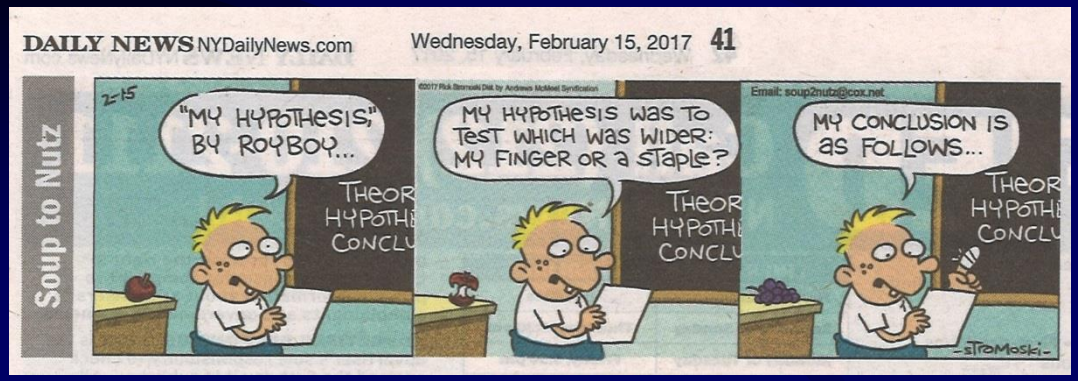
THE BIG SECRET

- Treat chemistry as a second language.
- IF YOU EVER DON'T UNDERSTAND A WORD YOU READ OR A WORD I SAY IN CLASS, LOOK IT UP OR ASK FOR CLARIFICATION.

1.3 How do we know what we know?

- Use of the SCIENTIFIC METHOD
  - A systematic approach to the discovery of new information
  - The testing of HYPOTHESES and THEORIES
  - (as opposed to just believing what “sounds right”)
  - Does not negate the effects of serendipity
    - Penicillin
    - Graphene





Experimentation

- QUALITATIVE analysis- what's it like?
- QUANTITATIVE analysis- how much of it is there?

And when it's not followed…

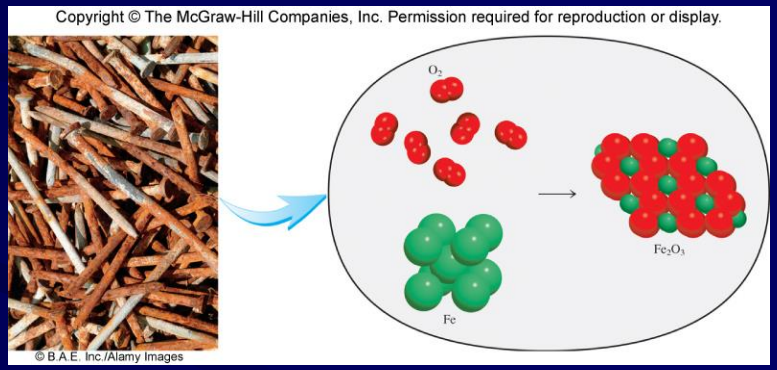
- Cold fusic
- Dr. Oz pr
  - http://www.np cures-in-5-easy-steps
  - http://www.cn
- FOX "new
- Caffeine u
  - http://bigthink -as-science
  - http://blog.doc nated-underwear
  - https://www.ft vear-claims

Scientific method (cont'd)

A ***hypothesis*** is a tentative explanation for a set of observations (facts, data).

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

Atomic Theory



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

Force = mass x acceleration

Question

"The sun rises in the East" is an example of a(n):

A. Observation
B. Hypothesis
C. Theory
D. Law

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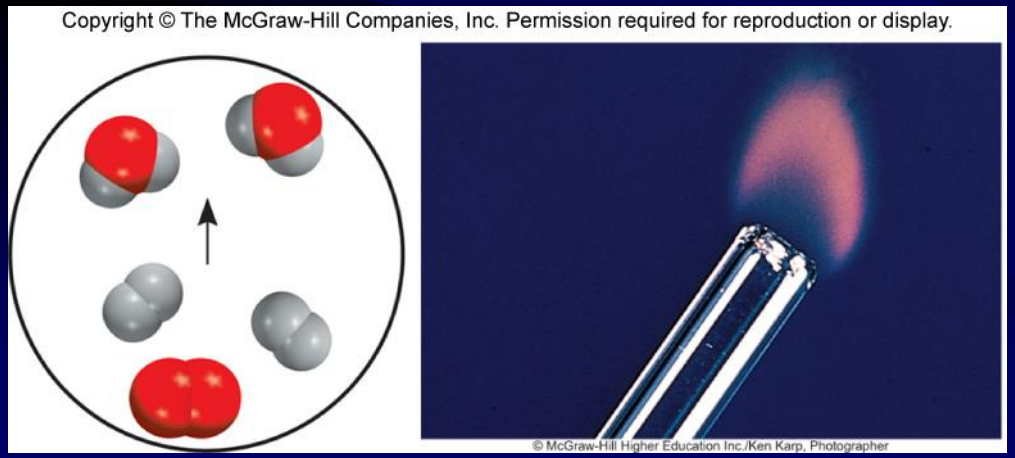
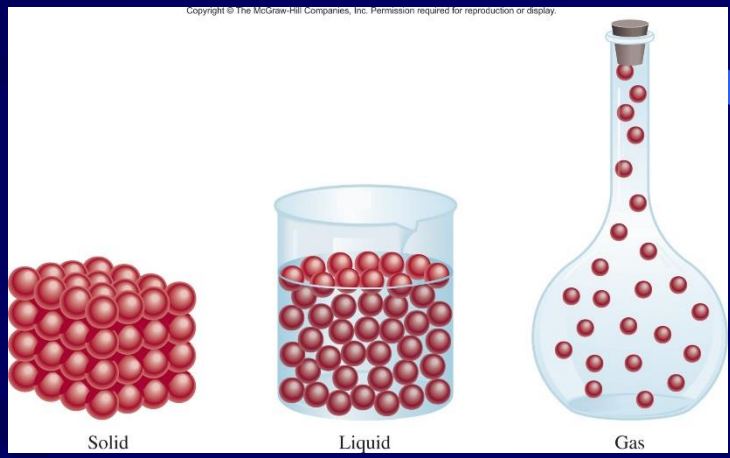
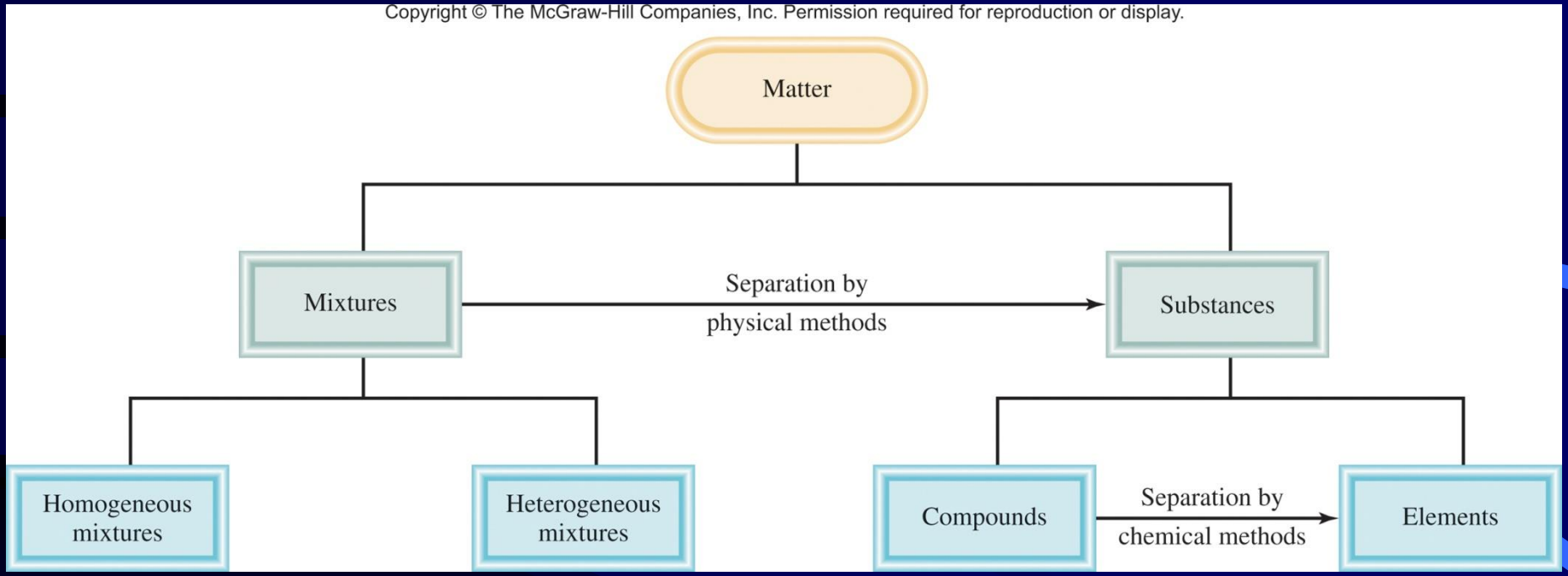
Chapter 1

Section 1.4





1.4 Classification of matter



Classification of matter (cont'd)

- A (pure) **THING/STUFF** is a form of matter that has a definite composition and distinct properties.


liquid nitrogen


gold ingots


silicon crystals

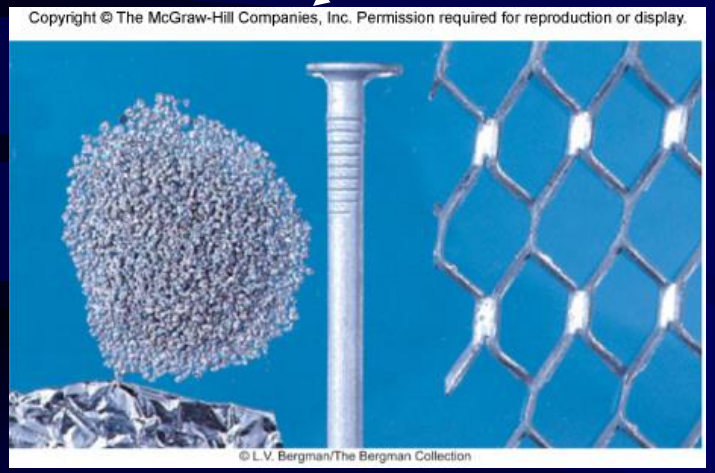
- A MIXTURE is a combination of two or more pure things in which the pure things retain their distinct identities.
  - Homogenous mixture– composition of the mixture is the same throughout (aka– solution)
  - Heterogeneous mixture– composition is not uniform throughout


solder

iron filings in sand

Elements

- An ELEMENT is a (pure) thing that cannot be separated into simpler things by chemical means.
  - 118 elements have been identified
  - 82 elements occur naturally on Earth
    - Ex- gold, aluminum, lead, oxygen, carbon, sulfur



