Chemistry 151

- Professor James H. Geiger
- Office: Chemistry Building, Room 9
- Office Hours: 1:30-2:30 PM MWF, and other times by appointment (send me an email).
- You can also drop by, but I might be busy.
- Email: geigerj@msu.edu

- Course website: google cem151 msu

Textbooks/other help

- **Textbooks**
- **An on-line version can be purchased from the publisher.**

  www.MasteringChemistry.com bundled with the on-line homework.

  You can also get the e version at the book store Brown, LeMay, and Bursten, Chemistry, the Central Science, 10th, 11th, 12th and 13th, editions

- **The same text will be used for CEM 152 in the spring semester.**
- **The 10th edition is stocked by campus bookstores. Also, it can be ordered from Amazon.com, barnesandnoble.com, or directly from the publisher.**
- **Lecture notes will be available on the web.**

On line homework

- Can be purchased masteringchemistry.com
- Will be required, is a big part of your grade
- Many of the problems are mini tutorials
- Make sure you do the introduction problem set, it is for credit as well.

Registering for Mastering Chemistry, What You Need:

A valid email address

A student access code

(Comes in the Student Access Code Card/Kit that may have been packaged with your new textbook or that may be available separately in your school's bookstore. Otherwise, you can purchase access online at www.masteringchemistry.com.)

The ZIP or other postal code for your school: 48825

A Course ID: cem1512016

1. Register

• Go to www.masteringchemistry.com and click **Students** under **Register.**

• To register using the student access code inside the MasteringChemistry Student Access Code Card/Kit,

select **Yes, I have an access code. Click Continue.**

–OR– *Purchase access online: Select* ***No, I need to purchase access online now.***

Select your textbook (Brown and Lamay Chemistry The Central Science 13th edition)

eText? •

License Agreement and Privacy Policy: Click I Accept

Pay.

2. Log In

• Go to www.masteringchemistry.com.

• Enter your Login Name and Password that you specified during registration and click **Log In.**

3. Join Your Instructor's Online Course and/or Open Self-Study Resources

Upon first login, you'll be asked to do one or more of the following:

• **Join a Course by entering the MasteringChemistry Course ID provided by your instructor. (cem1512016)**

you will be asked for a Student ID (follow on-screen instructions).

• **Explore the Study Area or Launch Your eText, if these resources are available for your textbook.**

To Access MasteringChemistry Again Later

Simply go to www.masteringchemistry.com, enter your Login Name and Password, and click **Log In.**

After you have joined a course: You can open any assignments from the ***Assignments Due Soon area or from the***
Assignments page. For self-study, click eText or Study Area, if these options are available.

Mastering continued

- Access Customer Support at
- http://www.masteringchemistry.com/support,
- where you will find:
- • System Requirements
- • Answers to Frequently Asked Questions
- • Registration Tips & Tricks video
- • Additional contact information for Customer Support, including Live Chat

Course organization

- Lectures MWF 12:40-1:30 pm (me)

  Recitation once a week (check your schedule). Small class, more individual help from Teaching assistants. Each section = 1 recitation group.

No Recitation this week.

They start next week.

This week only come to class WF 12:40-1:30 pm.

Grades

- Four exams (135 points/exam)x4 = 540 points
- On-line homework (180 points) (Mastering Chemistry)
- Some quizzes (50 points total).
- Recitation (50 points, can miss 3)
- **There will be no makeups.**
  - **quiz problems *will be directly copied from homework problems,* except the numerical values will be changed such that the numerical answer is different.**

Final exam (180 points). Will be given on exam week.

How to succeed:

- Attend lecture and recitation
- Do homework problems
- Do extra problems if you think you need them
- ***Being able to do the problems is key***
- Understand the concepts from lecture.

Lectures

- Will follow the book closely
- Example problems will be a key part.

Topics to be covered

First 9 chapters, Chapter 24 and 25 (10th ed.)

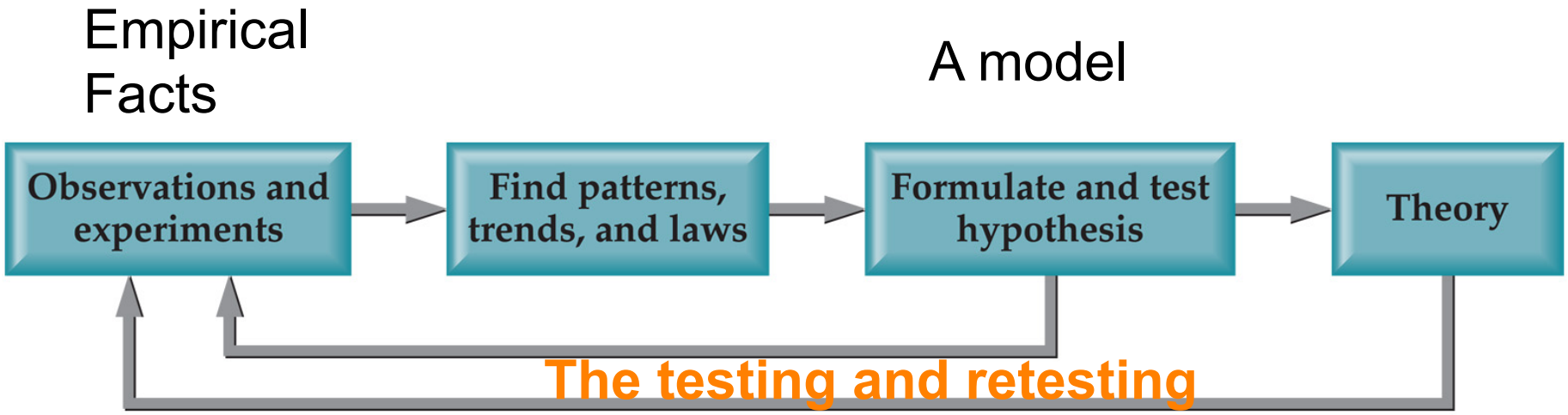
Chap 1 matter and measurement

- Chap 2, Atoms, molecules and Ions
- Chap 3 Stoichiometry, The Mole!
- Chap 4, reactions in water and solution stoichiometry
- Chap 5, Thermochemistry
- Chap 6, Electronic structure, atoms
- Chap 7, The periodic table
- Chap 8, Chemical bonding
- Chap 9, Molecular geometry
- Chap 24, Coordination chemistry
- Chap 25, Organic and biological chemistry

Chapter 1
Introduction:
Matter and Measurement

Scientific Method:

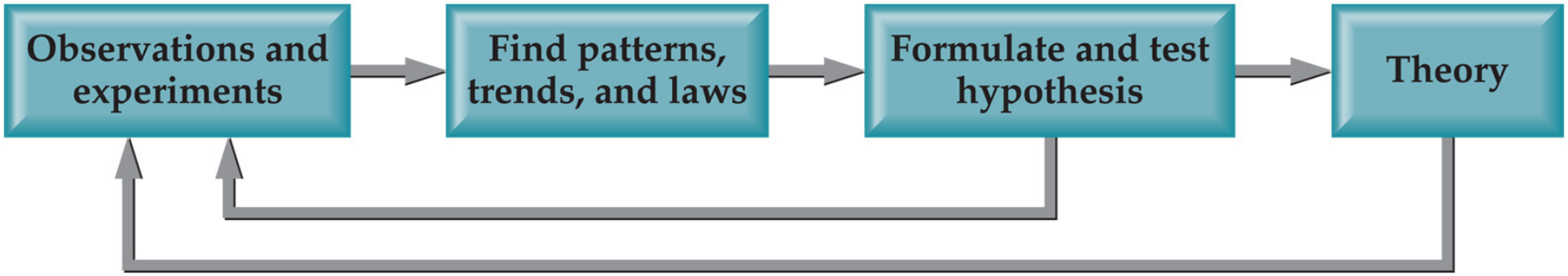
A systematic approach to solving problems.



THIS IS WHAT MAKES IT SCIENCE!

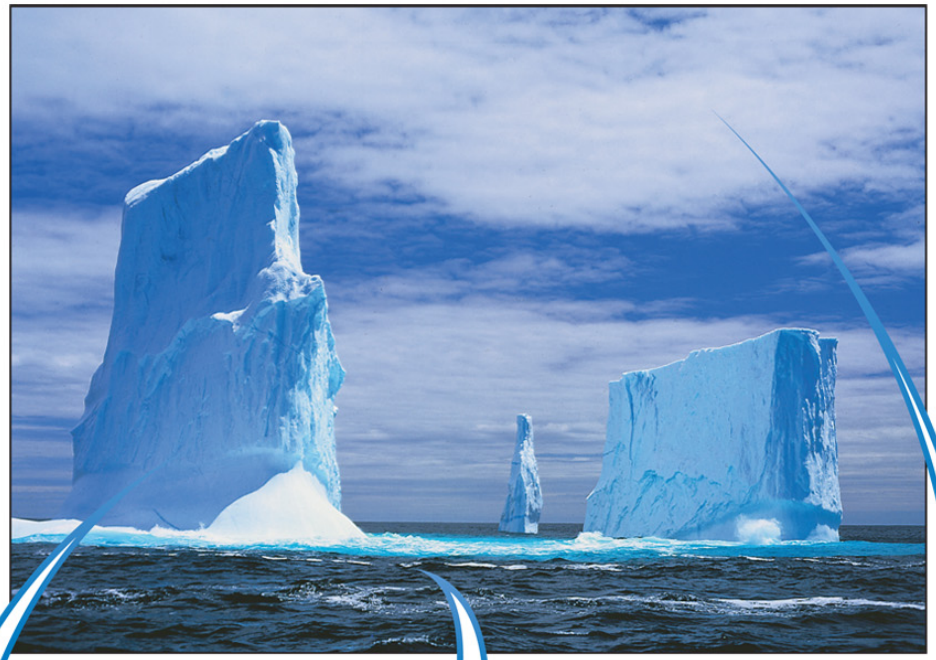
Scientific Method:

A systematic approach to solving problems.



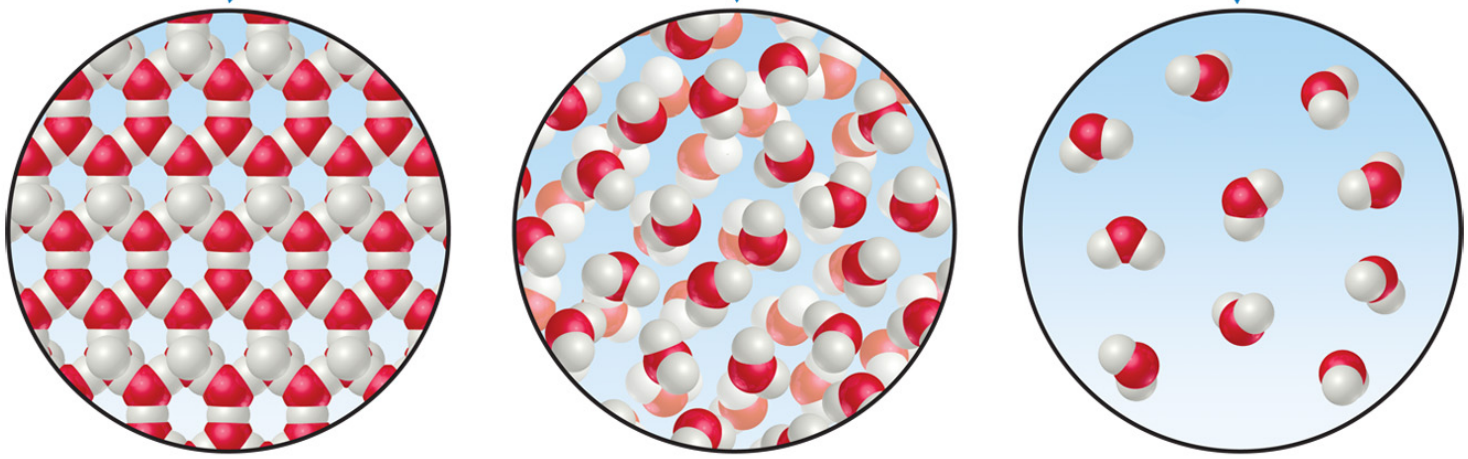
First devotee and developer: Alhazen (1000 AD), Iraqi (Persian?), optics.

