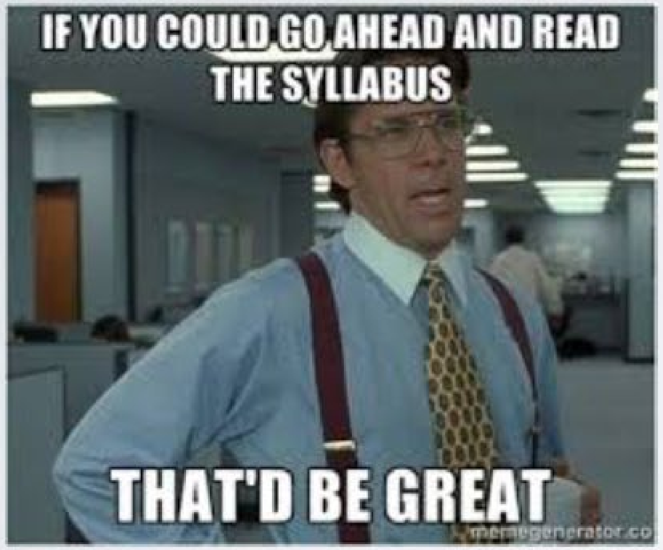
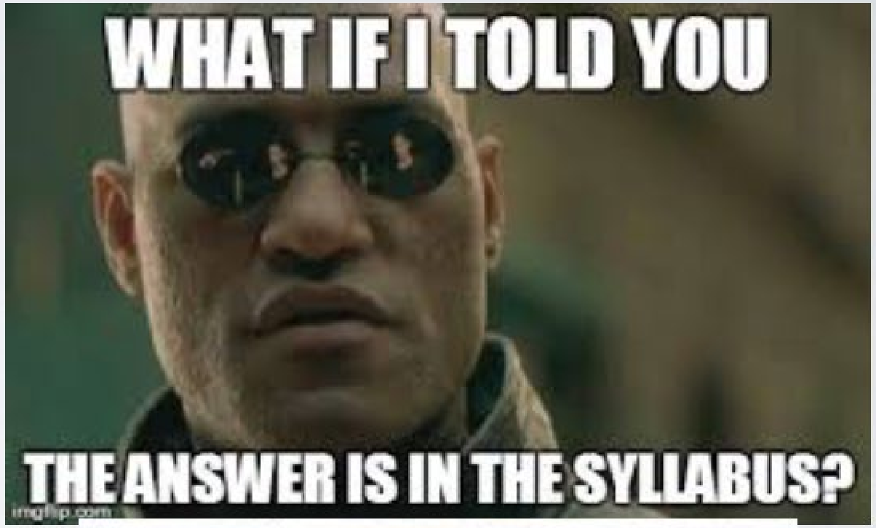
Chem 200

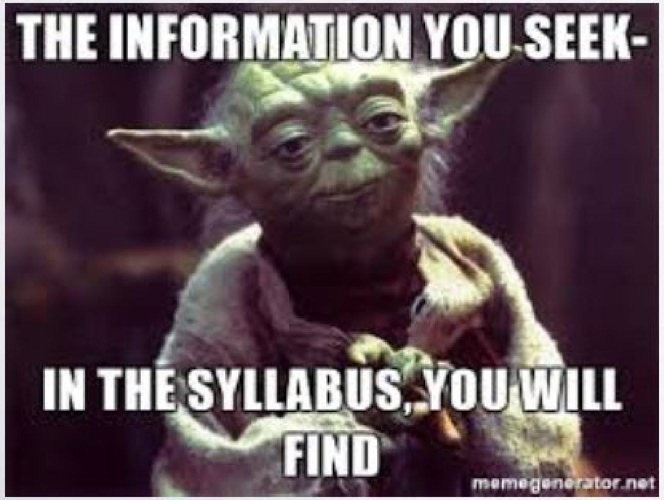
All emails sent to
chem200@sdsu.edu

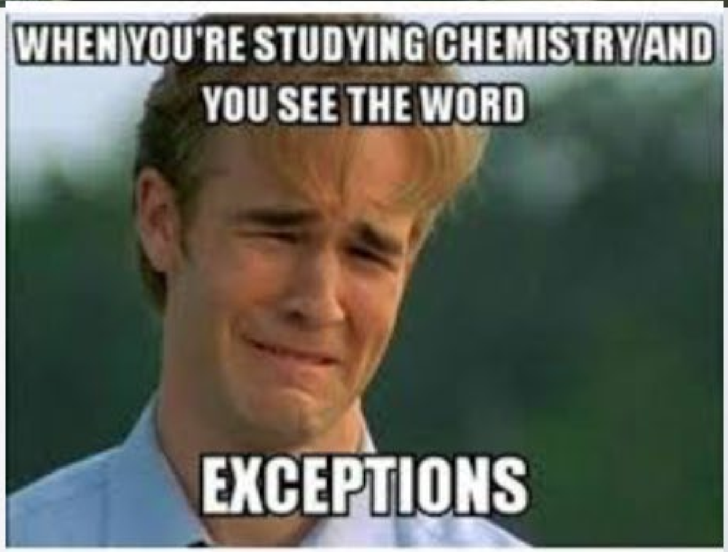
Office hours held virtually through the MSLC.
Tues 9.00 am to 11.00 am

PLEASE READ THE SYLLABUS









IMPORTANT ANNOUNCEMENTS

1. Email chem200@sdsu.edu ONLY unless its regarding lab or discussion which then you need to email your respective TA.

2. Follow the directions in adding OWL that Theresa provided you in Module 1.0 > Adding OWL (READ). She made a video and has a pdf file with directions.

3. **There is no course key for OWL.**

4. **Read the announcements and emails that Theresa, Megan, or your TAs sends out.**

5. Again read the syllabus. A lot of questions are being asked that are in the syllabus. For example, emailing when the lab will be and what will take place can be answered by the syllabus. In the syllabus there is a lab schedule, read, use it, and print it out.

6. And for good measure read the announcements before sending out emails. The majority (98%) of questions can be answered by: the syllabus, videos Theresa has made, and in the announcements.