  - 36 elements have been created by scientists
    - Ex- technetium, americium, seaborgium

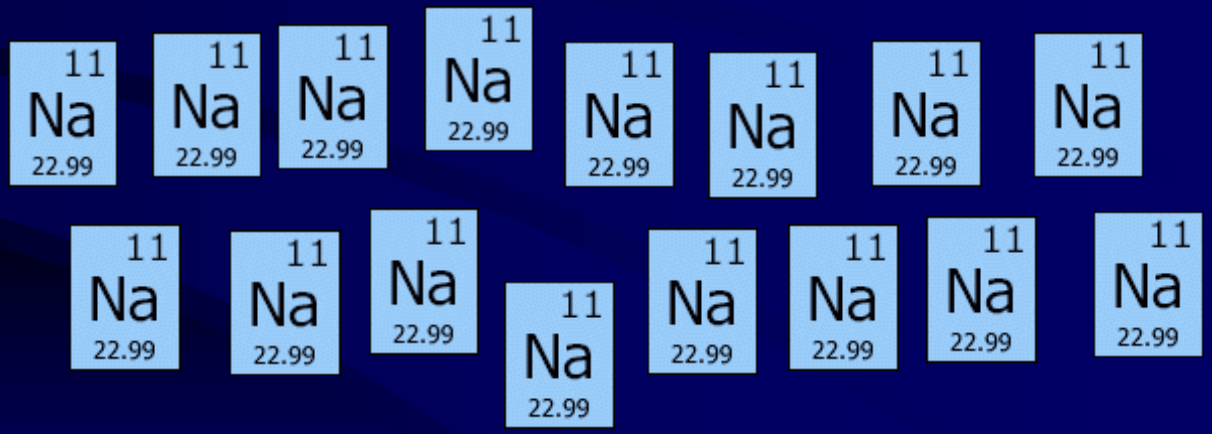
Elements (cont'd)

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

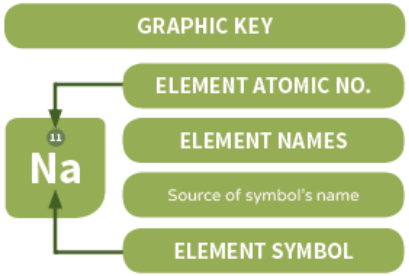
Atomic symbols

- May or may not make sense based on the English name of the element
- *16 sodium atoms walk into a bar, with Batman right behind them…*



CONFUSING ELEMENT SYMBOLS EXPLAINED

Most of the chemical symbols for elements in the periodic table make perfect sense; there are a small selection, however, that seem to bear no relation to their element's name. Here's a look at these rogue symbols, along with explanations of the reasons behind them.



Na — SODIUM – NATRIUM

Arabic – *natrun*

Sodium's Latin name, 'natrium', derives from the Greek 'nítron' (a name for sodium carbonate). Its original source is likely to be the Arabic work 'natrun'. A number of modern languages still call the element natrium instead of sodium.

K — POTASSIUM – KALIUM

Arabic – *al qalīy*

'Kalium' is potassium's Latin name, and derives from the Arabic 'al qalīy', meaning "calcined ashes" (the ashes left over when plant material is burned). As with sodium, a number of modern languages still refer to potassium as kalium.

Fe — IRON – FERRUM

Latin – *ferrum*

Iron's Latin name, 'ferrum', simply means 'iron' or 'sword', and is possibly of Semitic origin. The element is known by a myriad of various names in different languages, with some sources suggesting there are over 200 different names for it.

Cu — COPPER – CUPRUM

Greek – *kypros*

Copper's Latin name was 'cyprium', which itself comes from 'kypros', which is the Greek name for Cyprus. The island of Cyprus was famous centuries ago for its copper reserves. The name was eventually simplified to 'cuprum'.

Ag — SILVER – ARGENTUM

Latin – *argentum*

The Latin name for silver, 'argentum', is thought to derive originally from Indo-European, likely referring to the metal's shininess. The country Argentina is named after silver, and is the only country to be named after a chemical element.

Sn — TIN – STANNUM

Latin – *stannum/stagnum*

Tin's Latin name, 'stannum', may be derived from the Indo-European 'stag' (dripping) because tin melts at a low temperature. There's also speculation it could be derived from the Cornish 'stean' due to Cornwall's famous tin mines.

Sb — ANTIMONY – STIBIUM

Greek – *stíbi*

The Latin 'stibium' derives from the Greek word 'stíbi', meaning eye paint, referring to antimony's use as an ancient eye cosmetic. This is in turn likely derived from Arabic or Egyptian. Few countries refer to antimony as stibium today.

W — TUNGSTEN – WOLFRAM

German – *wolf rahm*

Wolfram was named after the mineral it was found in, wolframite. This is from the German 'wolf rahm', or 'wolf's foam', referring to the amount of tin 'eaten' by the metal during its extraction. Wolfram is still used in several languages.

Au — GOLD – AURUM

Latin – *aurum*

The Latin name for gold was 'aurum', meaning 'yellow', derived from the word 'aurora' ('dawn'). The name 'gold', used in Germanic languages, means 'yellow, shining metal'; many other European languages use derivatives of aurum.

Hg — MERCURY – HYDRARGYRUM

Greek – *hydrargyros*

Mercury's original Latin name was actually 'argentum vivum' (living silver), but Latin later borrowed from the Greek 'hydrargyros' (liquid silver) to give 'hydrargyrum'. The original English name for the element was 'quicksilver'.

Pb — LEAD – PLUMBUM

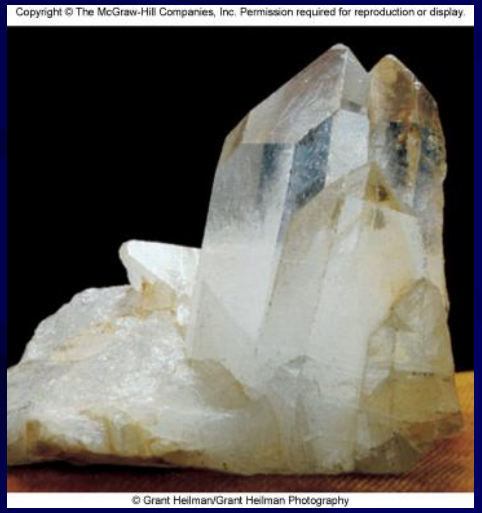
Latin – *plumbum*

Lead's Latin name, 'plumbum', likely originally derives from a language pre-dating Ancient Greek. This Latin name is also the source of the English words 'plumbing' and 'plumber', due to the historic use of lead in water pipes.

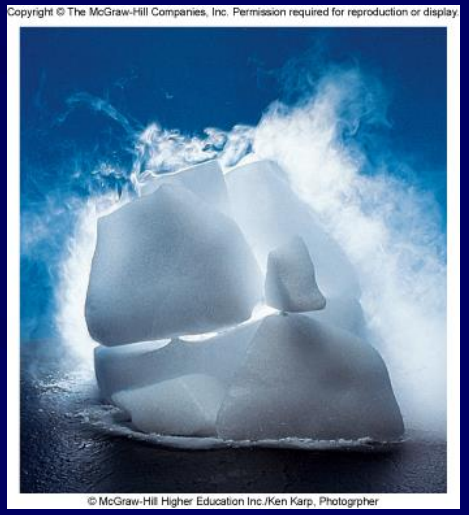
Compounds

- A COMPOUND is a substance composed of atoms of two or more elements chemically united in fixed proportions.
- Compounds can only be separated into their pure components (elements) by chemical means.

lithium fluoride



quartz



dry ice – carbon dioxide

Question:

The liquid in a can of Red Bull® is an example of an:

A. element

B. compound

C. heterogeneous mixture

D. homogeneous mixture

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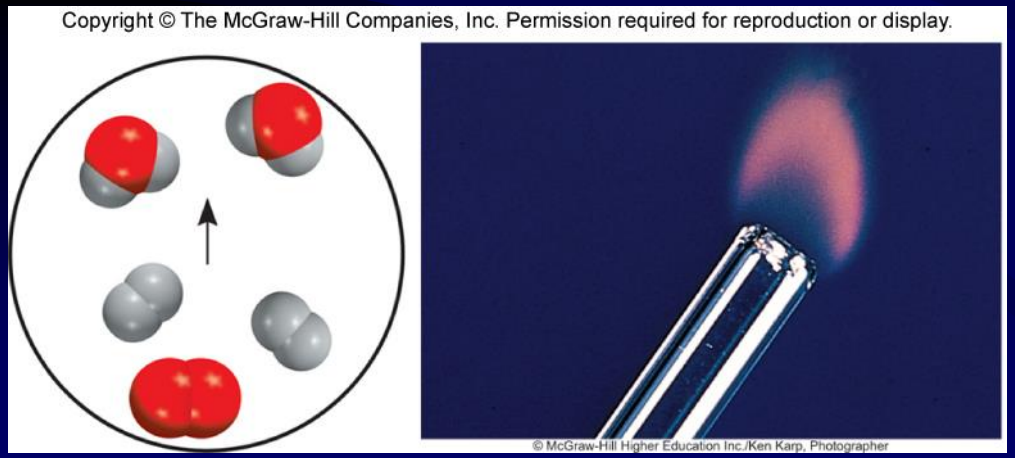
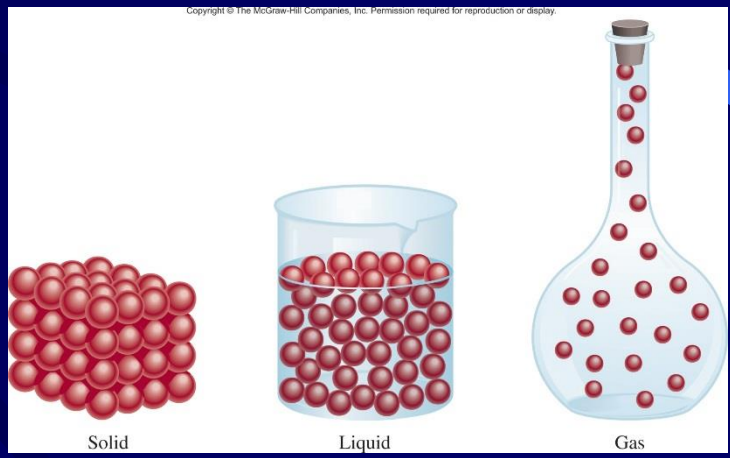
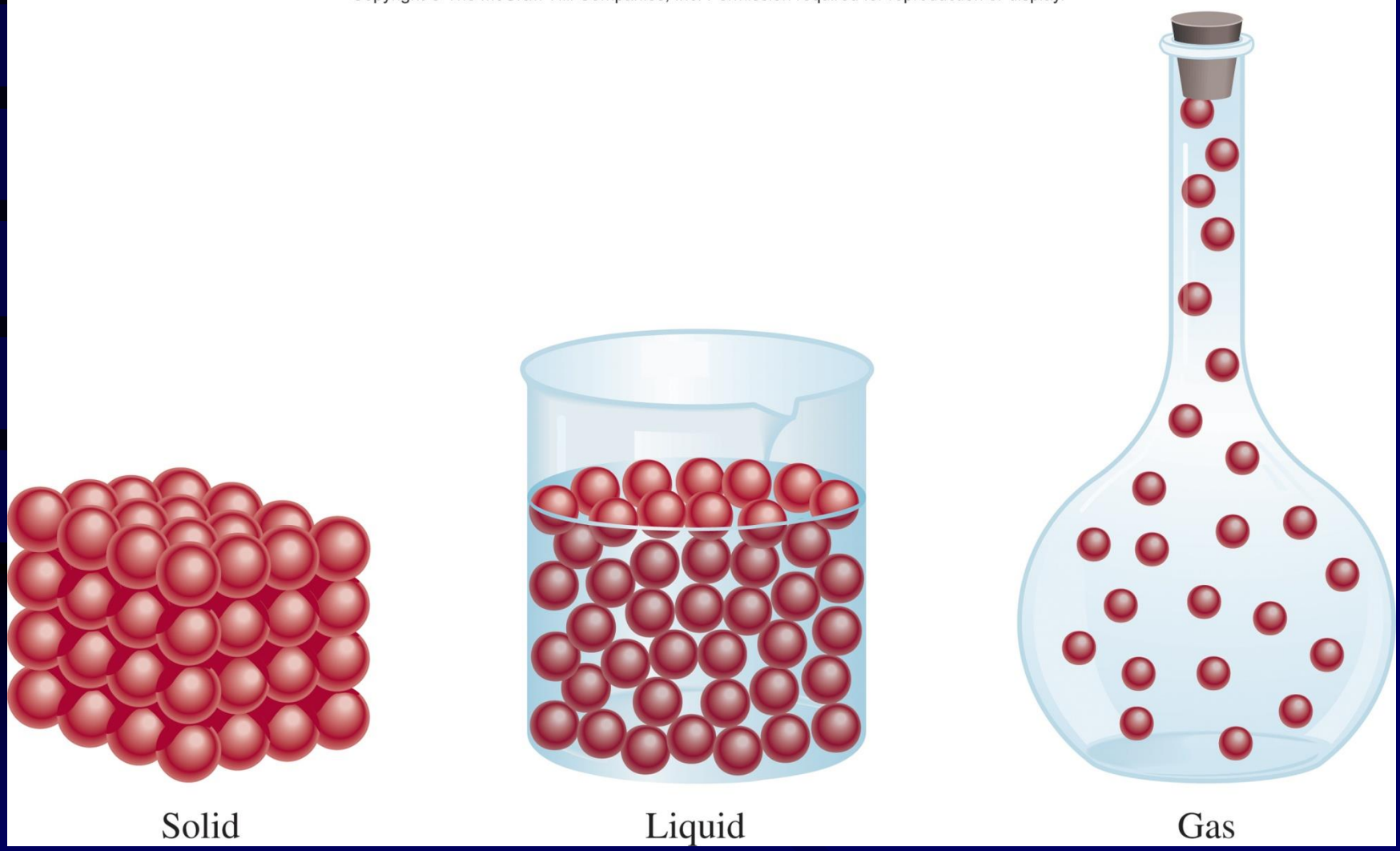
Chapter 1