Chemistry:



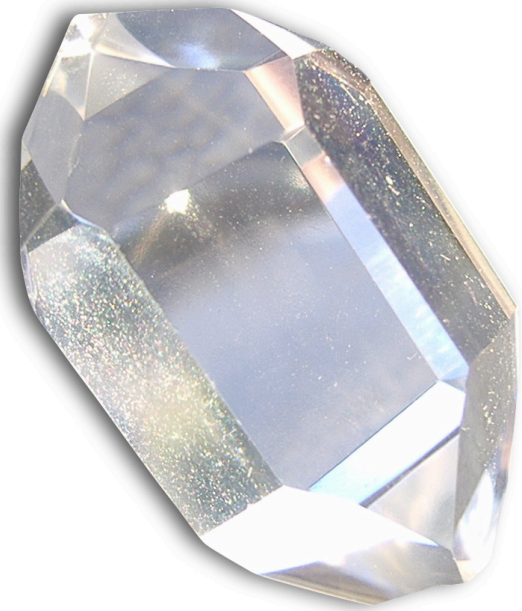
The study of matter

- What it is
- It's properties
- What it becomes

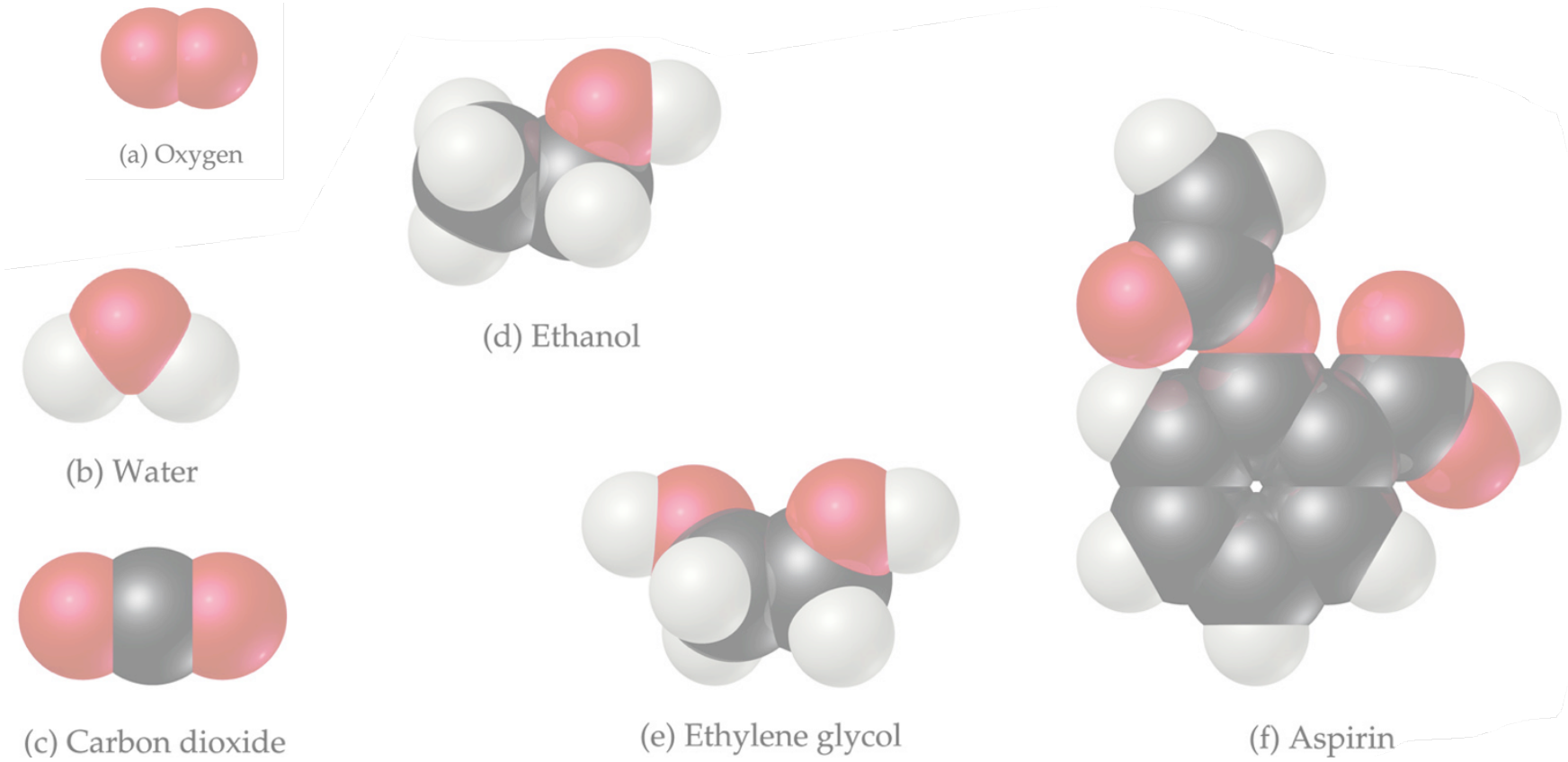


Matter:

Anything that has mass and takes up space.

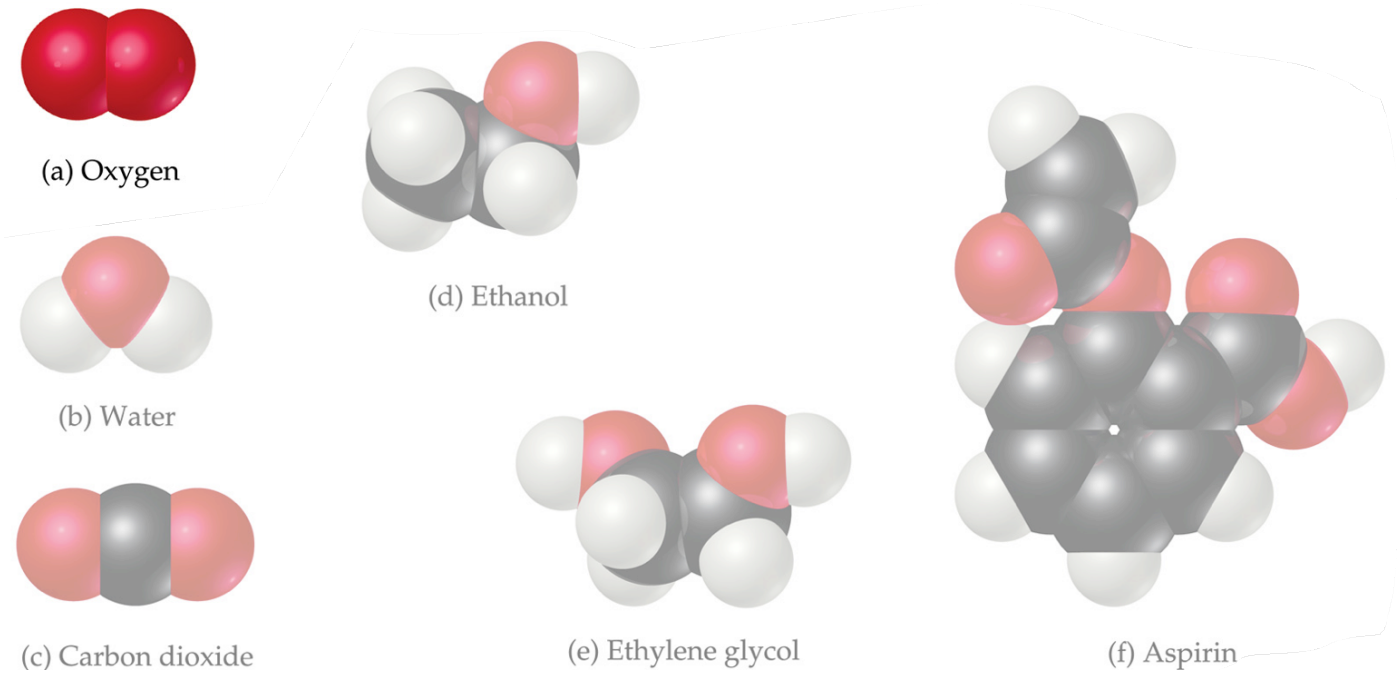


Matter



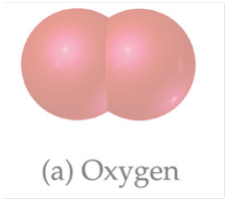
- Atoms are the building blocks of matter.

Matter



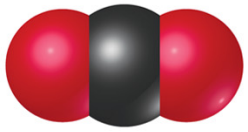
- Each element is made of the same kind of atom.