UPCOMING IMPORTANT DATES

- Safety Quiz due **Friday, February 3rd at 11:59 pm** (in OWL Lab & Canvas), *must pass with >60% to do in-person labs*
- How to write a lab notebook and prelab due **Sunday, February 5th at 11:59 pm**
- Volumetric Prelab due **Sunday, February 5th at 11:59 pm**
- Volumetric Lab Report due **Sunday, February 5th at 11:59 pm**
- Chapter 1-4 Chapter Problem Sets in OWL Lecture due **Thursday, February 9th at 11:59 pm** (**Start Now)**
- Chapter 1-4 Chapter Assessments in OWL Lecture is **Thursday, February 9th at 11:59 pm** (**Start Now**); 2 chances, no time limit
- Exam 1 starts at **3 pm Friday, February 10th and will close on Saturday, February 11th at 3pm** in OWL Lecture; Chapters 1-4. You have 24hrs. *Only 2 hrs once you start; be sure to give yourself a full 2 hr time slot.*

SUPPLEMENTAL INSTRUCTION (SI)

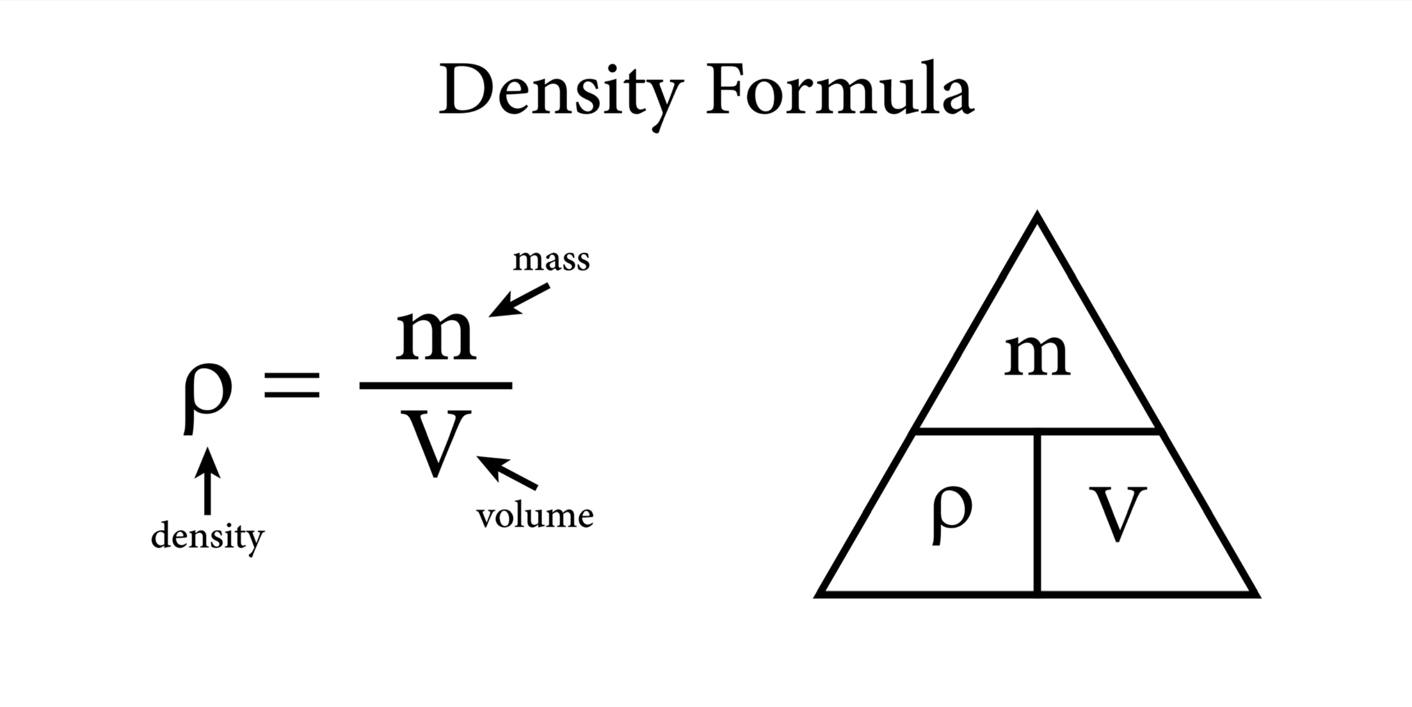
- Study sessions lead by former CHEM 200/202 students that excelled in the previous semesters class.
- Occur 15+ times a week.
- Free to access, no reporting to faculty.

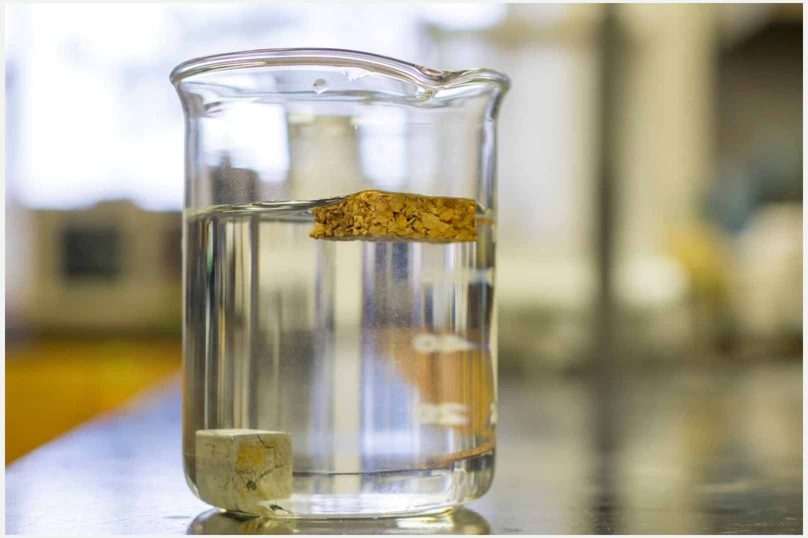
THE MATH AND SCIENCE LEARNING CENTER (MSLC)

Students are encouraged to make use of The Mathematics and Statistics Learning Center (MSLC) for free STEM tutoring, located in the Love Library, Room 328. For a full list of courses tutored, please visit the MSLC website: https://mlc.sdsu.edu/ .

The MSLC is supported by your student success fee. We strongly encourage you to use this wonderful, free resource. Some students believe that they shouldn't need to ask for help, but research has shown that the average grade for students who attend the MLC is almost one full grade higher than those who don't seek such support.