Section 1.5



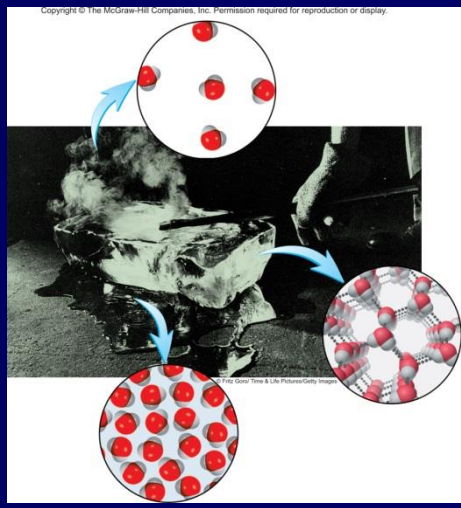


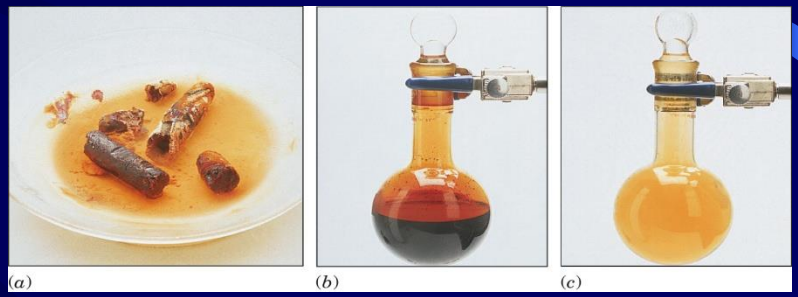
1.5 Overview- the three states of matter



The (three) states of matter

- Gas - particles widely separated
  - Has no definite shape or volume.
  - Expands to fill whatever container it is put into.
  - Is highly compressible.
- Liquid - particles closer together
  - Has no definite shape but a definite volume.
  - Is only slightly compressible.
- Solid - particles are very close together
  - Has a definite shape and volume.
  - Is essentially incompressible.





- Others?
- What determines what state matter will be found in?

Question:

Which form of water has a definite volume, but no definite shape?

a. Ice
b. Liquid water
c. Steam

Question:

Which form of water has molecules that are held together tightly by very strong forces?

a. Ice
b. Liquid water
c. Steam

Question:

Which form of water is compressible?

a. Ice
b. Liquid water
c. Steam

Physical & chemical properties

- PHYSICAL properties can be observed without changing the identity of the element/compound
  - Color
  - Smell (careful!)
  - State
  - Conductivity
- CHEMICAL properties can only be observed by altering the identity of the element/compound
  - Flammability
  - Reactivity with acid or base

Question

- Classify the following as either a chemical or physical property:
  - Color
  - Flammability
  - Hardness

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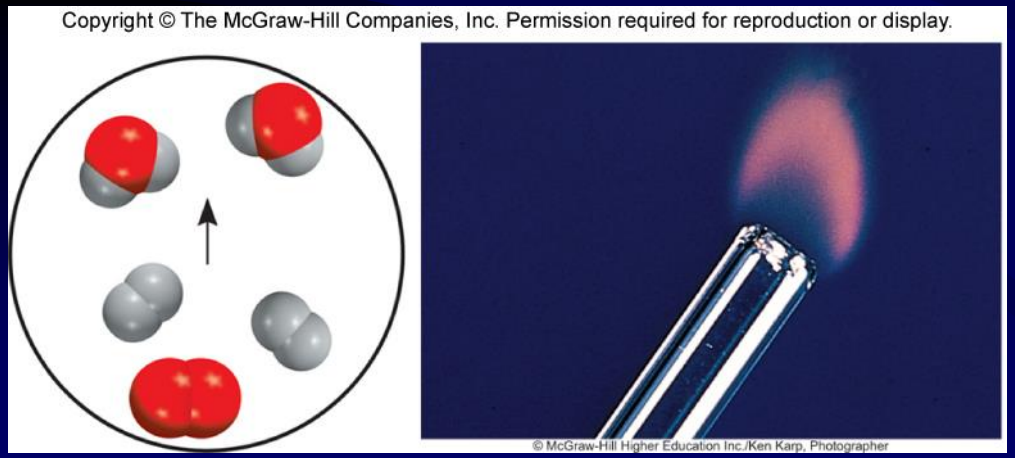
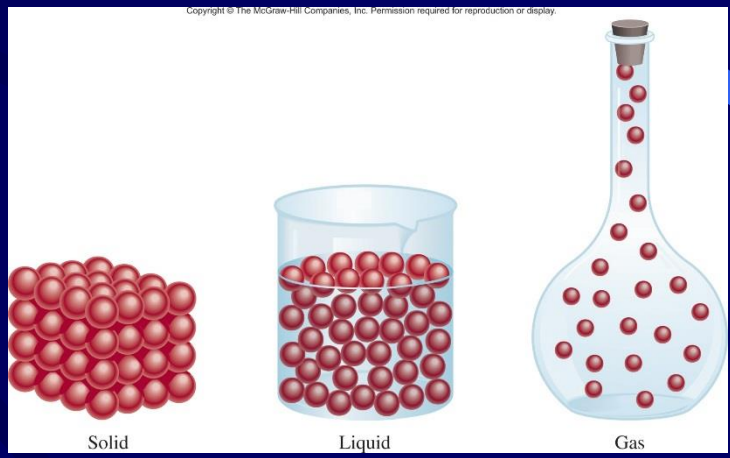
Chapter 1

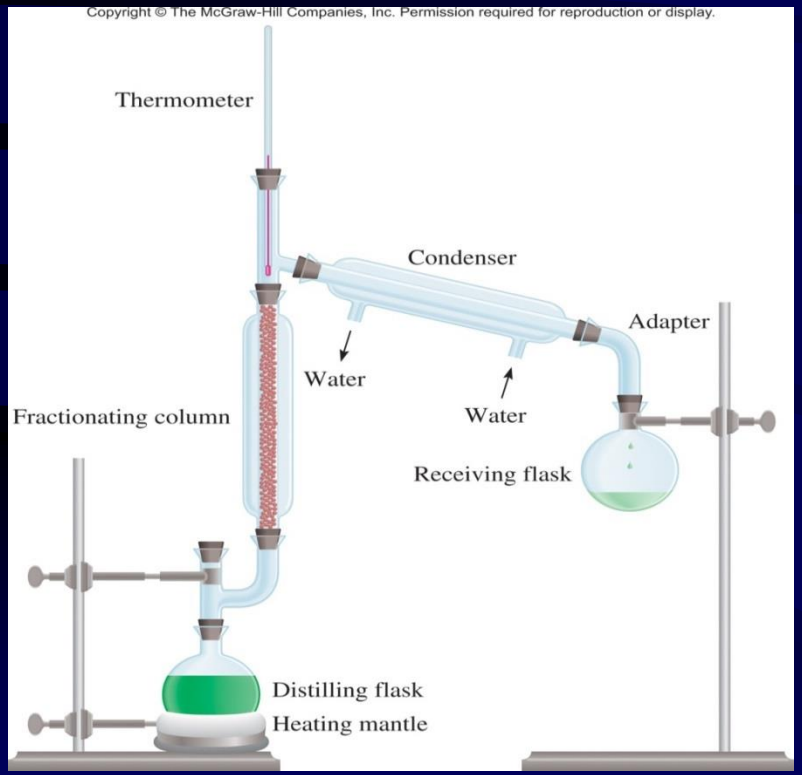
Section 1.6



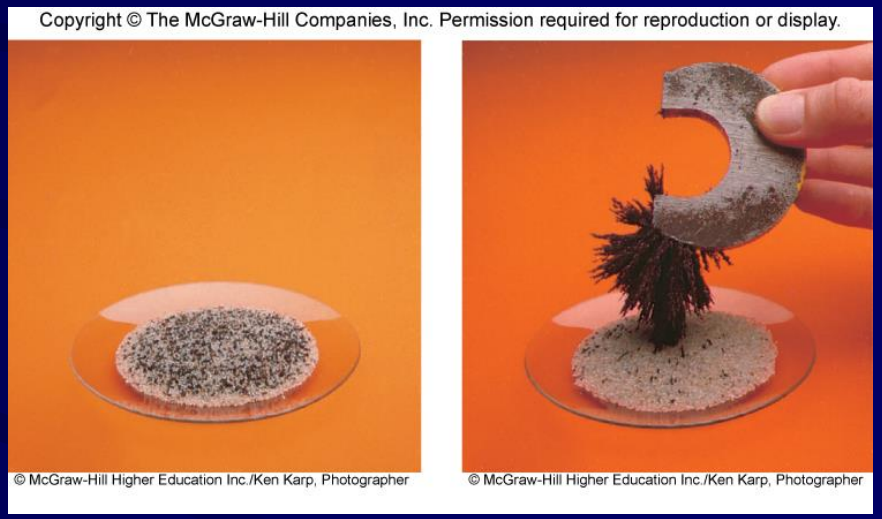


1.6 Separation of a mixture

Physical means (change of state; manual separation) can be used to separate a mixture into its pure components.