Matter

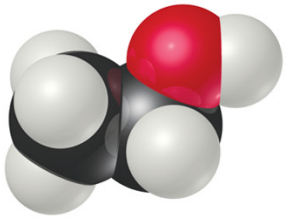


(a) Oxygen

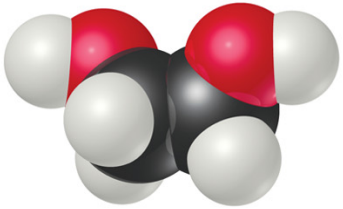
(b) Water



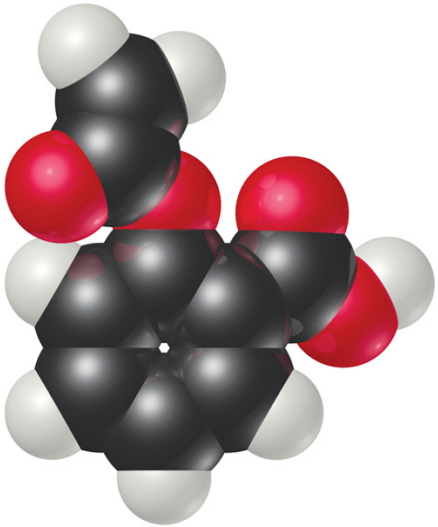
(c) Carbon dioxide



(d) Ethanol



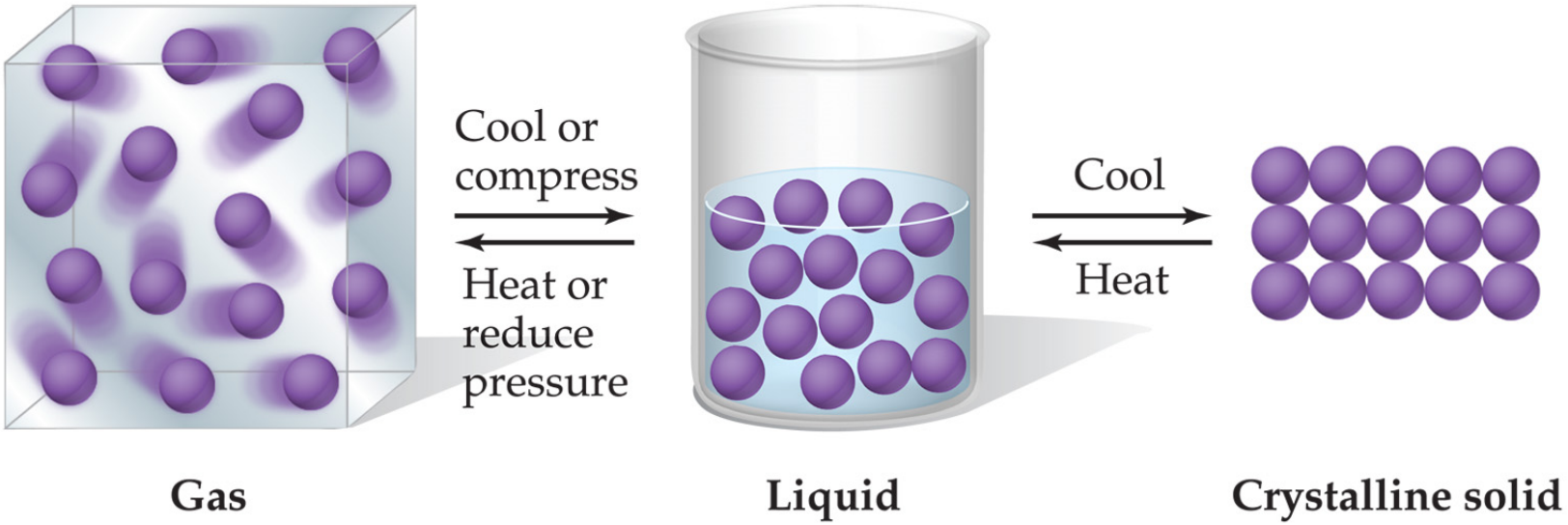
(e) Ethylene glycol



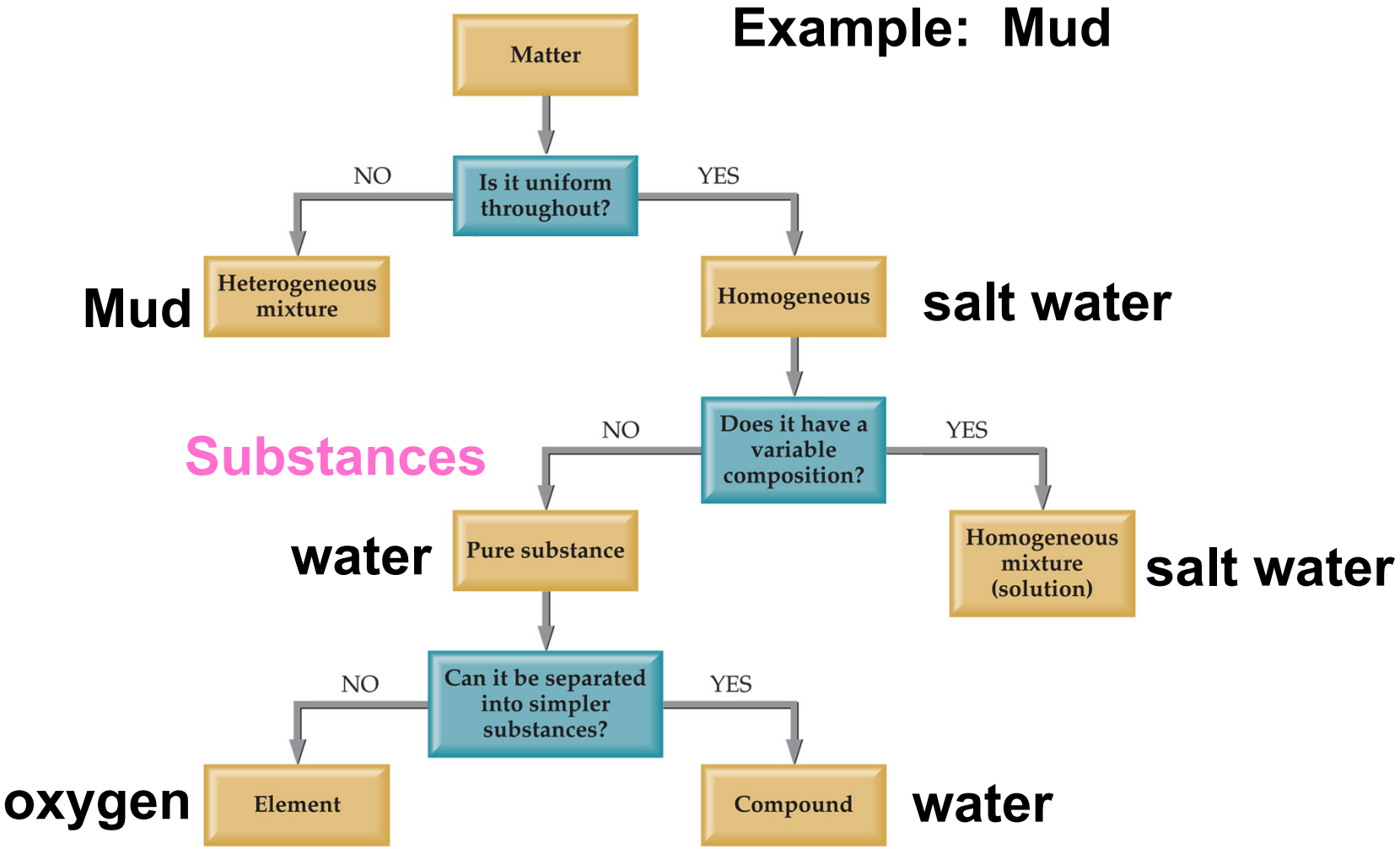
(f) Aspirin

- A compound is made of two or more different kinds of elements.

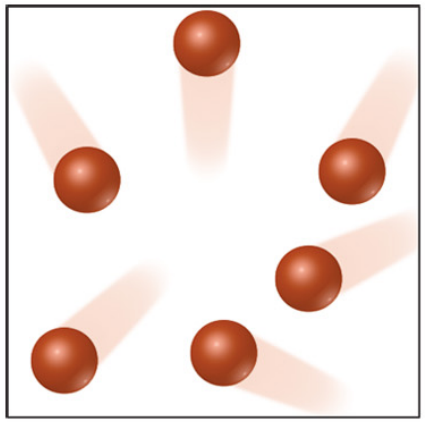
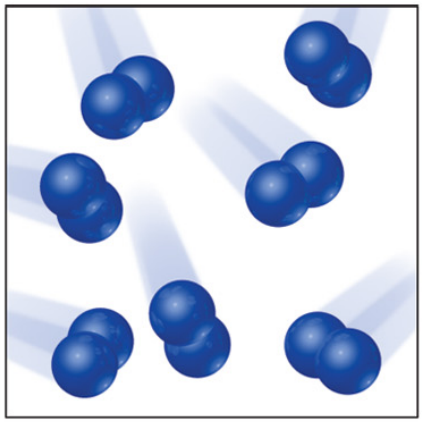
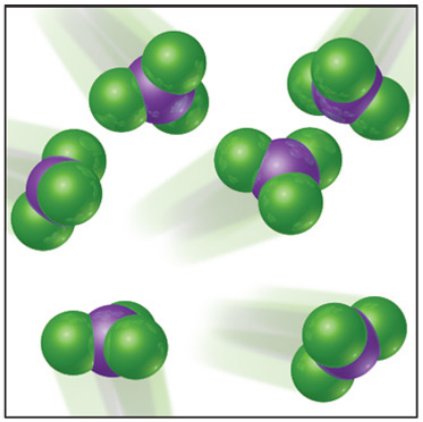
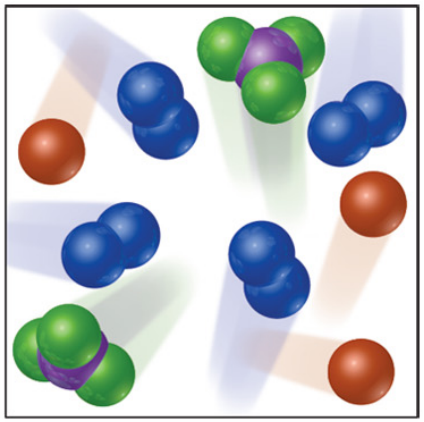
States of Matter



Classification of Matter



Mixtures and Compounds

Element (atoms)	Element (molecules)	Compound (molecules)	Mixture
			
(a) Atoms of an element	(b) Molecules of an element	(c) Molecules of a compound	(d) Mixture of elements and a compound
He, Ne	N_2, O_2, Cl_2	CO_2, H_2O, NH_3	Mix

Properties and Changes of Matter

Properties of Matter

- Physical Properties:
  - Must be observed without changing a compound/ element into another compound/element.
    - **Boiling point, density, mass, volume, etc.**
- Chemical Properties:
  - Can *only* be observed when a compound/element is changed into another compound/element.
    - **Flammability, corrosiveness, reactivity with acid, etc.**