Derived Units: Density





Example: Finding the Density

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

$$\rho = \frac{(69.658\ g)}{(22.4\ mL\ - 13.5\ mL)}$$

$$\rho = \frac{(69.658\ g)}{(8.9\ mL)}$$

$$\rho = 7.8\,\frac{\text{g}}{\text{mL}}$$

Uncertainty in Measurement

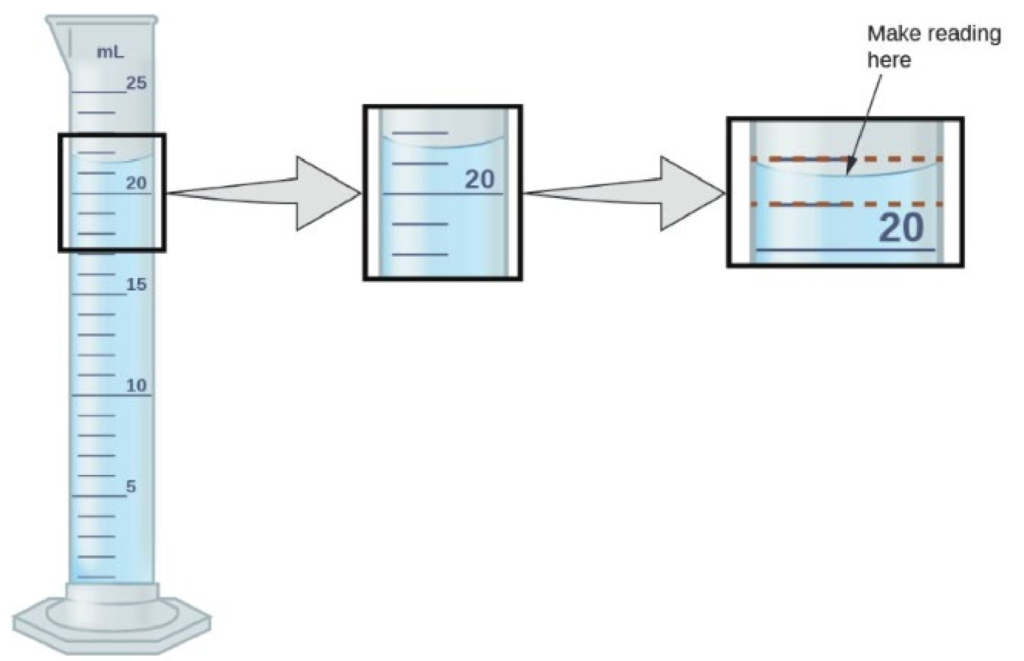


Figure 1.26 To measure the volume of liquid in this graduated cylinder, you must mentally subdivide the distance between the 21 and 22 mL marks into tenths of a milliliter, and then make a reading (estimate) at the bottom of the meniscus.

Person	Volume Recorded (mL)
1	21.7
2	21.8
3	21.6
4	21.7

Certain Digits

Uncertain Digits

Exact numbers

Values that have no uncertainty.

Examples:

- Defined Values
  - 12 in = 1 foot
  - 2.54 cm = 1 in
  - 1000 m = 1 km
- Quantities
  - Number of Trials
  - Number of Molecules
  - Number of People

Significant Figures

What is the difference between 5.67 g and 5.670 g?

The value 5.67 and 5.670 have 3 and 4 significant figures, respectively.

The more significant figures given in your answer, the more precise your results.

Significant Figures

1. Every non-zero digit is significant.
2. A zero between two non-zero numbers is significant; 402 has 3 sig figs
3. A zeros at the beginning of a number are not significant, they are "place holders" that locate the decimal point; 0.0034 has 2 sig figs.
    - 3.4 mg vs. 0.0034 g
4. A zero that comes to the right of a non-zero number after a decimal point is significant; 5.670 has 4 sig figs. The last digit would not have been recorded if it was not significant.
5. A zero that comes to the right of a non-zero number where there is no decimal point may or may not be significant. To specify the number of sig figs, the number can be written in scientific notation; 200 only has 1 sig fig while 2.00×10^2 has 3 sig figs.

Pacific–Atlantic Method

If a decimal point is Present, use the Pacific Method

Start counting from the first non-zero digit from the left side of the number

234.780

0.0000570

200.

If a decimal point is Absent, use the Atlantic Method

Start counting from the first non-zero digit from the right side of the number

48000

39200

67

How could you write 1400 with 3 Sig Figs??

$$1.40 \times 10^3$$

Operations with Sig Figs

<u>Addition and Subtraction:</u>

Answer will have the same number of decimal places as the number with the fewest decimal places

<u>Multiplication and Division:</u>

Answer will have the same number of Sig Figs as the number with the fewest Sig Figs

Operations with Sig Figs Example

$$83.5\ mL + 22.28\ mL = 106.78\ mL$$ 106.8 mL

$$865.90\ g - 2.8121\ g = 863.0879\ g$$ 863.09 g

$$15.6\ cm \times 6.023\ cm \times 0.34\ cm = 31.945992\ cm^3$$ 32 cm^3

$$500\ g \div 305.4\ mL = 1.6371971\ \frac{g}{mL}$$ 2 g/mL

Combining Operation

$$\frac{23.09\ g\ - 0.345\ g}{340.147\ mL\ + 0.00991\ mL} = \frac{22.75\ g}{340.156\ mL} = 6.687\ \times 10^{-2}\ \frac{g}{mL}$$

Rounding Rules

If the first digit to be removed is > 5 ROUND UP!

45.648 → 45.65

If the first digit to be removed is <5 ROUND DOWN!

319.0672 → 319.067

New RULE:

If the first digit to be removed is EQUAL to 5….

Round the to the nearest EVEN number

78.045 → 78.04

78.055 → 78.06

78.065 → 78.06

78.075 → 78.08

This prevents systematic error, since sometimes you will be rounding up and sometimes you will be rounding down!

Rounding Rules Examples

46.7435 to 5 sig figs

46.744

108.5 to 3 sig figs

108

23.97 to 3 sig figs

24.0

Errors in Measurement

- Random Errors: Can make your values larger or smaller. Unavoidable, but can be minimized by taking multiple measurements

- Systematic Errors: Make your values either larger or smaller, not both. Harder to recognize, can be minimized by calibration

Precision and Accuracy

Precision: How close are your values to EACH OTHER?

Less variation (low standard deviation) means high precision.

Random errors affect your precision much more than systematic errors.

You get better precision with better technique and more accurate instruments.

Accuracy: How close are your values to the ACTUAL VALUE?