distillation



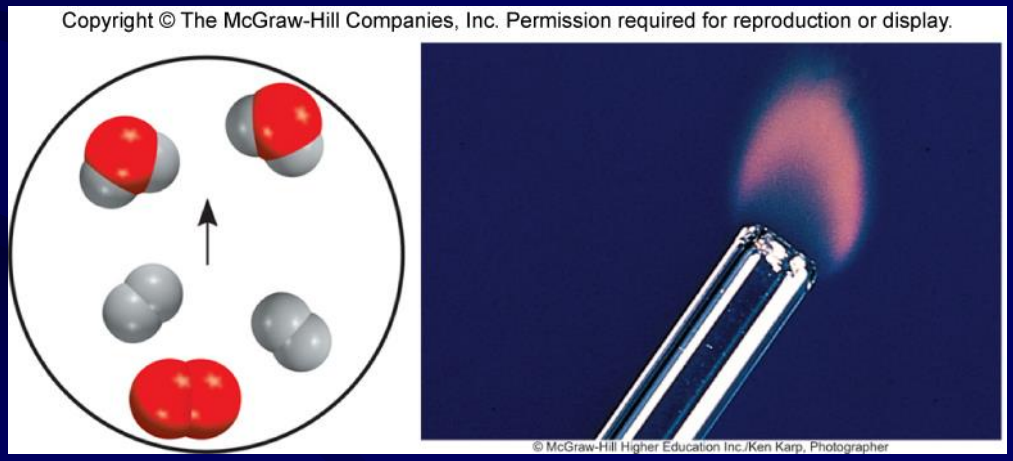
magnet

Types of change

- A PHYSICAL CHANGE does not alter the composition or identity of a substance.
  - Ex: ice melting; sugar dissolving in water

- A CHEMICAL CHANGE alters the composition or identity of the substance(s) involved.

Ex: hydrogen burns in air to form water



Question

- Classify the following as either a chemical or physical change:
  - Boiling water becomes steam
  - Butter turns rancid
  - Burning of wood
  - Mountain snow melting in spring
  - Decay of leaves in winter

Question:

A clear, colorless liquid is heated in a beaker until all of the liquid is gone, at which point you notice that the walls of the beaker are coated with a white crystalline solid. Assuming no chemical reaction took place, the *original* contents of the beaker could be classified as an:

A. element

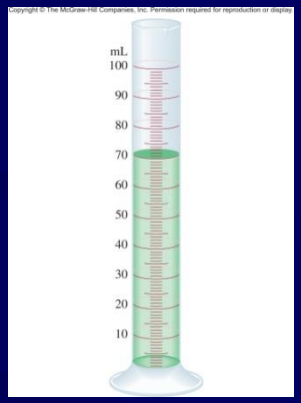
B. compound

C. homogeneous mixture

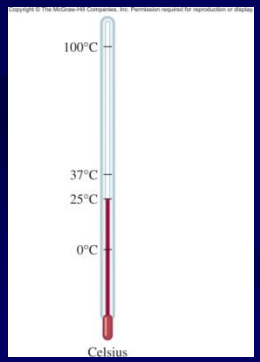
D. heterogeneous mixture

Extensive and intensive properties

- An EXTENSIVE PROPERTY of a material depends upon how much matter is being considered.
  - Mass
  - Length
  - Volume



- An INTENSIVE PROPERTY of a material does not depend upon how much matter is being considered.
  - Density
  - Temperature
  - Color
  - BP/MP



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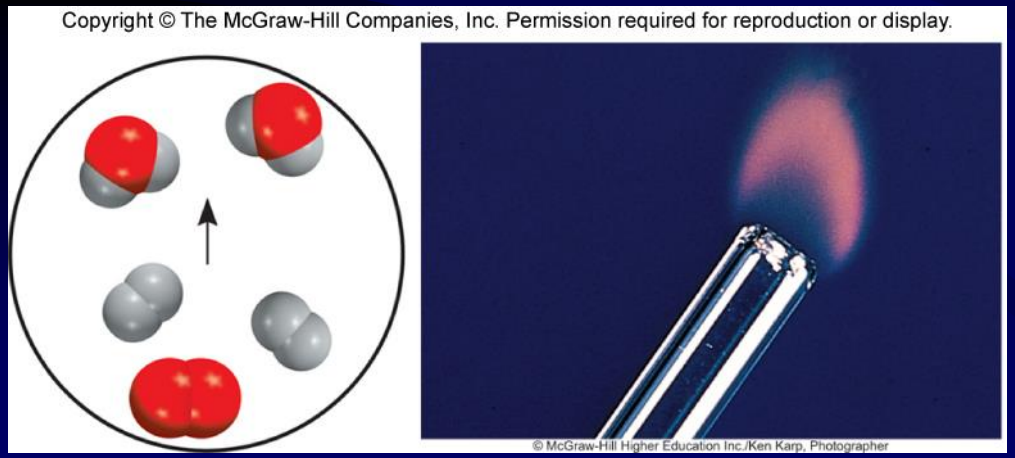
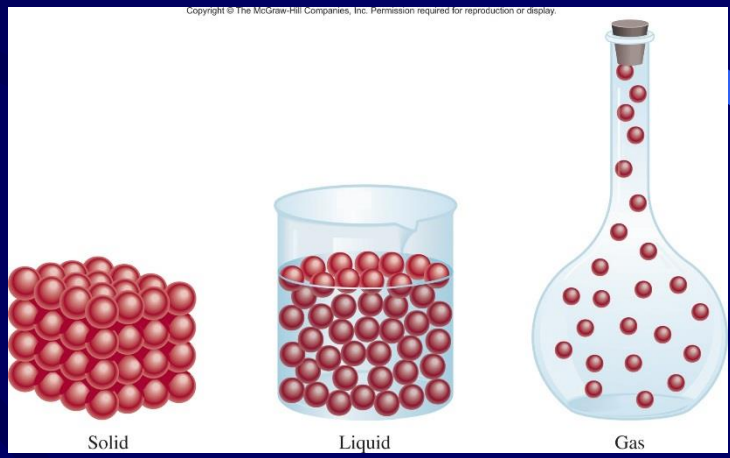
Chapter 1

Section 1.7





1.7 Units of measurement

- Units - the basic quantity of mass, volume or whatever quantity is being measured
  - A measurement is useless without its units
- English system - a collection of functionally unrelated units
  - Difficult to convert from one unit to another
  - Ex: 1 foot = 12 inches = 0.33 yard = 1/5280 miles
- Metric system - composed of a set of systematic units that are related to each other decimally
  - Units relate by powers of ten

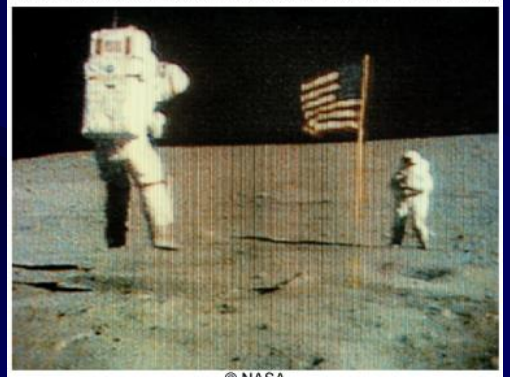
Mass vs. weight

- Reminder: matter is anything that occupies space and has mass.
- MASS– measure of the quantity of matter
  - SI (next slide) 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



© NASA

A 1 kg bar will weigh:

1 kg on earth

0.1 kg on moon

International system of units (SI)

- A common language...
- Sometimes referred to as the MKS system

Table 1.2 SI Base Units

Base Quantity	Name of Unit	Symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
Electrical current	ampere	A
Temperature	kelvin	K
Amount of substance	mole	mol
Luminous intensity	candela	cd

SI prefixes

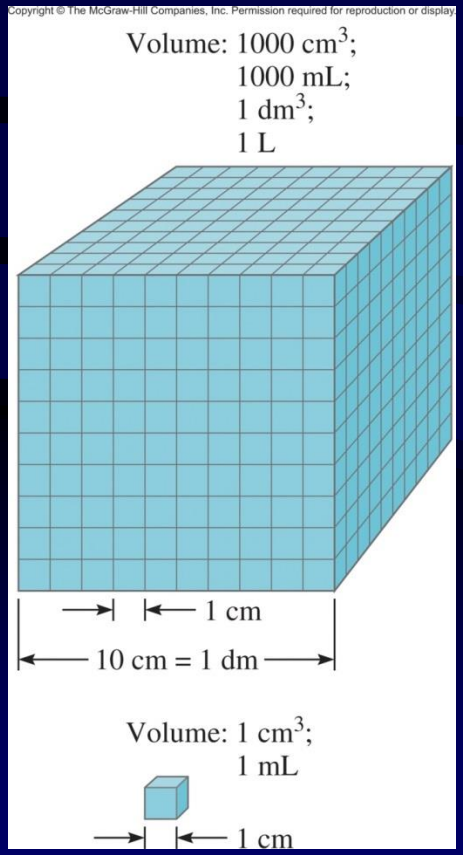
- Used to represent in shorthand very big and/or very small numbers, which come up a LOT in chemistry.