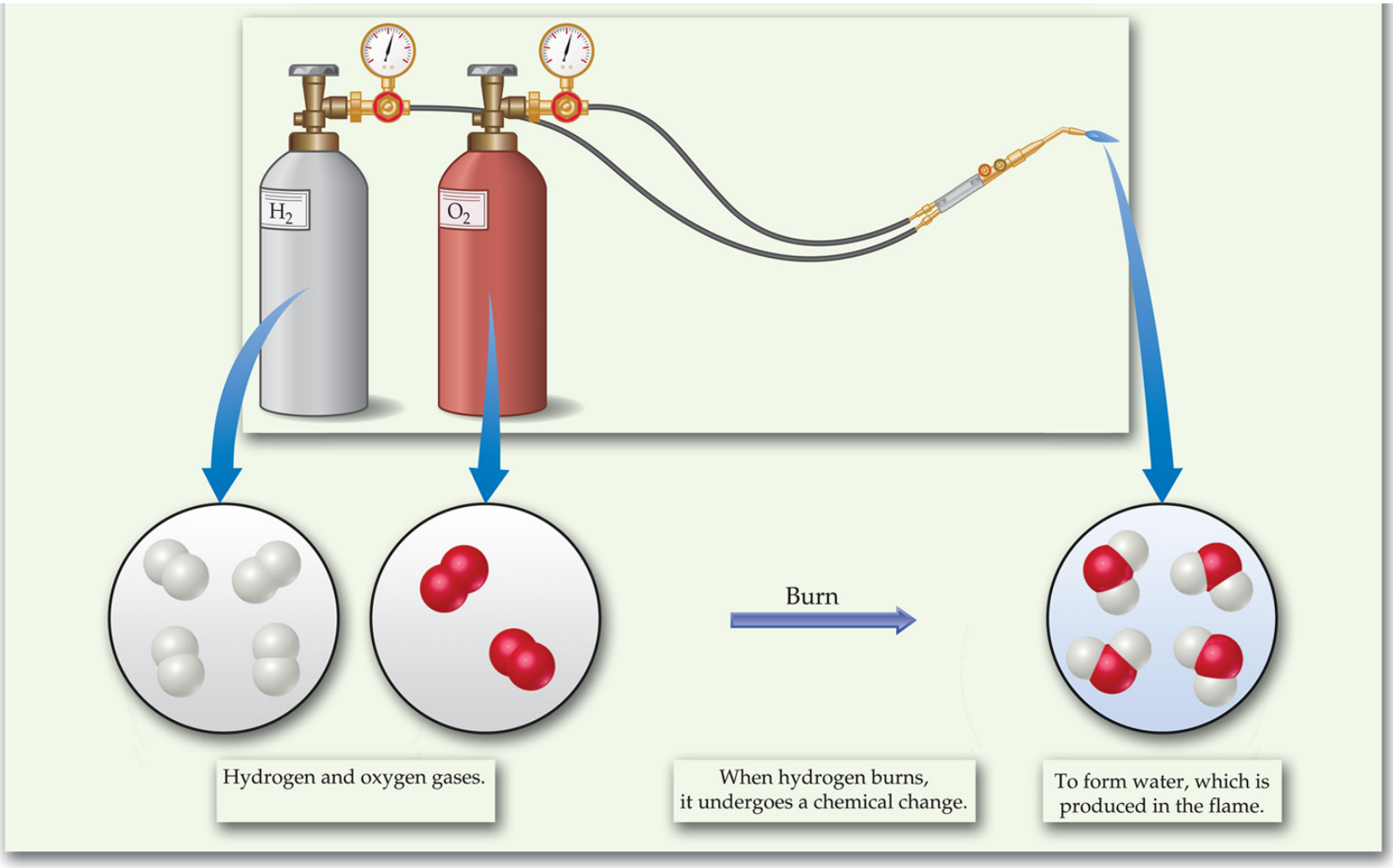
Properties of Matter

- Intensive Properties:
  - Independent of the amount of the matter that is present.
    - **Density, boiling point, color, etc.**
- Extensive Properties:
  - Dependent upon the amount of the matter present.
    - **Mass, volume, energy, etc.**

Changes of Matter

- Physical Changes:
  - Changes in matter that do not change the composition of a substance.
    - **Changes of state, temperature, volume, etc.**
- Chemical Changes:
  - Changes that result in new substances.
    - **Combustion, oxidation, decomposition, etc.**

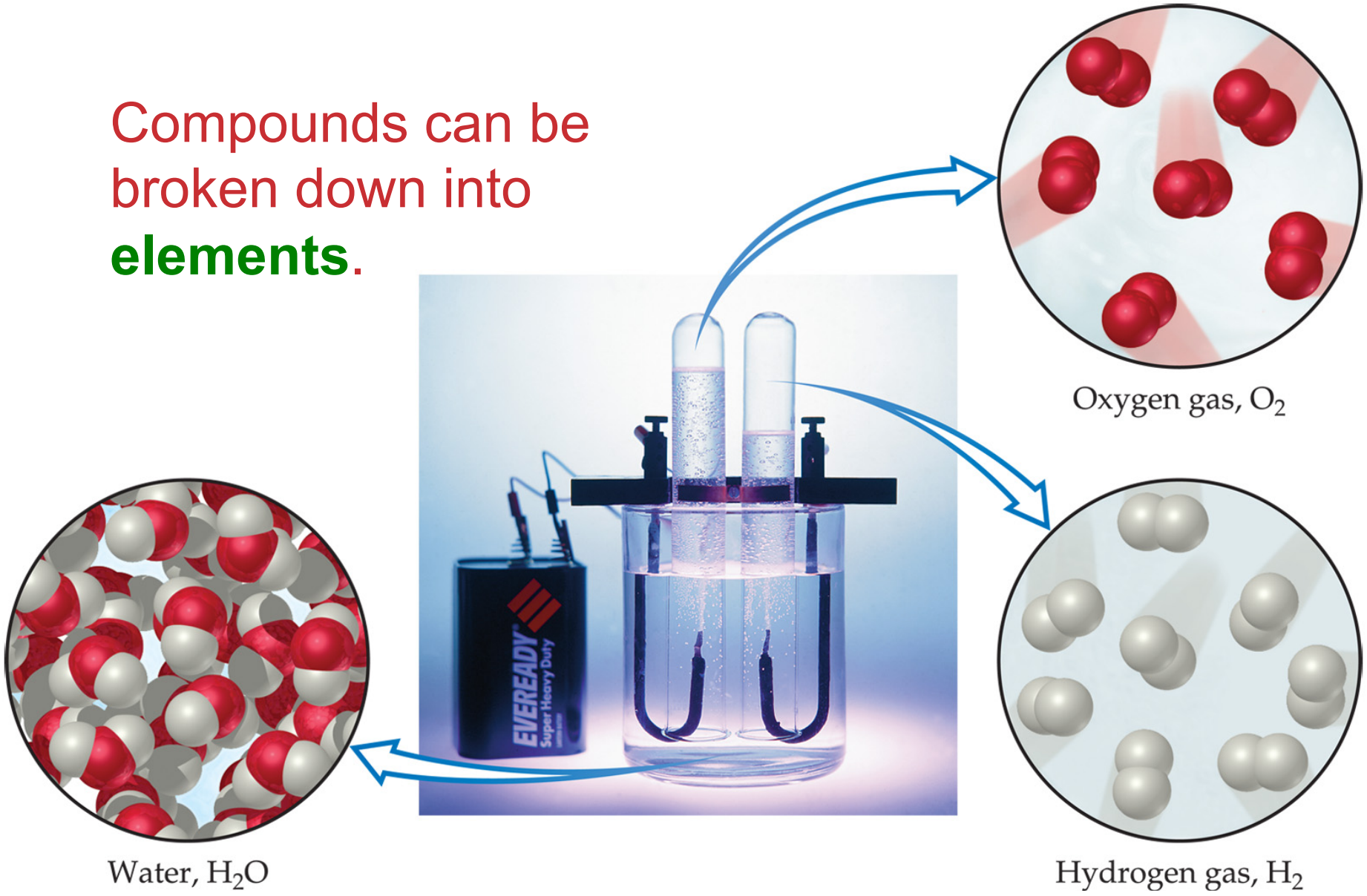
Chemical Reactions



In the course of a chemical reaction, the reacting substances are converted to new substances.

Compounds

Compounds can be broken down into **elements**.



Relative abundance of elements

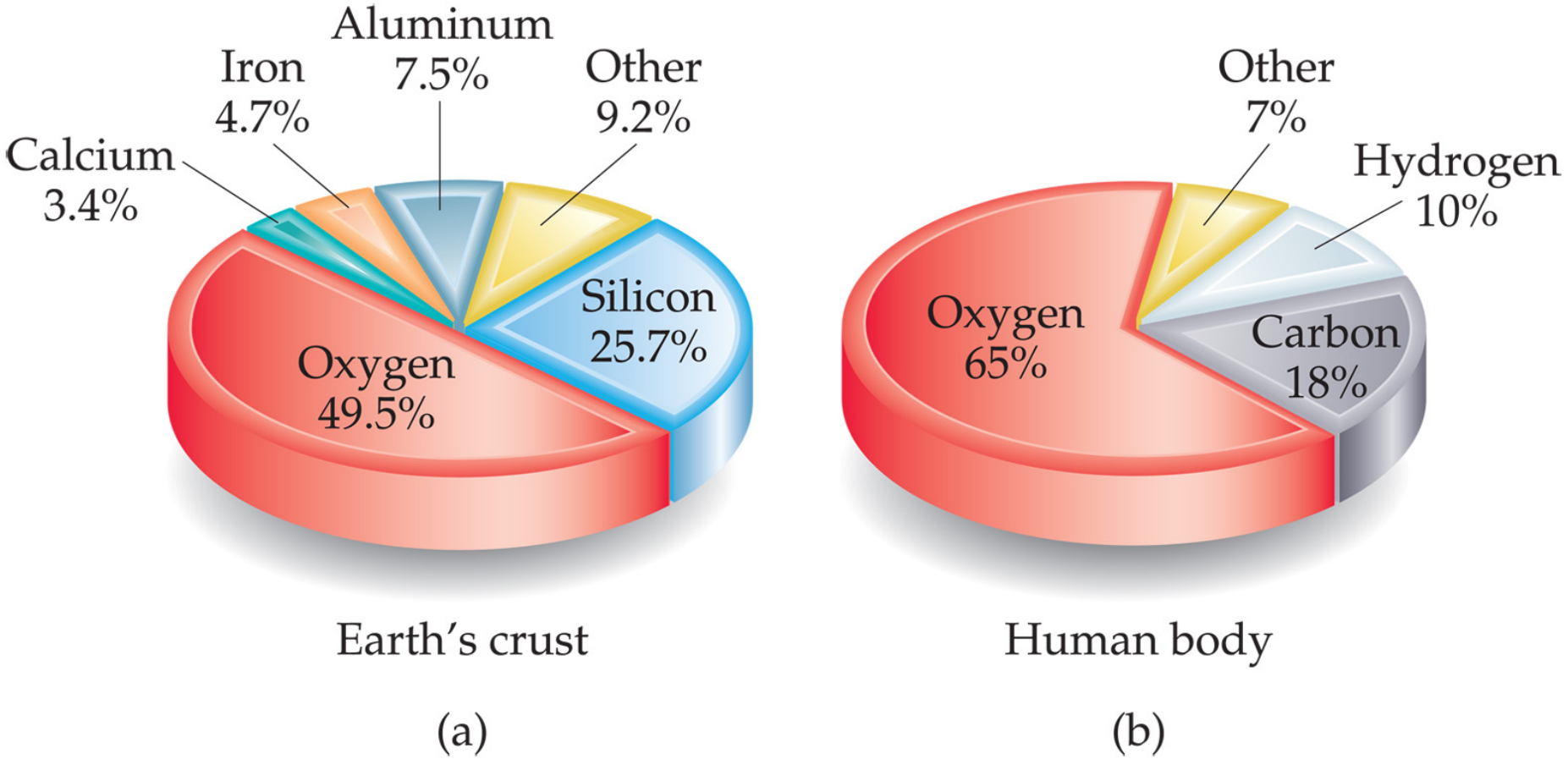


TABLE 1.1 The Top Ten Chemicals Produced by the Chemical Industry in 2002[a]

Rank	Chemical	Formula	2002 Production (billions of pounds)	Principal End Uses
1	Sulfuric acid	H_2SO_4	81	Fertilizers, chemical manufacturing
2	Nitrogen	N_2	73	Fertilizers
3	Oxygen	O_2	53	Steel, welding
4	Ethylene	C_2H_4	52	Plastics, antifreeze
5	Lime	CaO	38	Paper, cement, steel
6	Propylene	C_3H_6	32	Plastics
7	Ammonia	NH_3	29	Fertilizers
8	Chlorine	Cl_2	25	Bleaches, plastics, water purification
9	Phosphoric acid	H_3PO_4	24	Fertilizers
10	Sodium hydroxide	NaOH	20	Aluminum production, soap

[a]Most data from *Chemical and Engineering News*, July 7, 2003, pp. 53, 56.