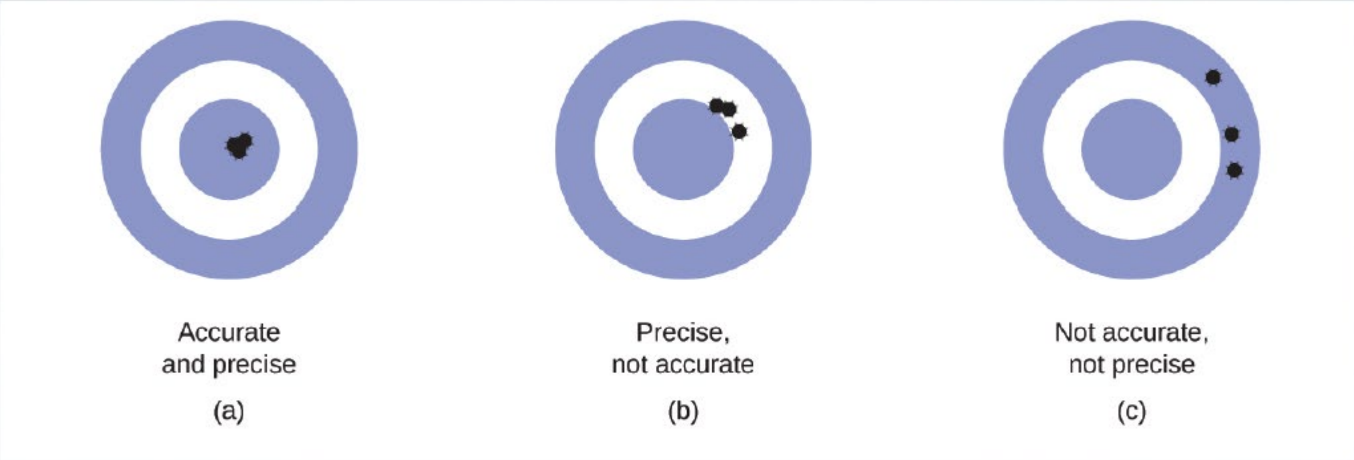
Low percent error means high accuracy

Sometimes the actual value (and therefore the level of accuracy) is not known

Systematic errors can greatly affect your accuracy, Random errors can be minimized by taking averages

You get better accuracy by eliminating systematic errors

Precision and Accuracy

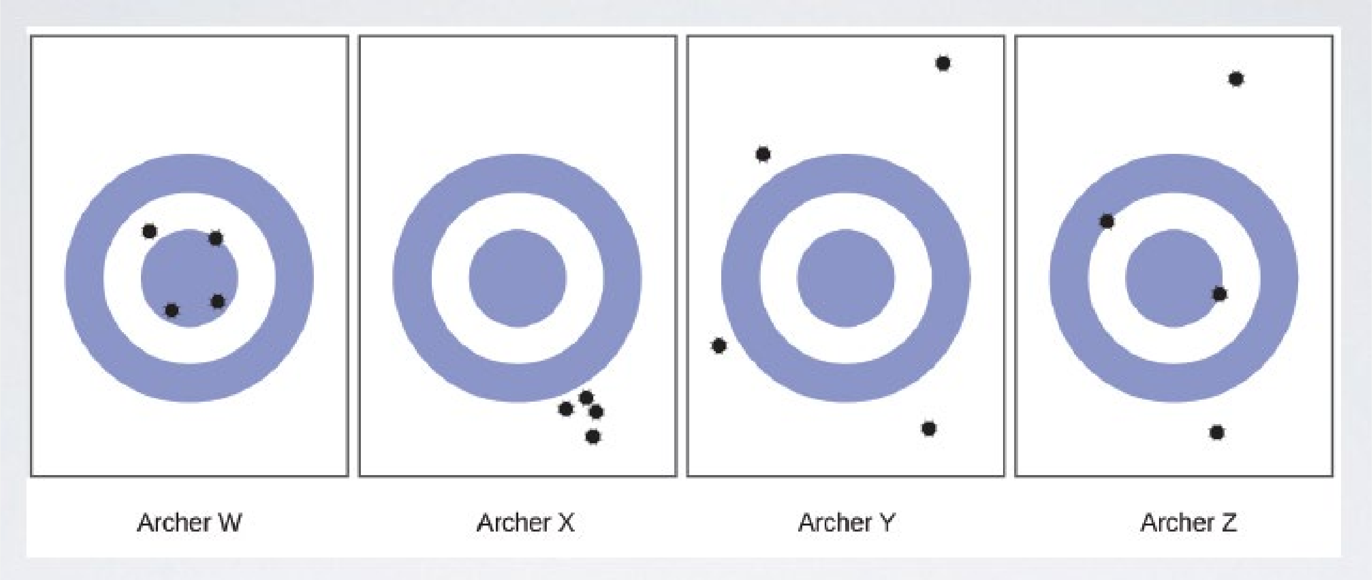


(a) These arrows are close to both the bull's eye and one another, so they are both accurate and precise.