Table 1.3 Prefixes Used with SI Units

Prefix	Symbol	Meaning	Example
tera-	T	1,000,000,000,000, or 10^{12}	1 terameter (Tm) = 1×10^{12} m
giga-	G	1,000,000,000, or 10^{9}	1 gigameter (Gm) = 1×10^{9} m
mega-	M	1,000,000, or 10^{6}	1 megameter (Mm) = 1×10^{6} m
kilo-	k	1,000, or 10^{3}	1 kilometer (km) = 1×10^{3} m
deci-	d	1/10, or 10^{-1}	1 decimeter (dm) = 0.1 m
centi-	c	1/100, or 10^{-2}	1 centimeter (cm) = 0.01 m
milli-	m	1/1,000, or 10^{-3}	1 millimeter (mm) = 0.001 m
micro-	μ	1/1,000,000, or 10^{-6}	1 micrometer (μm) = 1×10^{-6} m
nano-	n	1/1,000,000,000, or 10^{-9}	1 nanometer (nm) = 1×10^{-9} m
pico-	p	1/1,000,000,000,000, or 10^{-12}	1 picometer (pm) = 1×10^{-12} m

Volume

- SI derived unit for volume (the space occupied by an object) is the cubic meter (m^3), though most commonly expressed in L or mL



$1\ cm^3 = (1 \times 10^{-2}\ m)^3 = 1 \times 10^{-6}\ m^3$

$1\ dm^3 = (1 \times 10^{-1}\ m)^3 = 1 \times 10^{-3}\ m^3$

$1\ L = 1000\ mL = 1000\ cm^3 = 1\ dm^3$

$1\ mL = 1\ cm^3 = 1\ cc$

Density

- The SI derived unit for DENSITY (ratio of mass to volume) is kg/m^3

$$d = \frac{m}{V}$$

d = density
m = mass
V = volume

  - Most commonly expressed in g/mL for liquids & solids, and g/L for gases

- $1\ g/cm^3 = 1\ g/mL = 1000\ kg/m^3$
  - Yes, a cubic meter of water (264 gal) weighs 2205 pounds

Table 1.4

Densities of Some Substances at 25°C

Substance	Density (g/cm^3)
Air*	0.001
Ethanol	0.79
Water	1.00
Graphite	2.2
Table salt	2.2
Aluminum	2.70
Diamond	3.5
Iron	7.9
Mercury	13.6
Gold	19.3
Osmium†	22.6

*Measured at 1 atmosphere.
†Osmium (Os) is the densest element known.

Question

Gold is a precious metal that is chemically unreactive.
It is used mainly in jewelry, dentistry, and electronic devices.

A piece of gold ingot with a mass of 301 g has a volume of 15.6 cm^3. Calculate the density of gold.

gold ingots

Solution

Solution We are given the mass and volume and asked to calculate the density. Therefore, we write

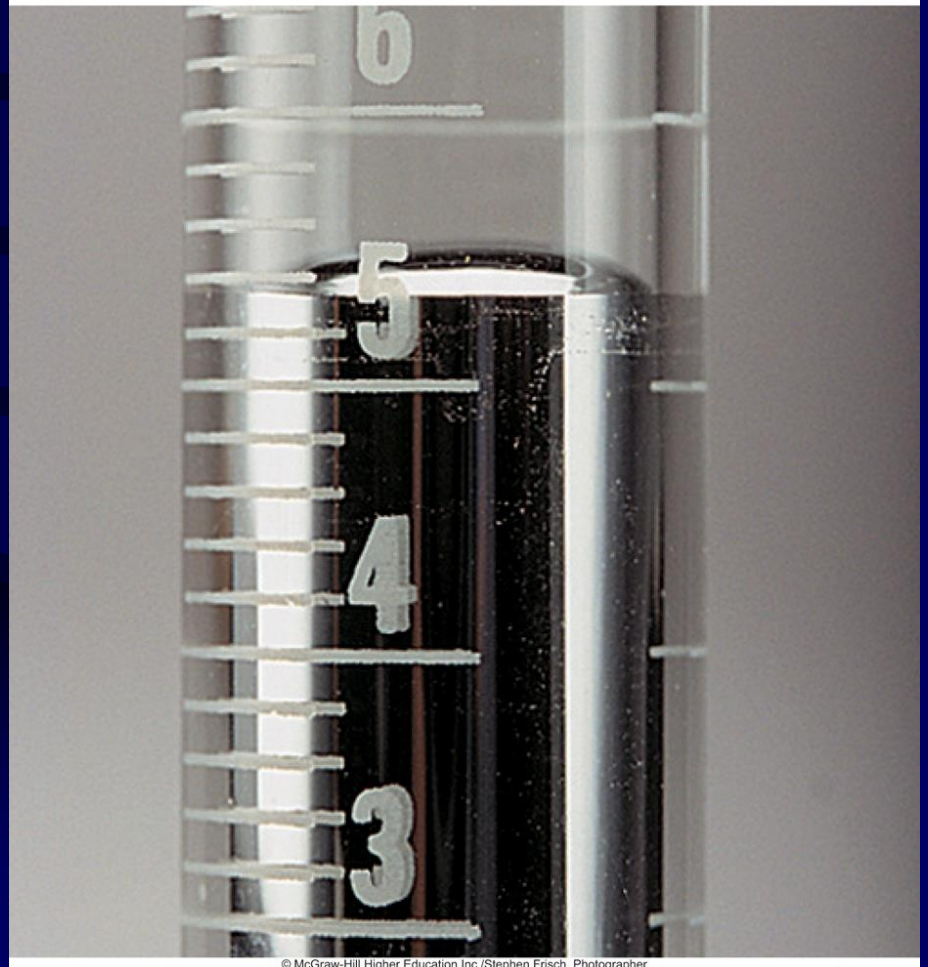
$$d = \frac{m}{V}$$

$$= \frac{301\ \text{g}}{15.6\ \text{cm}^3}$$

$$= 19.3\ \text{g/cm}^3$$

Question

The density of mercury, the only metal that is a liquid at room temperature, is 13.6 g/mL. Calculate the mass of 5.50 mL of the liquid.



Solution

Solution We are given the density and volume of a liquid and asked to calculate the mass of the liquid.

We rearrange to give

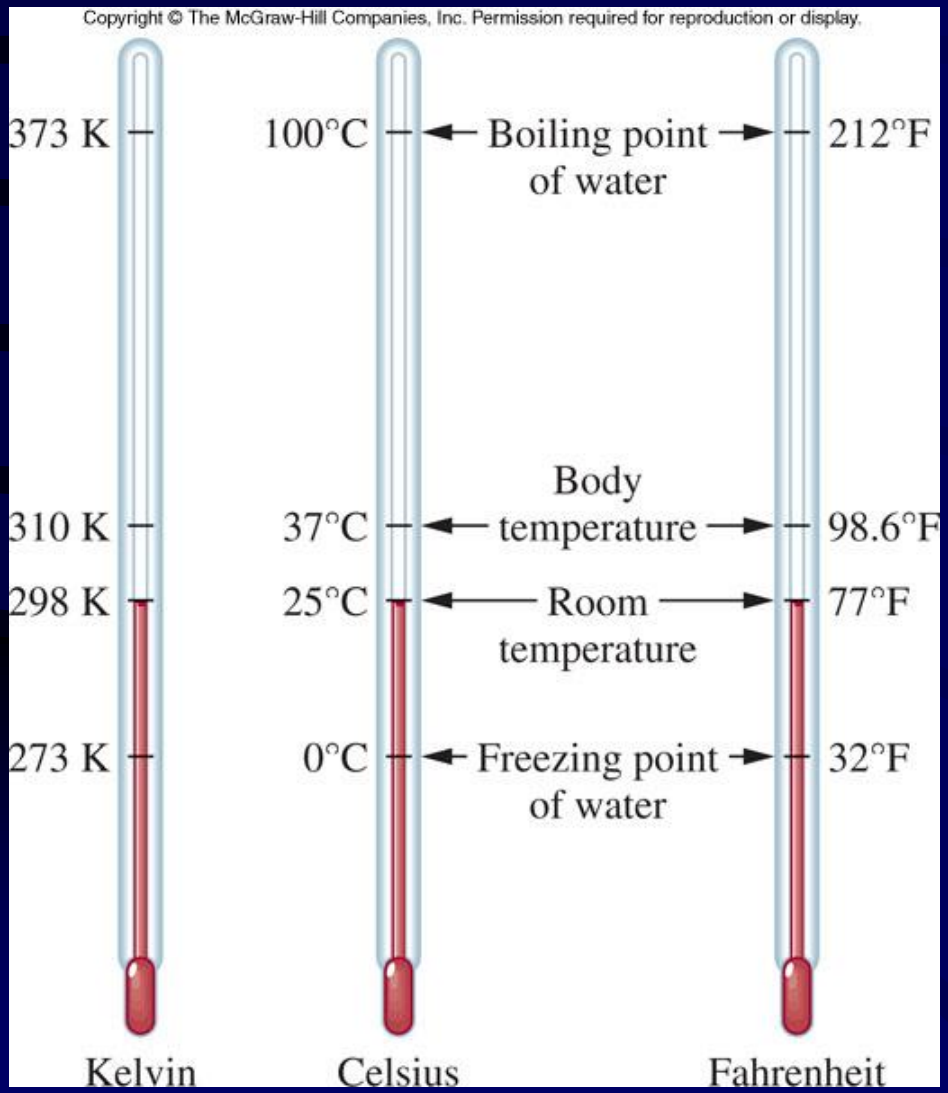
$$m = d \times V$$

$$= 13.6 \frac{\text{g}}{\text{mL}} \times 5.50 \text{ mL}$$

$$= 74.8 \text{ g}$$

Temperature

- A measure of how fast particles are moving



$K = {}^0C + 273.15$

$273.15\ K = 0\ {}^0C$

$373.15\ K = 100\ {}^0C$

$${}^0F = \frac{9}{5} \times {}^0C + 32$$

$32\ {}^0F = 0\ {}^0C$

$212\ {}^0F = 100\ {}^0C$

86°F = 30°C

77°F = 25°C

68°F = 20°C

59°F = 15°C

50°F = 10°C

41°F = 5°C

32°F = 0°C

23°F = −5°C

14°F = −10°C

Craig Nevill-Manning

Question

(a) Solder is an alloy made of tin and lead that is used in electronic circuits. A certain solder has a melting point of 224°C. What is its melting point in degrees Fahrenheit?

(b) Helium has the lowest boiling point of all the elements at -452°F. Convert this temperature to degrees Celsius.

(c) Mercury, the only metal that exists as a liquid at room temperature, melts at -38.9°C. Convert its melting point to Kelvin.

Solution

Solution These three parts require that we carry out temperature conversions. Keep in mind that the lowest temperature on the Kelvin scale is zero (0 K); therefore, it can never be negative.