Acids

Bases

Pure elements

Haber Bosch Process
Ammonia synthesis

- $N_2 + 3H_2 \rightarrow 2NH_3$

- Responsible for most of the fertilizer used worldwide
- Uses about 1% of world total energy
- Developed by Fritz Haber and Carl Bosch
- The trick: finding a metal **catalyst** that works

Haber Bosch Process

- $N_2 + 3H_2 \rightarrow 2NH_3$

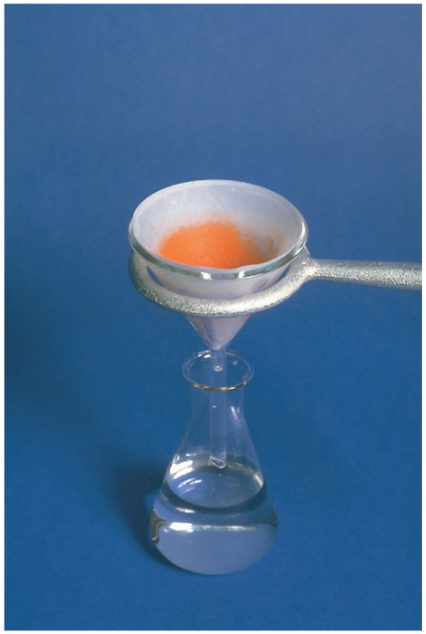
- Nitrates for gunpowder:
- $2NH_3 + 5/2O_2 \rightarrow 2NO + 3H_2O$
- $2NO + O_2 \rightarrow 2NO_2$
- $3NO_2 + H_2O \rightarrow 2HNO_3 + NO$

- Bottom line: once you have ammonia, you can make all kinds of N-containing compounds.

Ammonia fertilizer runoff Causes Algae blooms

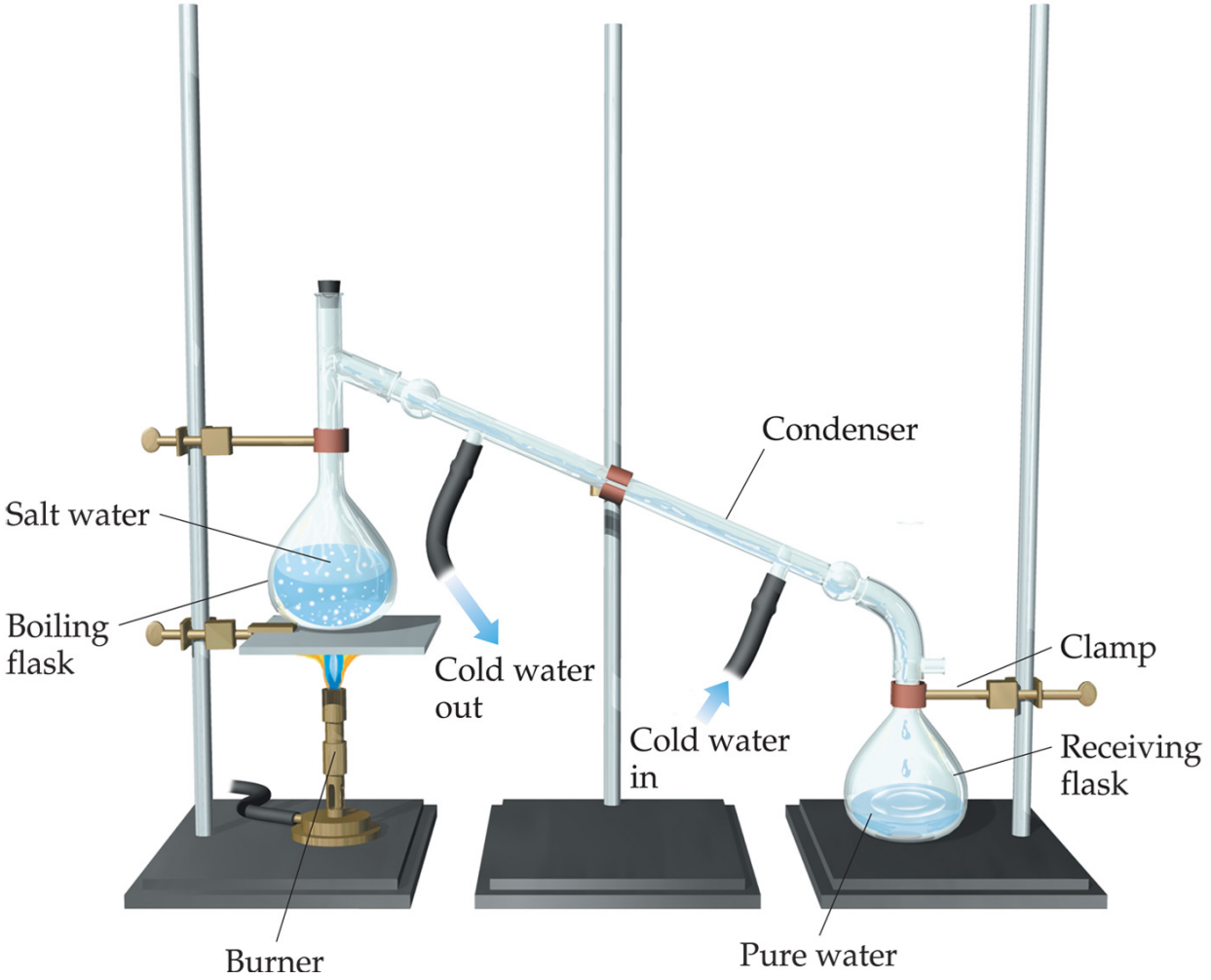
Separation of Mixtures

Filtration:



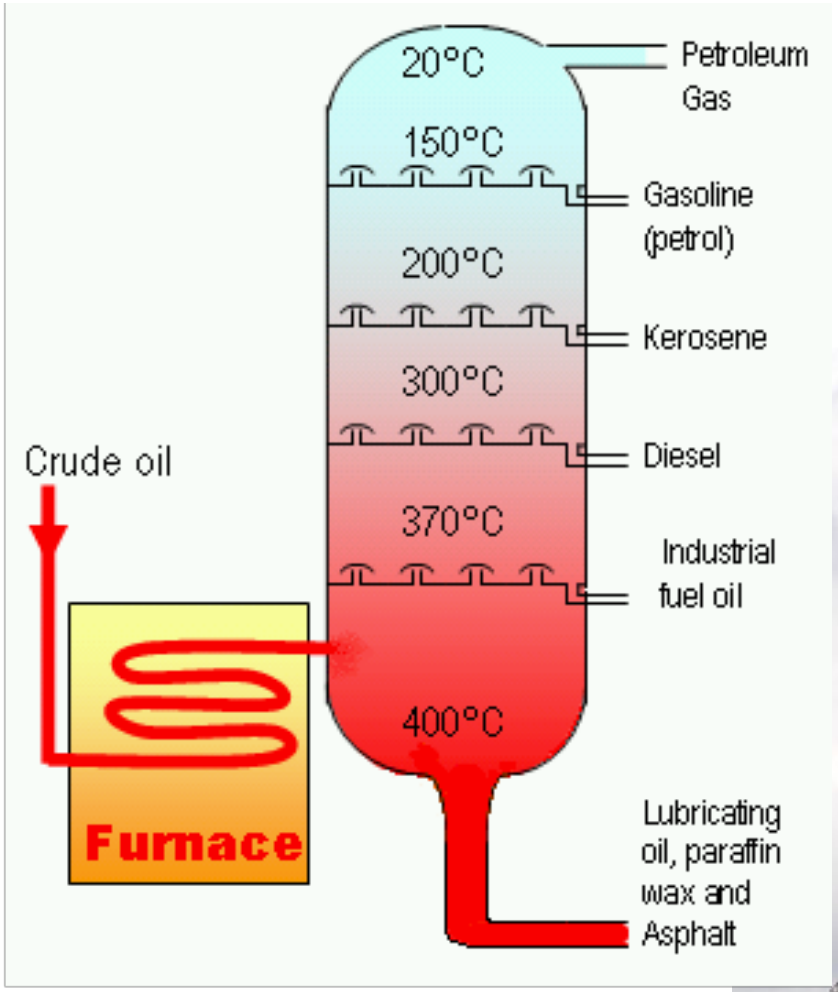
Separates heterogeneous mixture, solid substances from liquids and solutions.

Distillation:



Separates homogeneous mixture of liquids on the basis of differences in boiling point.

Distillation: petroleum refining



Chromatography:

Separates homogeneous mixtures on the basis of differences in solubility in a solvent, or in binding to a solid matrix.

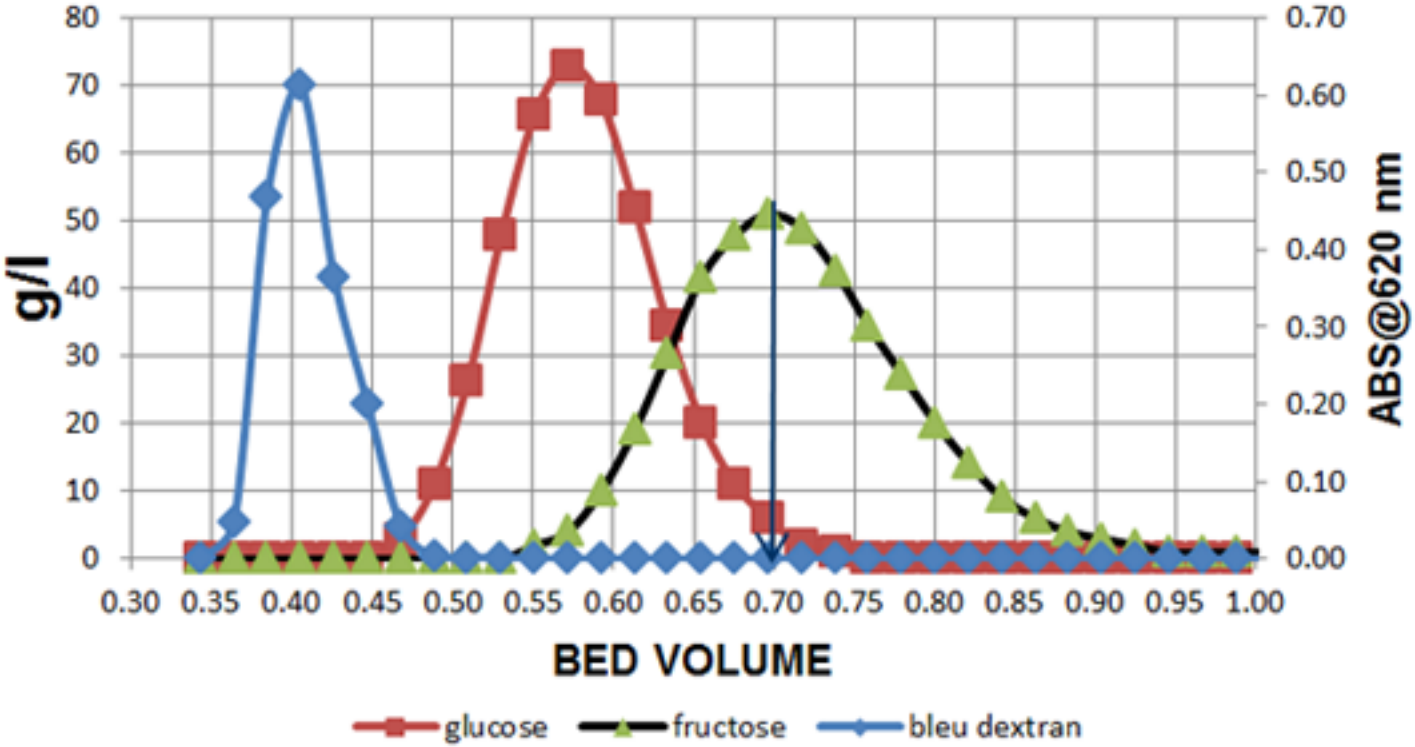


Separation techniques were critical to the development of the basic theories of chemistry.