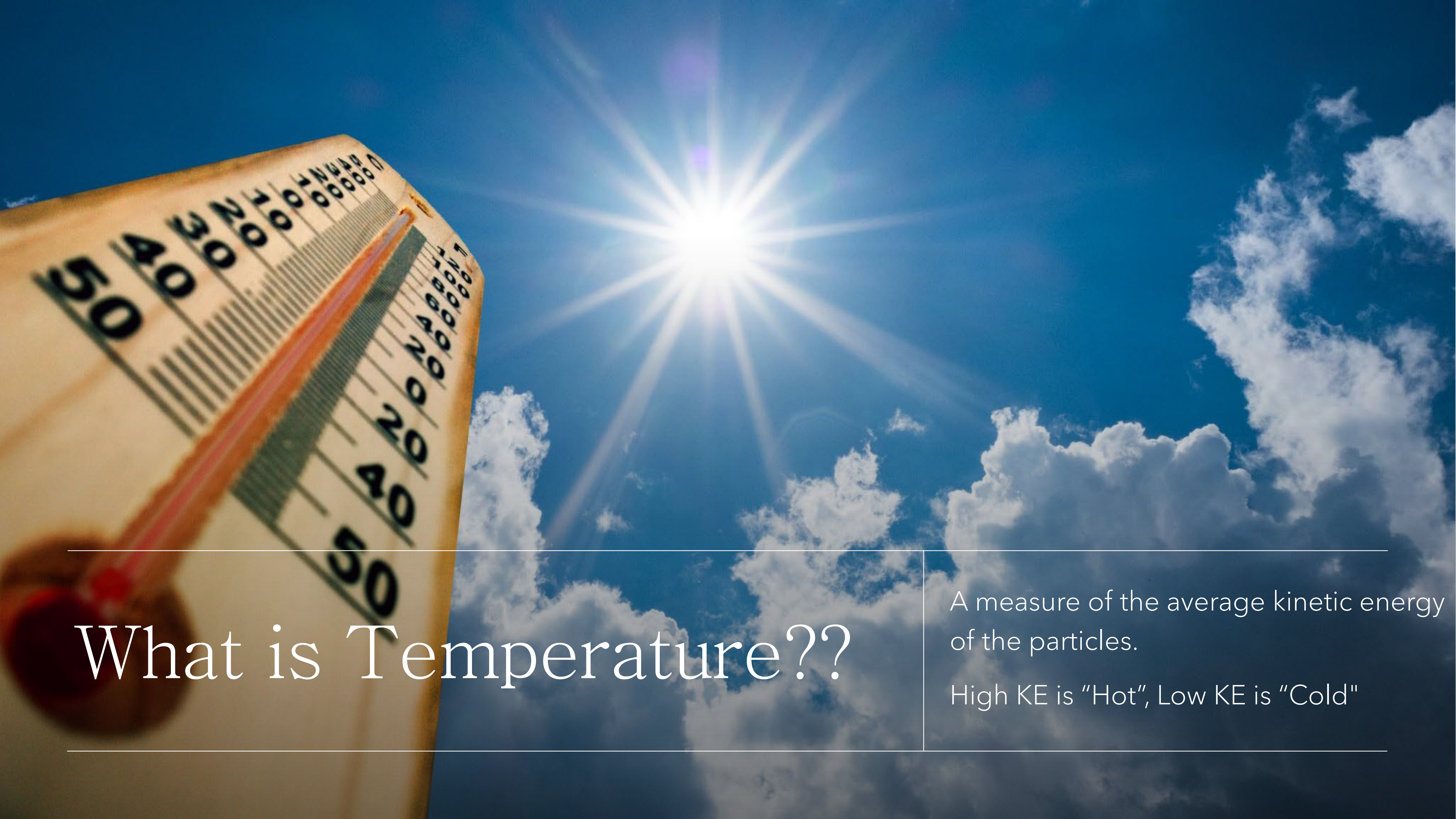
(b) These arrows are close to one another but not on target, so they are precise but not accurate.

(c) These arrows are neither on target nor close to one another, so they are neither accurate nor precise.

Lecture Participation:



1. Which archer is the most accurate?
2. Which archer is the most precise?
3. Which archer would you want to be?



What is Temperature??

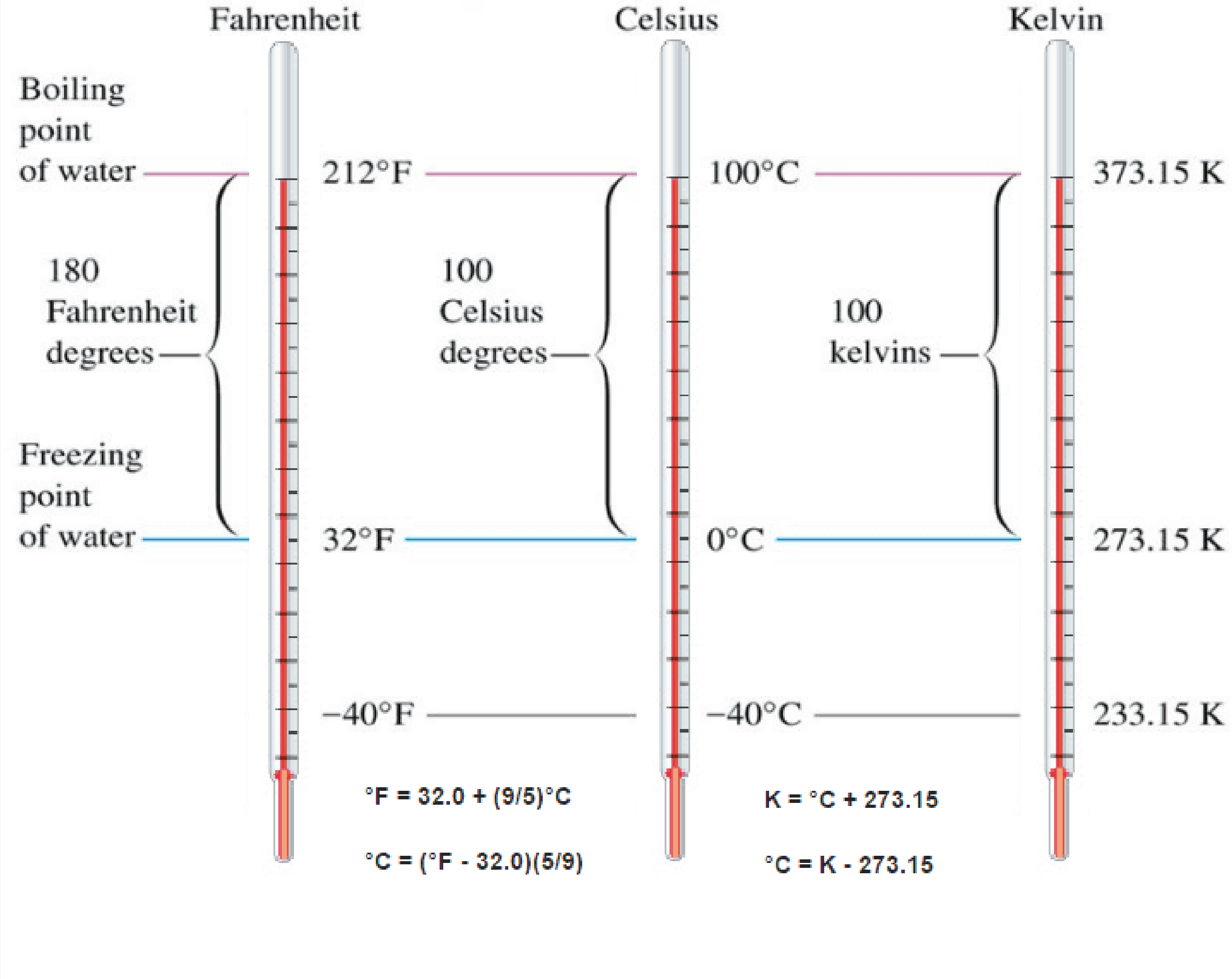
A measure of the average kinetic energy of the particles.