(a) This conversion is carried out by writing

$$\frac{9^\circ\text{F}}{5^\circ\text{C}} \times (224^\circ\text{C}) + 32^\circ\text{F} = 435^\circ\text{F}$$

(b) Here we have

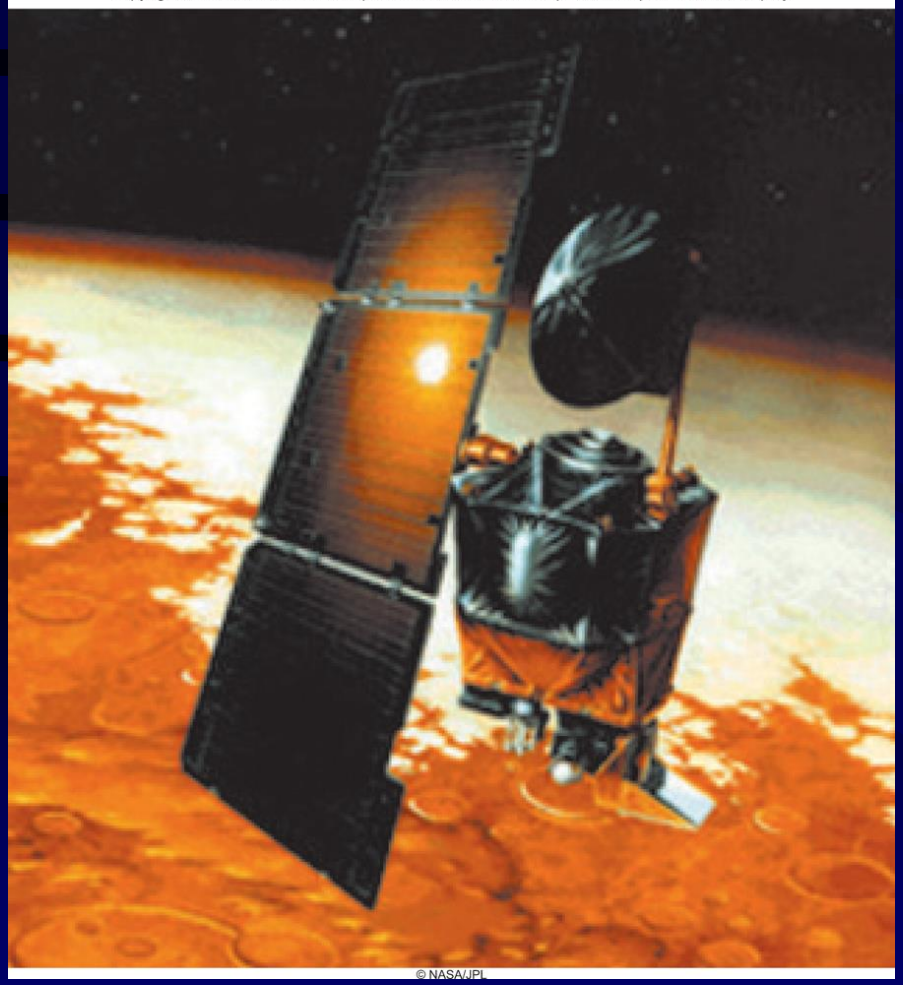
$$(-452^\circ\text{F} - 32^\circ\text{F}) \times \frac{5^\circ\text{C}}{9^\circ\text{F}} = -269^\circ\text{C}$$

(c) The melting point of mercury in Kelvins is given by

$$(-38.9^\circ\text{C} + 273.15^\circ\text{C}) \times \frac{1\ \text{K}}{1^\circ\text{C}} = 234.3\ \text{K}$$

Units, units, units!

On 9/23/99, $125,000,000 Mars Climate Orbiter entered Mars' atmosphere 100 km (62 miles) lower than planned and was destroyed by heat.



1 lb ~~=~~ 1 N

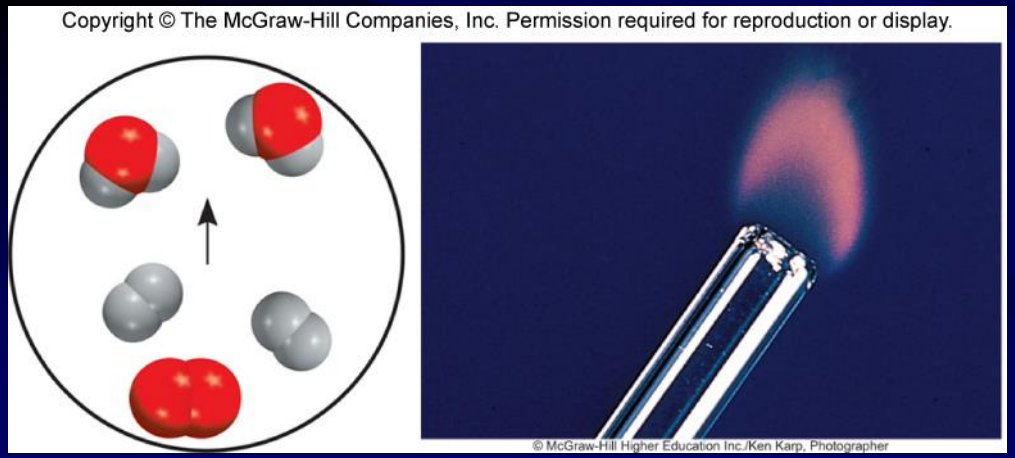
1 lb = 4.45 N

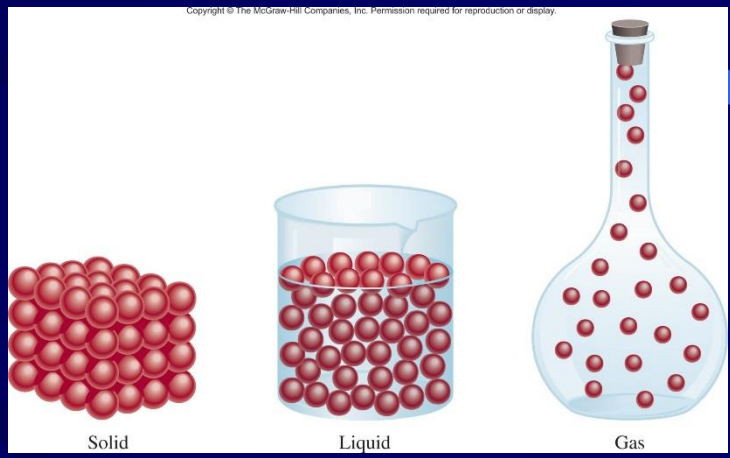
"This is going to be the cautionary tale that will be embedded into introduction to the metric system in elementary school, high school, and college science courses 'til the end of time."

Chemistry 151 - Kolack

Chapter 1

Section 1.8





1.8 Scientific notation

- Used to express very big and/or small numbers, which come up a LOT in chemistry.
- Preview:

The number of atoms in 12 g of carbon:

602,200,000,000,000,000,000,000

6.022×10^{23}

The mass of a single carbon atom in grams:

0.00000000000000000000000199

1.99×10^{-23}

$N \times 10^{n}$

N is a number between 1 and 10

n is a positive or negative integer

Scientific notation & math

568.762

← move decimal left

$n > 0$

$568.762 = 5.68762 \times 10^{2}$

0.00000772

→ move decimal right

$n < 0$

$0.00000772 = 7.72 \times 10^{-6}$

Addition or Subtraction

1. Write each quantity with the same exponent *n*
2. Combine N_1 and N_2
3. The exponent, *n*, remains the same

$4.31 \times 10^{4} + 3.9 \times 10^{3} =$

$4.31 \times 10^{4} + 0.39 \times 10^{4} =$

4.70×10^{4}

Scientific notation & math (cont'd)

Multiplication

1. Multiply N_1 and N_2
2. Add exponents n_1 and n_2

$(4.0 \times 10^{-5}) \times (7.0 \times 10^{3}) =$
$(4.0 \times 7.0) \times (10^{-5+3}) =$
$28 \times 10^{-2} =$
2.8×10^{-1}

Division

1. Divide N_1 and N_2
2. Subtract exponents n_1 and n_2

$8.5 \times 10^{4} \div 5.0 \times 10^{9} =$
$(8.5 \div 5.0) \times 10^{4-9} =$
1.7×10^{-5}

Scientific notation summary

- Chemists like shorthand
- Used to represent very large or small numbers, which are VERY common in chemistry, as powers of 10.
  - Numbers are expressed *showing only the significant digits*
  - eg 171,000 = 1.71×10^{5}
  - eg 0.0092 = 9.2×10^{-3}
  - Exactly 1 digit before the decimal place
- Don't forget your algebra rules, and/or know how to use your calculator!
  - To add/subtract, you need the same exponent
    - $(A \times 10^{x}) + (B \times 10^{x}) = (A + B) \times 10^{x}$
    - $(A \times 10^{x}) + (B \times 10^{y}) = ???$
  - For multiplication
    - $(A \times 10^{x}) \times (B \times 10^{y}) = (A \times B) \times 10^{x+y}$
  - For division
    - $(A \times 10^{x}) / (B \times 10^{y}) = (A / B) \times 10^{x-y}$
  - For exponentials
    - $(A \times 10^{x})^{y} = A^{y} \times 10^{xy}$

Scientific notation in the real world

- The prices of things
- Drug dosage
  - mg/kg vs g/kg
  - “the dose makes the poison”

Significant figures

- Any digit that is not zero is significant

  1.234 kg 4 significant figures

- Zeros between nonzero digits are sig.

  606 m 3 significant figures

5oz (142g)

- Zeros to the left of the first nonzero digit are **not** sig.

  0.08 L 1 significant figure

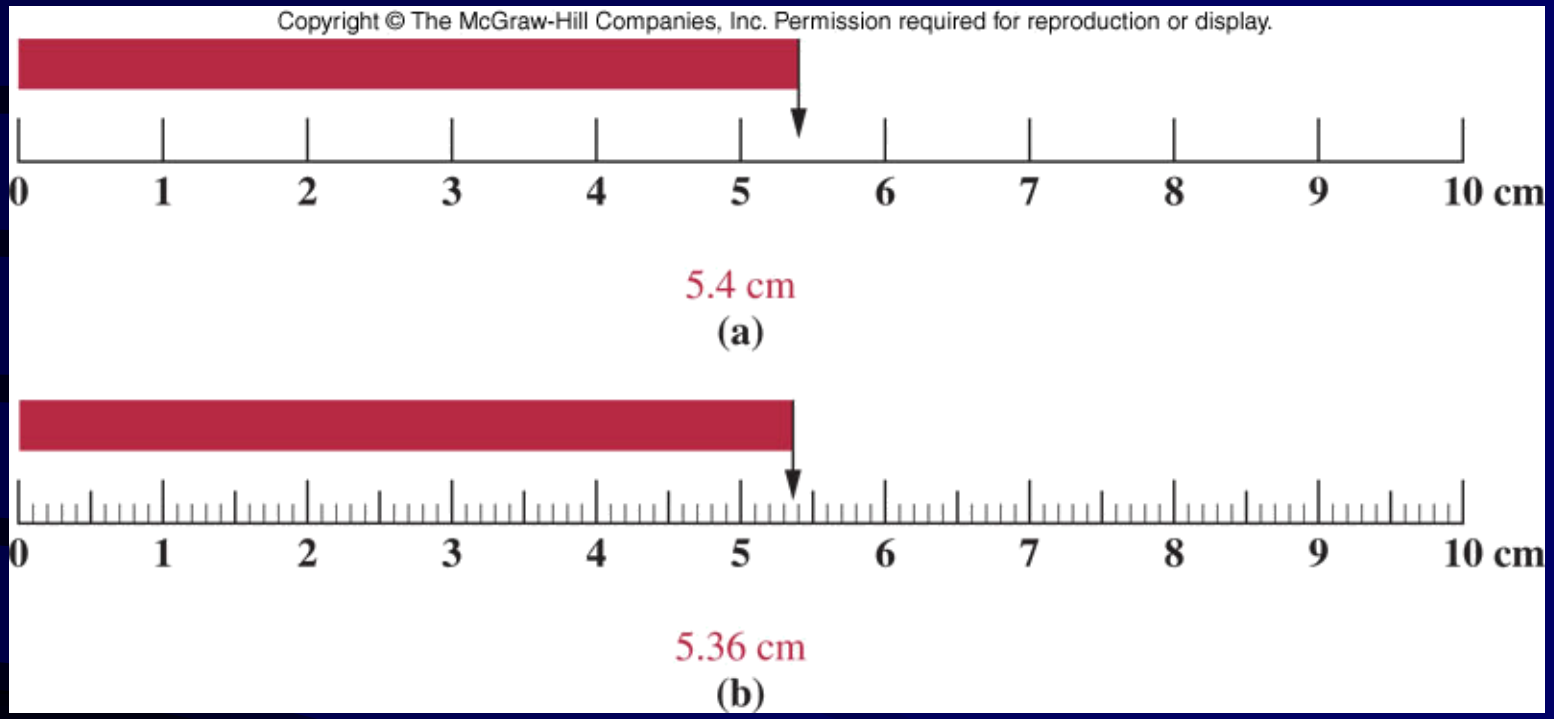
- If a number is greater than 1, then all zeros to the right of the decimal point are significant