How do we know there are homogeneous mixtures?

We can separate them.

Chromatography:



Units of Measurement

SI Units
Learn! symbols and all!

Physical Quantity	Name of Unit	Abbreviation
Mass	Kilogram	kg
Length	Meter	m
Time	Second	s[a]
Temperature	Kelvin	K
Amount of substance	Mole	mol
Electric current	Ampere	A
Luminous intensity	Candela	cd

[a]The abbreviation sec is frequently used.

- *Système International d'Unités*
- Uses a different base unit for each quantity

Metric System

Prefixes convert the base units into units that are appropriate for the item being measured.

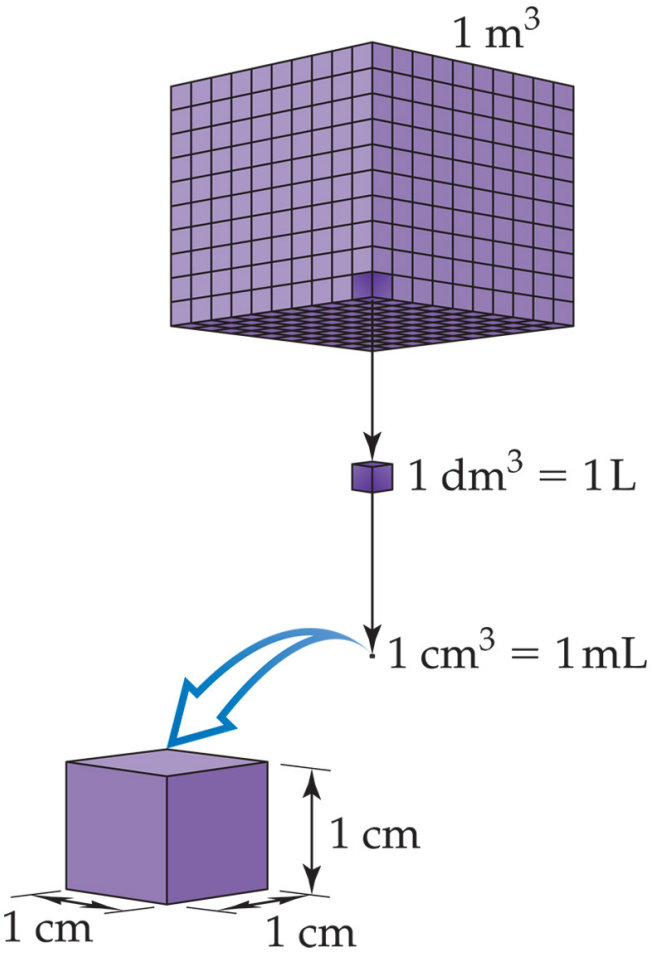
Learn! More important than it looks!!!

Prefix	Abbreviation	Meaning	Example
Giga	G	10^9	1 gigameter (Gm) = 1×10^9 m
Mega	M	10^6	1 megameter (Mm) = 1×10^6 m
Kilo	k	10^3	1 kilometer (km) = 1×10^3 m
Deci	d	10^{-1}	1 decimeter (dm) = 0.1 m
Centi	c	10^{-2}	1 centimeter (cm) = 0.01 m
Milli	m	10^{-3}	1 millimeter (mm) = 0.001 m
Micro	μ[a]	10^{-6}	1 micrometer (μm) = 1×10^{-6} m
Nano	n	10^{-9}	1 nanometer (nm) = 1×10^{-9} m
Pico	p	10^{-12}	1 picometer (pm) = 1×10^{-12} m
Femto	f	10^{-15}	1 femtometer (fm) = 1×10^{-15} m

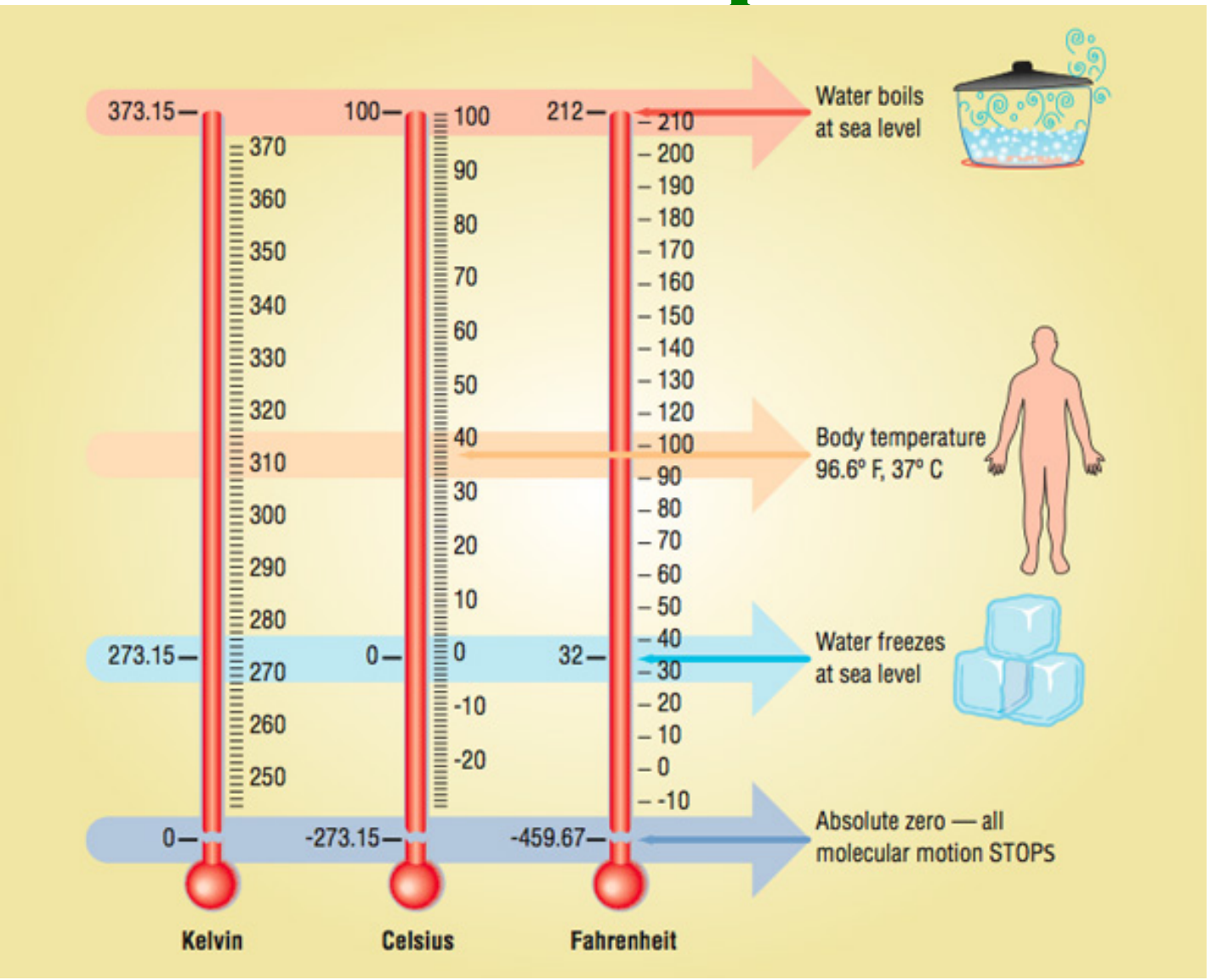
[a]This is the Greek letter mu (pronounced "mew").

Volume

- The most commonly used metric units for volume are the liter (L) and the milliliter (mL).
  - A liter is a cube 1 dm (10 cm) long on each side.
  - A milliliter is a cube 1 cm long on each side.



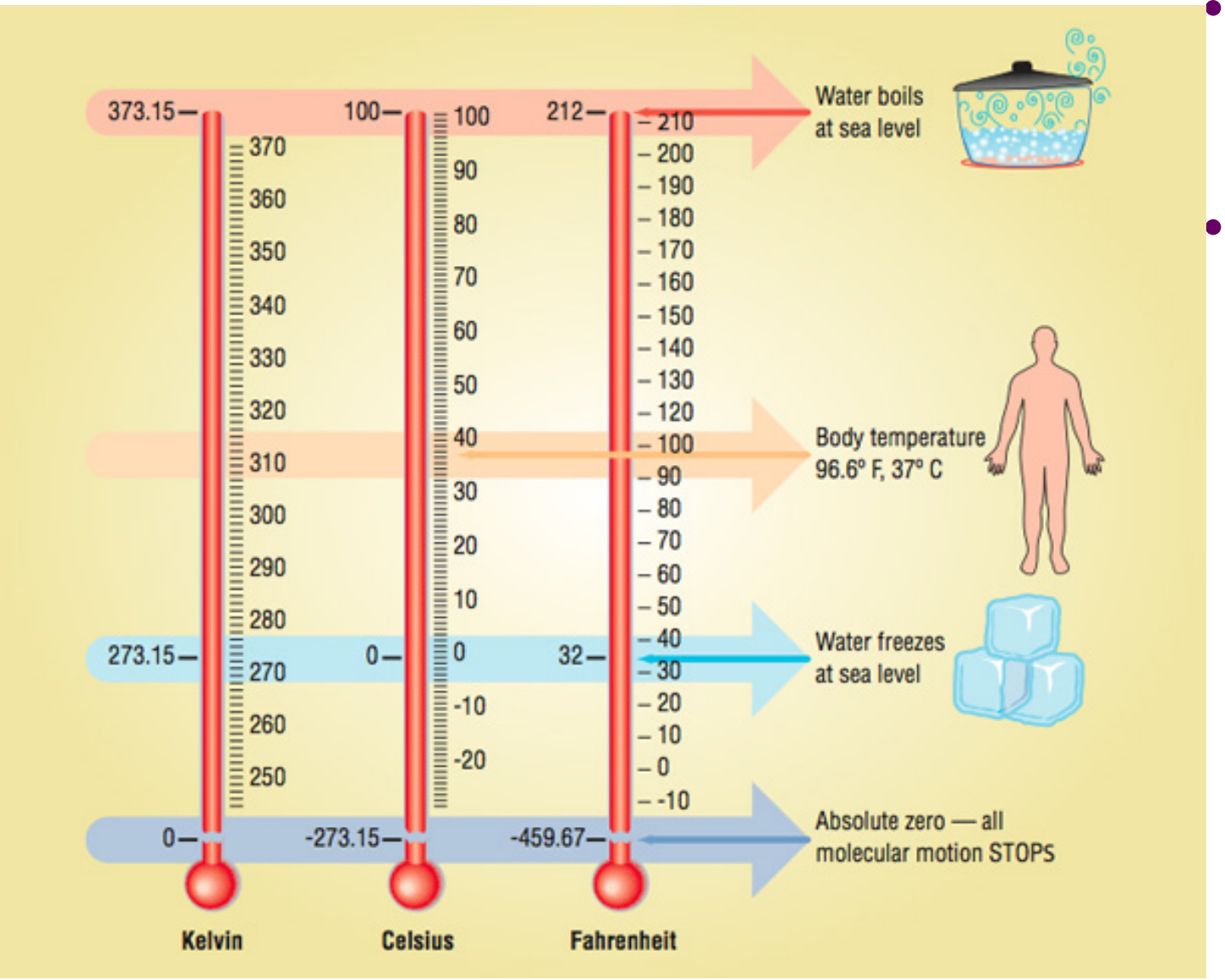
Temperature:



proportional to the average kinetic energy of the particles in a sample.