High KE is “Hot”, Low KE is “Cold"

Temperature Scales

- Fahrenheit (1724)
  - Generally not used in science
- Celsius (1742)
  - Principle temperature scale
- Kelvin (1848)
  - Absolute temperature scale
  - Same interval as Celsius scale
  - Incorrect to say "degree Kelvin"!

- Freezing Point of Water
  - 32 ˚F, 0 ˚ C, 273.15 K
- Boiling point of water
  - 212 ˚F, 100 ˚ C, 373.15 K



Temperature Conversion

$$T_C = \left(\frac{5}{9}\right)(T_F - 32)$$

$$T_K = T_C + 273.15$$

$$T_C = T_K - 273.15$$

Dimensional Analysis Examples

Convert 8.9 x 10^{18} m/s to km/day

$$\left(\frac{8.9\ \times 10^{18}\ m}{1\ s}\right)\left(\frac{1\ km}{1000\ m}\right)\left(\frac{60\ s}{1\ min}\right)\left(\frac{60\ min}{1\ hr}\right)\left(\frac{24\ hrs}{1\ day}\right) = 7.7\ \times 10^{20}\ \ km/day$$

How many miles in 1 light year?

$$\left(\frac{3.00\ \times 10^{8}\ m}{1\ s}\right)\left(\frac{100\ cm}{1\ m}\right)\left(\frac{1\ inch}{2.54\ cm}\right)\left(\frac{1\ ft}{12\ inches}\right)\left(\frac{1\ mile}{5280\ ft}\right)\left(\frac{3600\ s}{1\ hr}\right)\left(\frac{24\ hrs}{1\ day}\right)\left(\frac{365.25\ days}{1\ year}\right) = 5.88\ \times 10^{12}\ miles\ per\ year$$

Question

- You have a recipe that says to use 410 g of flour and to set you oven to 250 C. Your scale only has units of oz, and your oven uses Fahrenheit. How much flour are you going to measure out and what will you set your oven temperature to?

- 1 oz= 28 g

480 ˚C

15 oz

$$T_C = \left(\frac{5}{9}\right)(T_F - 32)$$

$$T_K = T_C + 273.15$$

$$T_C = T_K - 273.15$$

EARLY ATOMIC THEORY

THE SUB-ATOMIC PARTICLES

ISOTOPES AND IONS

MOLECULAR AND IONIC COMPOUNDS

NOMENCLATURE

Chapter 2: Atoms, Molecules and Ions

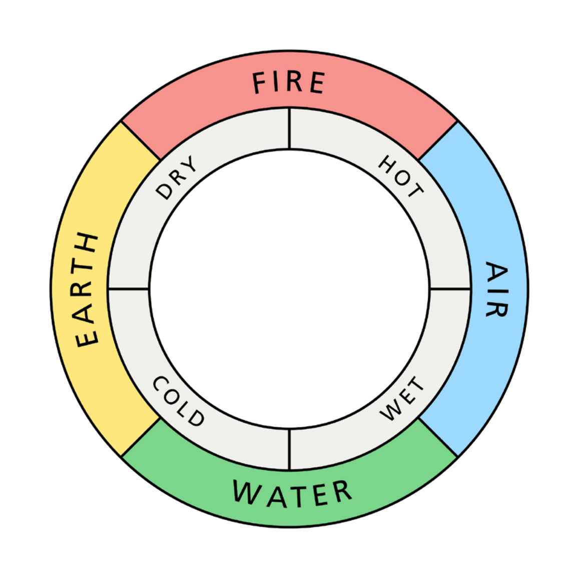
Early Theories About Matter

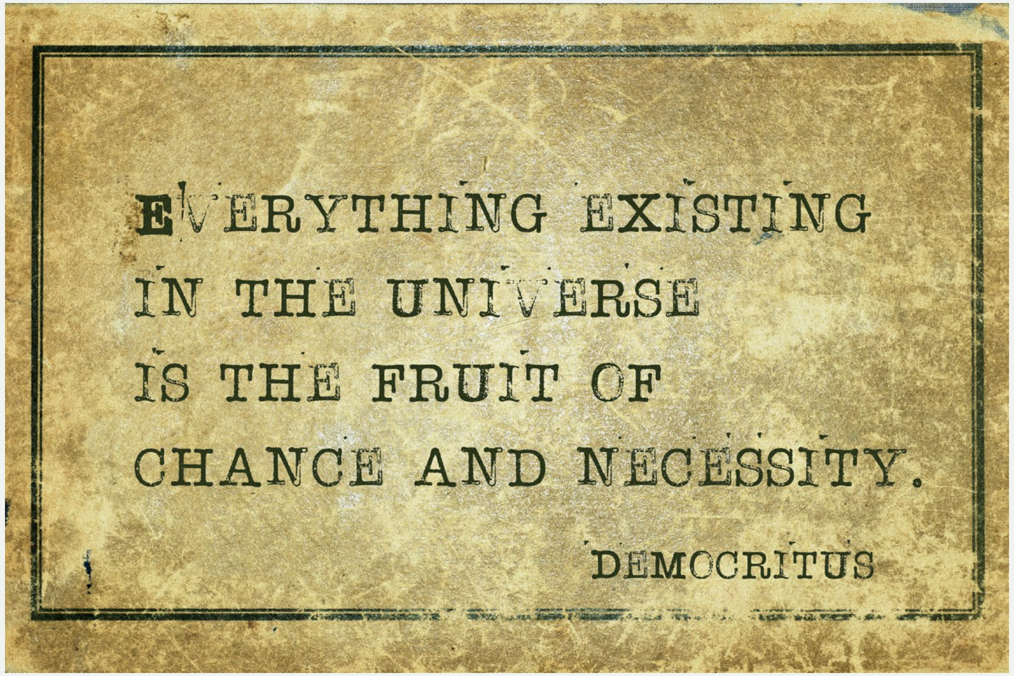
The Greeks:

Can matter be divided into infinitely smaller pieces?

If not, what is the smallest unit of matter?