  2.0 mg 2 significant figures

- If a number is less than 1, then only the zeros that are at the end and in the middle of the number are sig.

  0.00420 g 3 significant figures

Significant figures in measurements



Significant figures - all digits in a number representing data or results that are known with certainty plus one uncertain digit

Grand vision *Visitors take in Diego Rivera's* Detroit Industry *at the Motor City's Institute of Arts*

JEFF KOWALSKY—GETTY IMAGES; THE WEDDING DANCE, 1566—PIETER BRUEGEL THE ELDER, COURTESY DETROIT INSTITUTE OF ARTS

CITIES

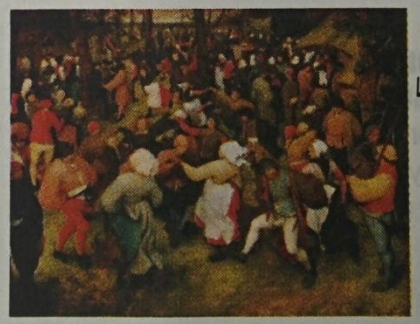
SAVING DETROIT'S ART FROM THE AUCTION BLOCK

In a bankrupt city of such well-documented woes as blighted houses, broken streetlights and persistent crime, few issues have galvanized Detroiters like the possibility that their art museum could be stripped of its treasures.

That prospect became quite real after the city's emergency manager was given the legal authority to explore selling pieces from the Detroit Institute of Arts to help settle the city's nearly $18 billion debt. A Christie's appraisal of the city-owned works pegged their value at $454 million to $867 million, which would—if they were sold—help shore up city retirees' endangered pensions.

To avert that outcome, a group of foundations has been quietly working for months on a deal that would effectively buy the museum from the city, shielding it from future salvage raids. On Jan. 13, the consortium announced pledges of $330 million to do just that. The city would be required to use the money to defray debt and underwrite pensions.

Many hurdles remain. The pledges aren't enough to match Christie's appraisal, and Detroit's creditors are certain to challenge what they view as a lowball valuation of the art. Yet if a deal can be arranged, it will be a rare bright spot for a city sorely in need of one. Nurtured with auto money in Detroit's golden age, the museum is unlikely to be replicated in the current economy for decades, or maybe ever. —MICHELINE MAYNARD



$200 million

Amount that *The Wedding Dance* by Pieter Bruegel the Elder—one of the Detroit Institute of Arts' prized possessions—could potentially fetch at auction, according to a Christie's appraisal

1/27/14 TIME

Significant figures (cont'd)

The 5 Best Parts Of The NY Post's In-Depth Investigation Into Subway's Footlong Subs

NEW YORK POST

Some Subway 'Footlong' subs don't measure up

By KAYLEE OSOWSKI and NATALIE O'NEILL
Last Updated: 10:41 AM, January 17, 2013
Posted: 1:07 AM, January 17, 2013

They deserve a knuckle sandwich.

Stingy Subway sandwich honchos are shorting customers by serving 11-inch "Footlong" subs, hungry New Yorkers say.

The Post discovered that the city's lunchtime crowds are getting short-changed after a muckraking Australian revealed the company's famous "Five-dollar Footlongs" were smaller than advertised.

Four out of seven Footlongs — purchased at Subway locations in Manhattan, Brooklyn and Queens — measured only 11 or 11.5 inches, according to the test.

And that's not the only corner Subway is cutting — the shops have sliced their cold-cut sizes by 25 percent in the past few months, a Manhattan franchise owner told The Post.

"The distributor has increased the food cost on the individual owners by 4 to 5 percent every year and provided the owners with less food," the owner explained.

Smaller heroes and less meat have fired up loyal regulars — who now have a different kind of beef.

"They're cheating us!" said 32-year-old Juan Rivera, who runs a hardware shop in Brooklyn Heights.

He eats Subway every other day with his father — but now he feels betrayed.

"That's foul and misleading. They state it's a foot long, so it should be a foot long!"

His regular Subway shop in Brooklyn Heights — on Montague and Henry streets — sold The Post a $6.75 "Italian BMT" that measured only 11 inches.

And those extra few bites can really add up.

Significant figures (cont'd)

Huge Drill Bit That Almost Hit F Train Was Caused By "Human Error"

F train riders in Queens got a huge scare this week when a 10-inch wide drill bit nearly went through the packed train car. The train was headed to Jamaica, Queens at around 11:45 a.m. Thursday when the drill hit the train car as it left the 21st Street-Queensbridge station.

MTA via WCBS 2

There was some confusion and questions over what caused the incident, but wonder no more: it was human error. "At this point in the investigation, the incident appears to have been caused by human error and doesn't involve equipment malfunction," MTA spokesman Kevin Ortiz told the Daily News.

It seems that the drill's operator, who works for Griffin Dewatering New England Inc.—a subcontractor on the MTA's East Side Access project—broke ground about seven feet from where he was supposed to be. Ortiz added that the operator was "fully qualified to perform his function."

http://gothamist.com/2014/11/01/huge_drill_bit_that_almost_hit_f_tr.php

Question

Determine the number of significant figures in the following measurements:

(a)478 cm

(b)6.01 g

(c)0.825 m

(d)0.043 kg

(e)1.310×10^{22} atoms

(f)7000 mL

Solution

(a) 478 cm – Three, because each digit is a nonzero digit.

(b) 6.01 g – Three, because zeros between nonzero digits are significant.

(c) 0.825 m – Three, because zeros to the left of the first nonzero digit do not count as significant figures.

(d) 0.043 kg – Two. Same reason as in (c).

(e) 1.310×10^{22} atoms – Four, because the number is greater than one so all the zeros written to the right of the decimal point count as significant figures.

(f) 7000 mL – This is an ambiguous case. The number of significant figures could be four (7.000×10^3), three (7.00×10^3), two (7.0×10^3), or one (7×10^3). It should be written in scientific notation to remove the ambiguity.

Significant figures & math

Addition or Subtraction

The answer cannot have more digits to the right of the decimal point than any of the original numbers.

89.332
+1.1 ⟵ one significant figure after decimal point
90.432 ⟵ round off to 90.4

3.70 ⟵ two significant figures after decimal point
-2.9133
0.7867 ⟵ round off to 0.79

Significant figures & math (cont'd)

Multiplication or Division

The number of significant figures in the result is set by the original number that has the ***smallest*** number of significant figures.

$$4.51 \times 3.6666 = 16.536366 = 16.5$$

3 sig figs

round to 3 sig figs

$$6.8 \div 112.04 = 0.0606926 = 0.061$$

2 sig figs

round to 2 sig figs

Exact numbers

Exact Numbers

Numbers from definitions or numbers of objects are considered to have an infinite number of significant figures.

The average of three measured lengths: 6.64, 6.68 and 6.70?

$$\frac{6.64 + 6.68 + 6.70}{3} = 6.67333 = 6.67 = \cancel{7}$$

Because 3 is an ***exact number***

Question

Carry out the following arithmetic operations to the correct number of significant figures:

(a)11,254.1 g + 0.1983 g

(b)66.59 L − 3.113 L

(c)8.16 m × 5.1355

(d) 0.0154 kg ÷ 88.3 mL

(e) 2.64×10^3 cm + 3.27×10^2 cm

Solution

In addition and subtraction, the number of decimal places in the answer is determined by the number having the lowest number of decimal places. In multiplication and division, the significant number of the answer is determined by the number having the smallest number of significant figures.

(a)

11,254.1 g
\+ 0.1983 g

11,254.2983 g ⟵ round off to 11,254.3 g

(b)

66.59 L
\- 3.113 L

63.477 L ⟵ round off to 63.48 L

Solution (cont'd)

(c) $8.16\ \text{m} \times 5.1355 = 41.90568\ \text{m} \longleftarrow$ round off to 41.9 m