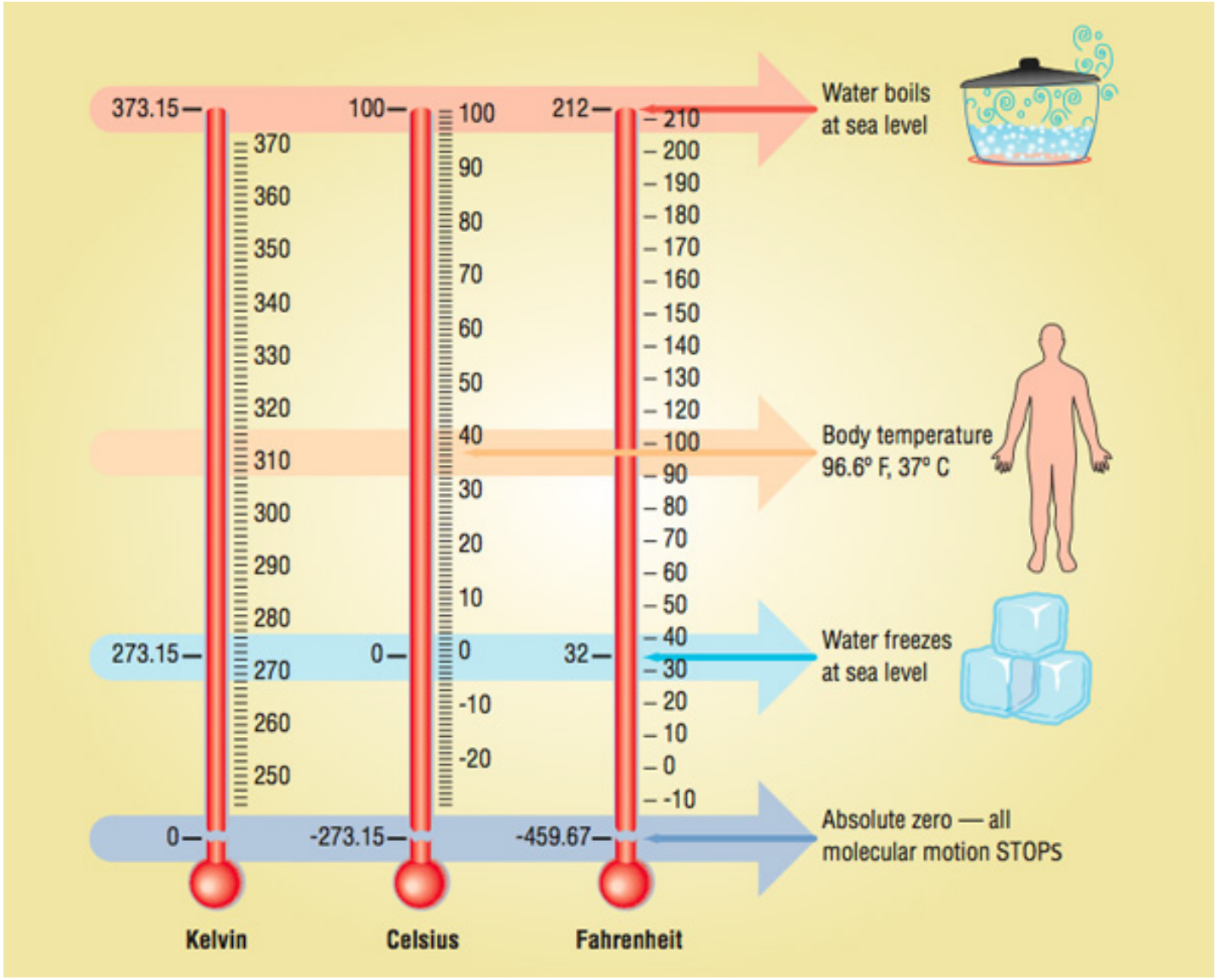
K.E. = $1/2mv^2$

Temperature



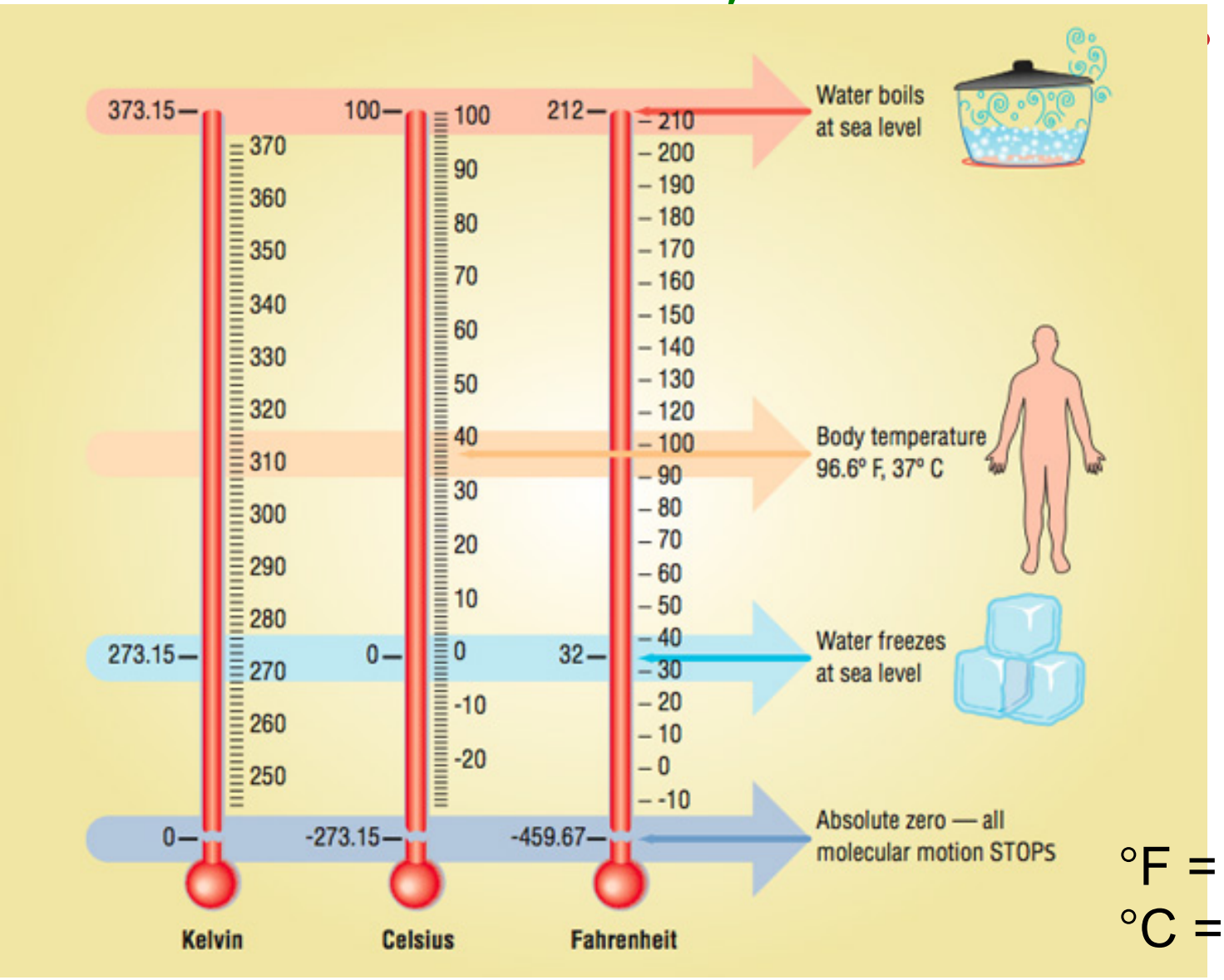
- Celsius and Kelvin scales
- The Celsius scale is based on water.
  - 0°C is the freezing point of water.
  - 100°C is the boiling point of water.

Temperature



- The Kelvin is the SI unit of T. It is based on the properties of gases.
- 0 K = 0 K.E.
- There are no negative Kelvin T.
- K = °C + 273.15

Temperature



The Fahrenheit not used in science

$°F = 9/5(°C) + 32$

$°C = 5/9(°F) - 32$

Density:

Physical property of a substance

Intensive.

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

Density of selected substances

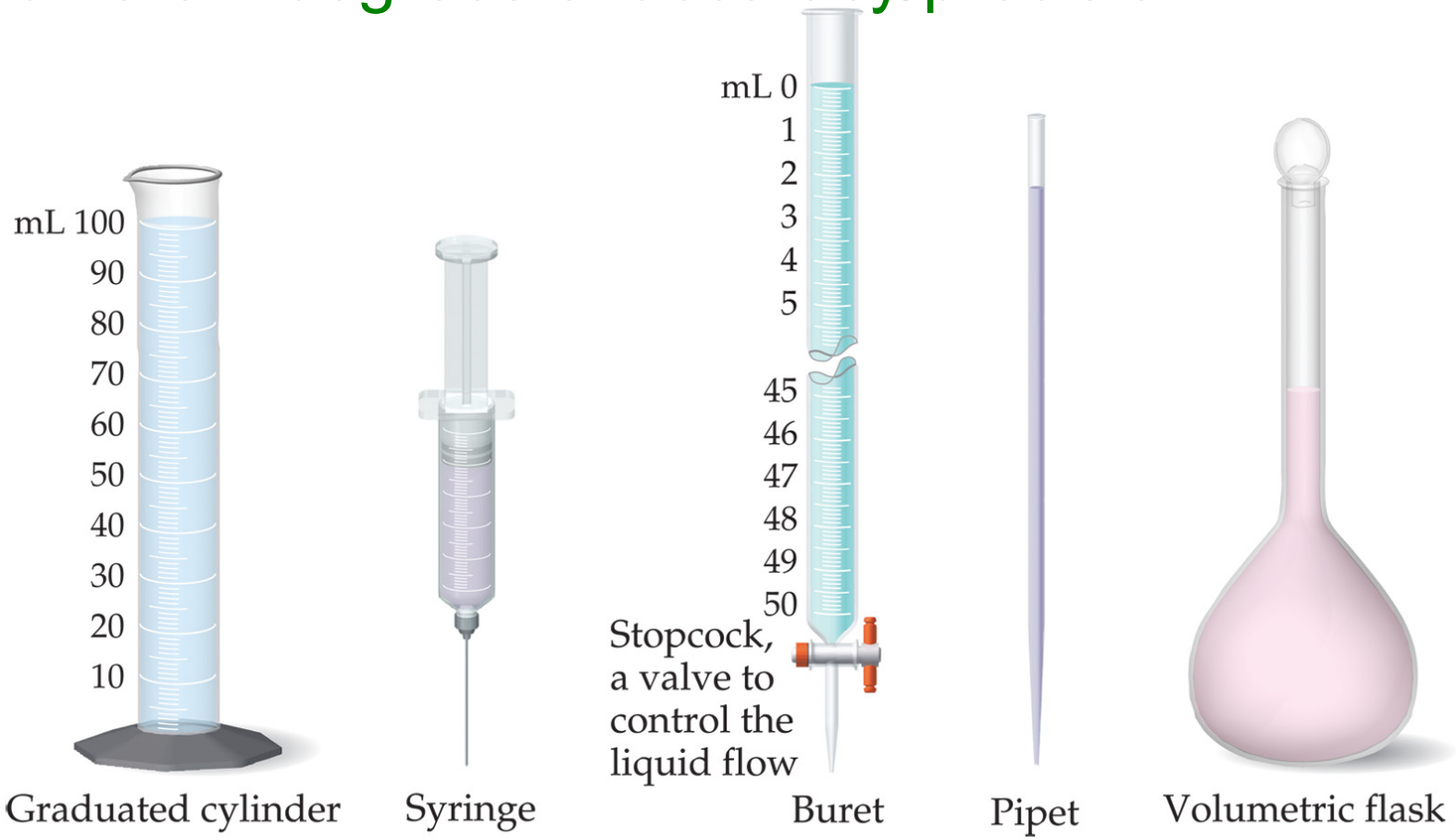
TABLE 1.6 Densities of Some Selected Substances at 25°C

Substance	Density (g/cm^3)
Air	0.001
Balsa wood	0.16
Ethanol	0.79
Water	1.00
Ethylene glycol	1.09
Table sugar	1.59
Table salt	2.16
Iron	7.9
Gold	19.32

Uncertainty in Measurement

Uncertainty in Measurements

Different measuring devices have different uses and different degrees of accuracy/precision.