"Atomos"- Indivisible



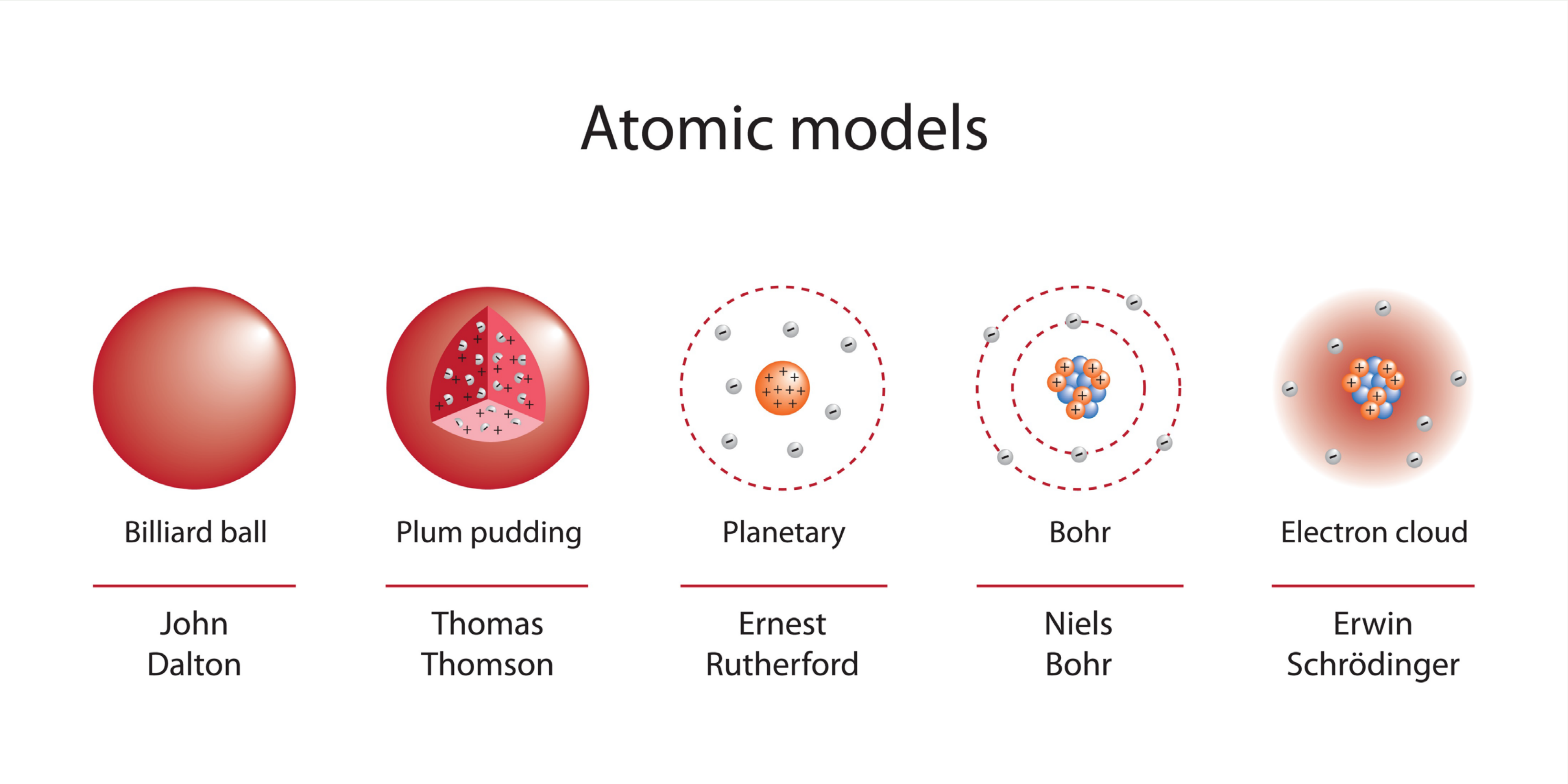


Early Theories about Matter

Alchemists-

Tried to "transmute" lead in to gold, among other things.

Very secretive, not sharing knowledge


Atomic models
Billiard ball
Plum pudding
Planetary
Bohr
Electron cloud
John
Dalton
Thomas
Thomson
Ernest
Rutherford
Niels
Bohr
Erwin
Schrödinger

Dalton's Atomic Theory

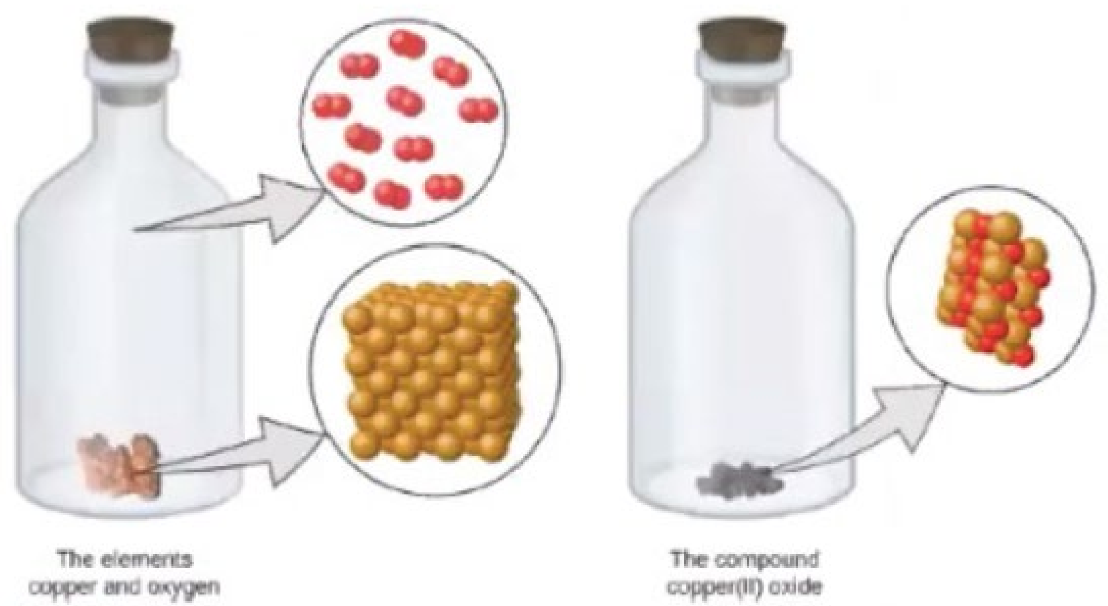


Figure 2.4 When the elements copper (a shiny, red-brown solid, shown here as brown spheres) and oxygen (a clear and colorless gas, shown here as red spheres) react, their atoms rearrange to form a compound containing copper and oxygen (a powdery, black solid). (credit copper: modification of work by http://images-of-elements.com/copper.php)