(d) $$\frac{0.0154\ \text{kg}}{88.3\ \text{mL}} = 0.000174405436\ \text{kg/mL} \leftarrow \text{round off to}$$

$$0.000174\ \text{kg/mL}$$

$$\text{or } 1.74 \times 10^{-4}\ \text{kg/mL}$$

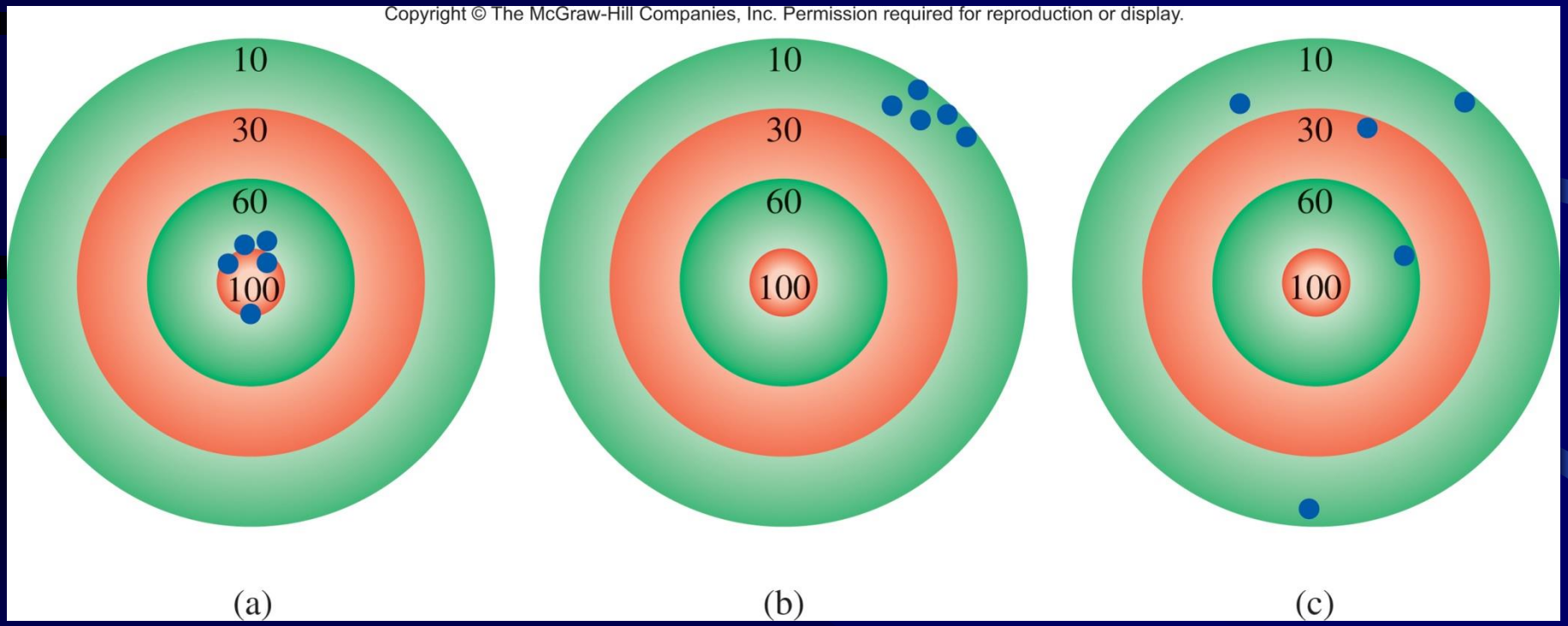
(e) First we change 3.27×10^2 cm to 0.327×10^3 cm and then carry out the addition (2.64 cm + 0.327 cm) $\times 10^3$. Following the procedure in (a), we find the answer is 2.97×10^3 cm.

Accuracy and precision

Accuracy – how close a measurement is to the *true* value

Precision – how close a set of measurements are to each other

(also refers to how many decimal places an instrument measures to)

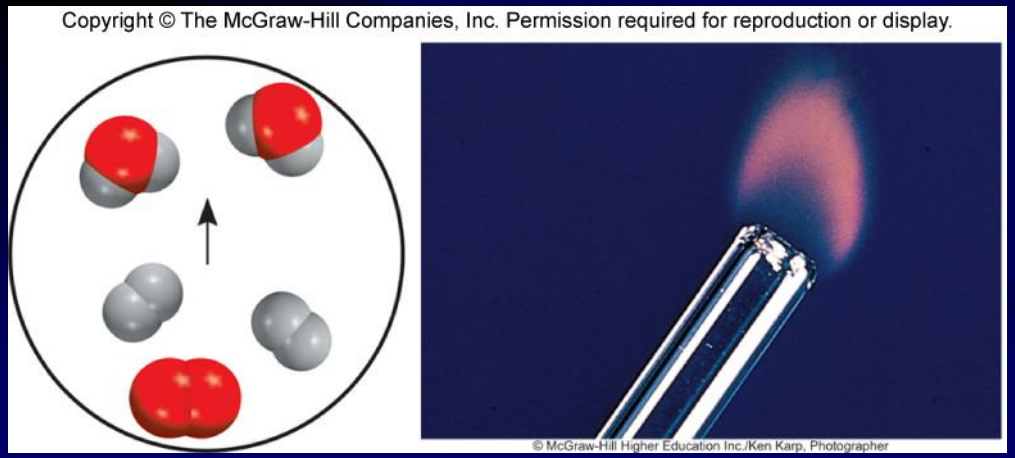


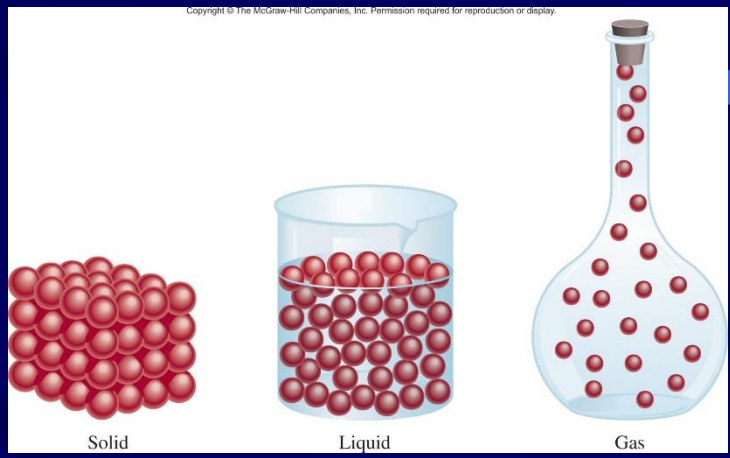
accurate & precise	precise but not accurate	not accurate & not precise

Chemistry 151 - Kolack

Chapter 1

Sections 1.9-1.10





1.9 Dimensional analysis

- Find the numbers & units of the givens and the unit of the answer desired.
- Carry units through the calculation.
- If all units cancel except for the ***desired unit(s)***, then the problem was solved correctly.

given quantity x conversion factor = desired quantity

$$\text{given unit} \times \frac{\text{desired unit}}{\text{given unit}} = \text{desired unit}$$

- MANTRA- if your units are right, your answer is right!

Dimensional analysis proof

- Since 1in=2.54cm, if you divide both sides by 2.54cm:
  (1in/2.54cm)=(2.54cm/2.54cm)
  then
  (1in/2.54cm)=1
  and anything times 1 is itself, so this can be used as a CONVERSION FACTOR (a ratio of two different units, used as a multiplier to change from one system or unit to another)!

Question

A person's average daily intake of glucose (a form of sugar) is 0.0833 pound (lb). What is this mass in milligrams (mg)?
(1 lb = 453.6 g.)

Solution

The sequence of conversions is

$$\text{pounds} \longrightarrow \text{grams} \longrightarrow \text{milligrams}$$

Using the following conversion factors

$$\frac{453.6\ \text{g}}{1\ \text{lb}} \quad \text{and} \quad \frac{1\ \text{mg}}{1 \times 10^{-3}\ \text{g}}$$

we obtain the answer in one step:

$$?\ \text{mg} = 0.0833\ \cancel{\text{lb}} \times \frac{453.6\ \cancel{\text{g}}}{1\ \cancel{\text{lb}}} \times \frac{1\ \text{mg}}{1 \times 10^{-3}\ \cancel{\text{g}}} = 3.78 \times 10^{4}\ \text{mg}$$

(I think the need for a “plan” is greatly overstated in your textbook...)

1.10 Does the answer make sense?

It's always a good idea to check!!!

As an estimate, we note that 1 lb is roughly 500 g and that 1 g = 1000 mg. Therefore, 1 lb is roughly 5×10^5 mg.

Rounding off 0.0833 lb to 0.1 lb, we get 5×10^4 mg, which is close to the preceding quantity.

Question

An average adult has 5.2 L of blood. What is the volume of blood in m^3?

Solution

We need two conversion factors here: one to convert liters to cm^3 and one to convert centimeters to meters:

$$\frac{1000\ cm^3}{1\ L} \quad \text{and} \quad \frac{1 \times 10^{-2}\ m}{1\ cm}$$

Because the second conversion factor deals with length (cm and m) and we want volume here, it must therefore be cubed to give

$$\frac{1\times10^{-2}\ m}{1\ cm} \times \frac{1\times10^{-2}\ m}{1\ cm} \times \frac{1\times10^{-2}\ m}{1\ cm} = \left(\frac{1\times10^{-2}\ m}{1\ cm}\right)^3$$

This means that $1\ cm^3 = 1 \times 10^{-6}\ m^3$.

Thus,

$$?\ m^3 = 5.2\ \cancel{L} \times \frac{1000\ cm^3}{1\ \cancel{L}} \times \left(\frac{1\times10^{-2}\ m}{1\ cm}\right)^3 = 5.2\times10^{-3}\ m^3$$

Question

Liquid nitrogen is obtained from liquefied air and is used to prepare frozen goods and in low-temperature research.

The density of the liquid at its boiling point (−196°C or 77 K) is 0.808 g/cm^3. Convert the density to units of kg/m^3.

liquid nitrogen

Solution

We saw that 1 cm^3 = 1 $\times 10^{-6}$ m^3. The conversion factors are

$$\frac{1\ kg}{1000\ g} \quad \text{and} \quad \frac{1\ cm^3}{1\times 10^{-6}\ m^3}$$

Finally

$$?\ kg/m^3 = \frac{0.808\ \cancel{g}}{1\ \cancel{cm^3}} \times \frac{1\ kg}{1000\ \cancel{g}} \times \frac{1\ \cancel{cm^3}}{1\times 10^{-6}\ m^3} = 808\ kg/m^3$$

Does the answer make sense? Because 1 m^3 = 1 × 10^6 cm^3, we would expect much more mass in 1 m^3 than in 1 cm^3. Therefore, the answer is reasonable.

Weather to aid in recovery from the Blizzard of 2016

January 25, 2016; 9:51 AM ET

Monday Morning

The blizzard that dropped 18 to 42 inches from West Virginia to the New York City area has moved way out into the North Atlantic. In New York City alone, just over 105 billion pounds of snow came down. The calculation was made by using the precipitation total of 2.32 inches (which produced just over 26 inches of snow). I have these values calculated on a spreadsheet using each city's area. On a 10 ft by 10 ft section of driveway in New York City, the snow weighed just over 1,200 pounds.

There is one area of controversy in snow measurement. Official measurements are taken

- Is the Accuweather® story correct?
- Givens:
  ~26” snow = 2.32” rain
  1 gal = 231 in^3
  1 gal water = 8.33 lb
  NYC = 304.6 mi^2
- Could calculate 0.03606 lb/in^3, but why bother?
- What are we starting with, and what are we looking for?
- http://www.accuweather.com/en/weather-blogs/abrams/monday-morning-january-25-2016/55004462

$$\frac{2.32in}{} \left| \frac{304.6mi^2}{} \right| \frac{5{,}280ft}{1mi} \left| \frac{5{,}280ft}{1mi} \right| \frac{12in}{1ft} \left| \frac{12in}{1ft} \right| \frac{1gal}{231in^3} \left| \frac{8.33lb}{1gal} \right| = \frac{102{,}301{,}321{,}199.616\ lb}{}$$

$$= \underline{102 \text{ billion lb}}$$

Question

- Let's say it's 12 miles from your house to your job. How much faster (min, sec) can you get to work if you could drive 55mph instead of 40mph behind that #*&!$% jerk in the fast lane?

Finis

- Thus endeth Chapter 1.
- Be sure you have read the chapter.
- Do the homework!!
- Come to office hours with questions.