Exact versus inexact numbers

Exact	**Inexact**
1000 g/kg	ruler measure
2.54 cm/in	Temp. reading
12/dozen	volume or mass
any conversion	etc. **Things you**
Factor	**measured**

Exact numbers are defined

Inexact numbers are measured

Example

- There are 12 eggs in a dozen
- Each egg weighs about 50.5 g
- How much does a dozen eggs weigh?
- How many sig. figs in your answer?

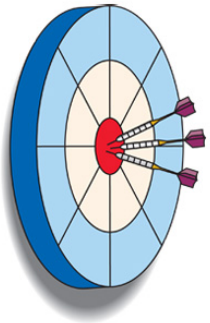
Example

- There are 12 eggs in a dozen
- Each egg weighs about 50.5 g
- How much does a dozen eggs weigh?
- How many sig. figs in your answer?

$$\frac{50.5g}{1egg}\left(\frac{12egg}{1dozen}\right) = 606g$$

Accuracy versus Precision

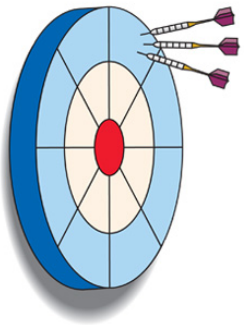
- Accuracy How close a measurement is to the true value. (How right you are)



Good accuracy
Good precision

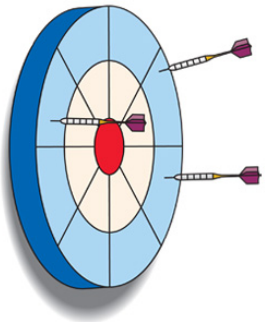
Good accuracy
Good precision

- Precision How close measurements are to each other. (Reproducibility). Precise but incorrect data are often the result of systematic errors.



Poor accuracy
Good precision

Good accuracy
Terrible precision
Your calibration is Off.



Poor accuracy
Poor precision

Bad accuracy
Bad precision

Significant Figures

- The term significant figures refers to digits *that were measured*.
- When rounding calculated numbers, we pay attention to significant figures so we do not overstate or understate the precision of our answers.

Significant Figures

1. All nonzero digits are significant. (sig figs in **red**)

   423.444

2. Zeroes between two significant figures are themselves significant.

   42,300045 42,340.0025

3. Zeroes at the beginning of a number are never significant.

   00042345.0 0.00048

4. Zeroes at the end of a number are significant if a decimal point is written in the number.

   423,000 versus: 423,000. or: 423,000.000

Significant Figures

- When addition or subtraction is performed, answers are rounded to the least significant decimal place.

```
  24.245
+22.33488
----------
  46.57988 = 46.580
```

- When multiplication or division is performed, answers are rounded to the number of digits that corresponds to the *least* number of significant figures in any of the numbers used in the calculation.

```
  35.8750      (6 sig figs)
X40.006800  (8 sig figs
-------------------------
1435.24395 = 1435.24  (6 sig figs)
```

- **This is the way that errors are properly propagated through a calculation**

Dimensional analysis

What do virtually all problems in chemistry have in common?

Dimensional analysis

Convert centimeters to feet: 1 cm = ? feet

Know: 2.54 cm = 1 in, 12 in = 1 foot.

$$\frac{1in}{2.54cm}\left(\frac{1ft}{12in}\right) = 0.0328\frac{ft}{cm}$$

Dimensional Analysis

- What do I need on top?
- What do I need on the bottom?
- What do I know?
- How do I get there?
- Note: You will always be given the conversion factors you need, you don't have to memorize them.

Dimensional Analysis

- Remember, you can write any conversion factor 2 ways:
- Example: 2.54 cm = 1 in
- 1 in/2.54 cm
- 2.54 cm/1 in

Dimensional analysis, examples

The speed of light is 2.998×10^{10} cm/s. What is it in km/hr?

Know: 1 km =1000m, 1m=100cm 60 min =1 hr, 60 sec =1 min

What do I need on top? *kilometers*

What do I need on the bottom? *hours*

Dimensional analysis, examples

The speed of light is 2.998×10^{10} cm/s. What is it in km/hr?

Know: 1 km =1000m, 1m=100cm 60 min =1 hr, 60 sec =1 min

What do I need on top? *kilometers*

What do I need on the bottom? *hours*

$$2.998x10^{10}\frac{cm}{s}\left(\frac{1m}{100cm}\right)\left(\frac{1km}{1000m}\right)\left(\frac{60\,\text{sec}}{1\,\text{min}}\right)\left(\frac{60\,\text{min}}{1hr}\right)=1.089x10^{9}\,km/hr$$

Dimensional analysis, examples

The Vehicle Assembly Building (VAB) at the Kennedy Space Center has a volume of: 3,666,500m^3. What is it in liters?

Know: 1 L = 1 dm^3, 1dm = 0.1 m

What do I need on top? *Liters*

What do I need on the bottom? *building*

$$3{,}666{,}500\left(\frac{\cancel{m^3}}{building}\right)\left(\frac{\cancel{dm}}{0.1\cancel{m}}\right)^3\left(\frac{1L}{1\cancel{dm^3}}\right)=3.6665x10^9\,\frac{L}{building}$$

Dimensional analysis, examples

An individual suffering from high cholesterol has 232 mg cholesterol per 100.0 mL of blood. How many grams of cholesterol in the blood, assuming a blood volume of 5.2 L?

Know: 1 L = 1000 mL, 1g = 1000mg,

5.2 L blood = patient blood

What do I need on top? *grams*

What do I need on the bottom? *patient*

$$232\,\frac{\cancel{mg}}{100.0\cancel{mL}}\left(\frac{1g}{1000\cancel{mg}}\right)\left(\frac{1000\cancel{mL}}{1\cancel{L}}\right)\left(\frac{5.2L}{patient}\right)=12.\frac{g}{patient}$$

Problem

- Consider a piece of gold jewelry that weighs 9.35 g and has a volume of 0.695 mL . The jewelry contains only gold and silver, which have densities of 19.3 and 10.5 , respectively. If the total volume of the jewelry is the sum of the volumes of the gold and silver that it contains, calculate the percentage of gold (by mass) in the jewelry.

$$\frac{V_{Au}}{V_{Au}+V_{Ag}} = 1 - \frac{V_{Ag}}{V_{Au}+V_{Ag}} = F_{VolAu} = 1 - F_{VolAg}$$

$$D_{Au} = \frac{m_{Au}}{V_{Au}} \qquad m_{Au} = V_{Au} D_{Au}$$

$$D_{Jew} = \frac{m_{Jew}}{V_{Jew}} = \frac{V_{Au}D_{Au} + V_{Ag}D_{Ag}}{V_{Au}+V_{Ag}} = D_{Au}\frac{V_{Au}}{V_{Au}+V_{Ag}} + D_{Ag}\frac{V_{Ag}}{V_{Au}+V_{Ag}} = D_{Au}\left(1 - F_{VolAg}\right) + D_{Ag}F_{VolAg}$$

$$D_{Jew} = D_{Au} + F_{Ag}(D_{Ag} - D_{Au}) \qquad F_{Ag} = \frac{D_{Jew} - D_{Au}}{D_{Ag} - D_{Au}}$$

$$D_{Jew} = \frac{9.35}{0.695} = 13.45 \qquad F_{VolAg} = \frac{13.45 - 19.3}{10.5 - 19.3} = 0.664 \quad F_{VolAu} = 0.335$$

$$F_{VolAu}(V_{Jew})D_{Au} = m_{Au} \qquad \frac{m_{Au}}{m_{Jew}} = F_{mAu} \quad \frac{(0.336)(0.695cm^3)(19.3g/cm^3)}{(9.35g)} = 0.481$$

Another way to look at it

F_{VAu} fractional volume for Au (gold) D_{Au} Density of gold

F_{Ag} fractional volume for Ag (gold) D_{Ag} Density of silver

V_{Au} Volume of gold m_{Jew} mass of Jewelry

V_{Ag} Volume of silver V_{Jew} Volume of Jewelry

$$F_{VAu}(V_{Jew}) = V_{Au}$$

$$V_{Au}(D_{Au}) = m_{Au} \qquad V_{Ag}(D_{Ag}) = m_{Ag}$$

$$F_{VAg} = 1 - F_{VAu}$$

$$m_{Au} + m_{Ag} = m_{Jew}$$

$$F_{VAu}(V_{Jew})(D_{Au}) + (1 - F_{VAu})(V_{Jew})(D_{Ag}) = m_{Jew}$$

$$F_{VAu}(V_{Jew})(D_{Au} - D_{Ag}) + (V_{Jew})(D_{Ag}) = m_{Jew}$$

$$F_{VAu} = \frac{m_{Jew} - (V_{Jew})(D_{Ag})}{(V_{Jew})(D_{Au} - D_{Ag})} = \frac{9.35g - (0.695cm^3)10.5gcm^{-3}}{0.695cm^3((19.3 - 10.5)gcm^{-3}} = \frac{2.0525}{6.117} = .336$$

$$F_{VolAu}(V_{Jew})D_{Au} = m_{Au} \qquad \frac{m_{Au}}{m_{Jew}} = F_{mAu} \qquad \frac{(0.336)(0.695cm^3)(19.3g/cm^3)}{(9.35g)} = 0.481$$

Mastering chemistry hell

- Their on-line help chat. This is supposed to be there 24 hours a day: http://247pearsoned.custhelp.com/app/chat/chat_launch

- Or you can call them:
- STUDENT SUPPORTToll free (800) 677-6337Mon - Fri Noon - 8:00 pm EST.
- Either way, they should have no problem taking care of your problem. If this does not work, or they want to charge you money, email me and I'll give them much grief.

Facts and theories

http://en.wikipedia.org/wiki/Tunguska_event

*Fact: on June 30, 1908 in Tunguska, Siberia, an explosion equivalent to about 15 million tons of TNT occurred.

* **Hypothesis** is that a comet or meteor collided with the Earth.

Testing: look for elements and substances characteristic of extraterrestrial objects, elements not found in the area. Such elements (Nickel, Iridium) were found.

However, there is no crator.

Theory: Meteor exploded above the ground.