1. Matter consists of atoms
2. Atoms are the smallest unit of an element that still has the properties of that element
3. Elements consist of only one type of atom
4. Atoms of one element differ in properties from atoms of another element
5. A compound is made from atoms of tow or more different elements combined in small whole number rations (Law of Constant Composition)
6. During chemical reactions, atoms are not created or destroyed but rather rearranged to form different compounds (Law of Conservation of Mass)

Law of Constant Composition

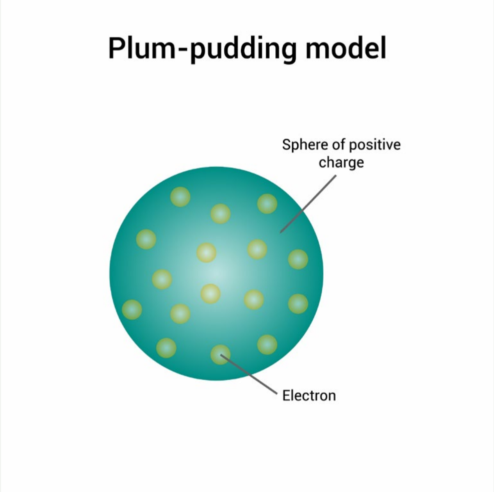
All samples of a Pure Compound contain the same elements in the same proportions

Constant Composition of Isooctane

Sample	Carbon	Hydrogen	Mass Ratio
A	14.82 g	2.78 g	$\frac{14.82\text{ g carbon}}{2.78\text{ g hydrogen}} = \frac{5.33\text{ g carbon}}{1.00\text{ g hydrogen}}$
B	22.33 g	4.19 g	$\frac{22.33\text{ g carbon}}{4.19\text{ g hydrogen}} = \frac{5.33\text{ g carbon}}{1.00\text{ g hydrogen}}$
C	19.40 g	3.64 g	$\frac{19.40\text{ g carbon}}{3.63\text{ g hydrogen}} = \frac{5.33\text{ g carbon}}{1.00\text{ g hydrogen}}$

Table 2.1

J.J. Thomson



Discovery of Electrons

Calculated the mass to charge ratio for electrons

https://youtu.be/o1z2S3ME0cI

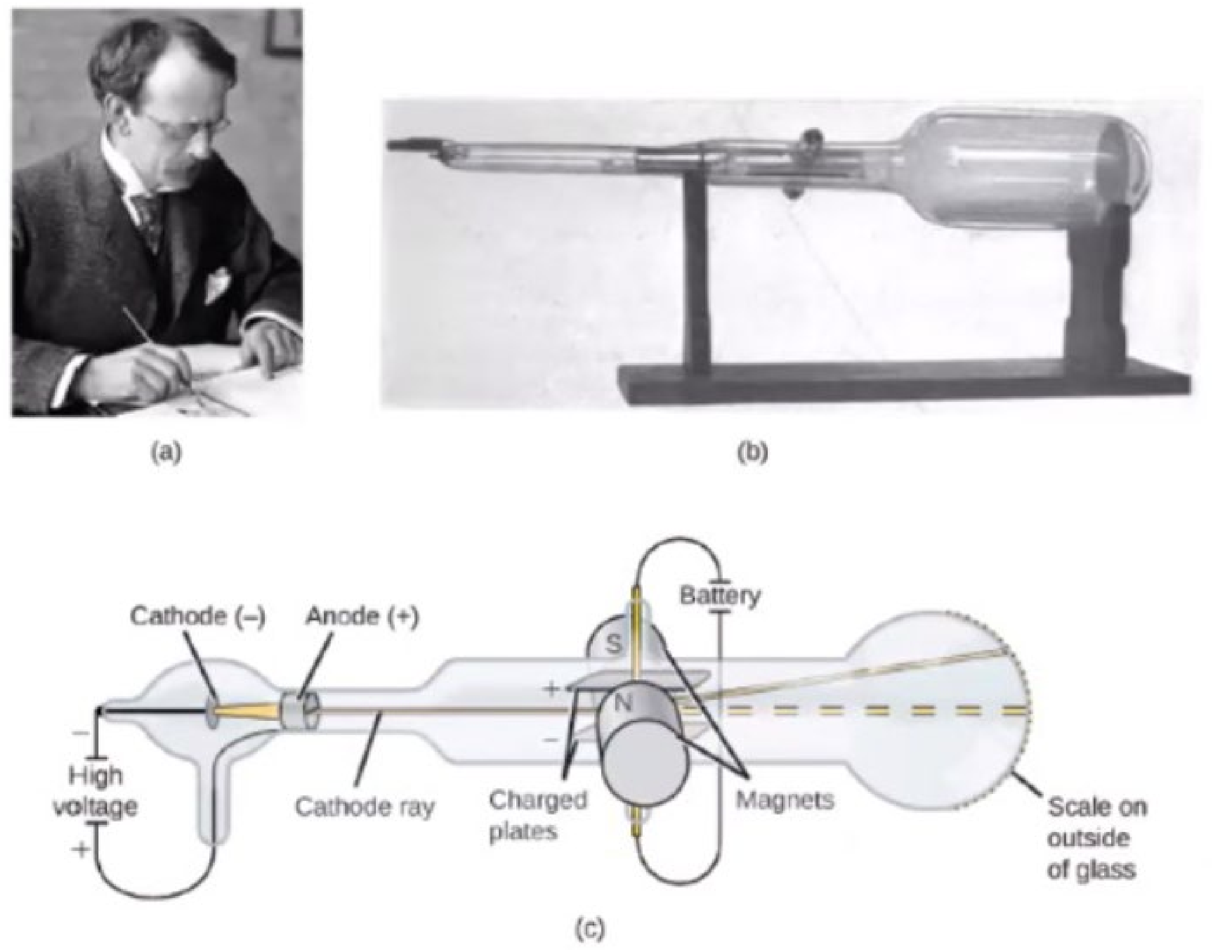
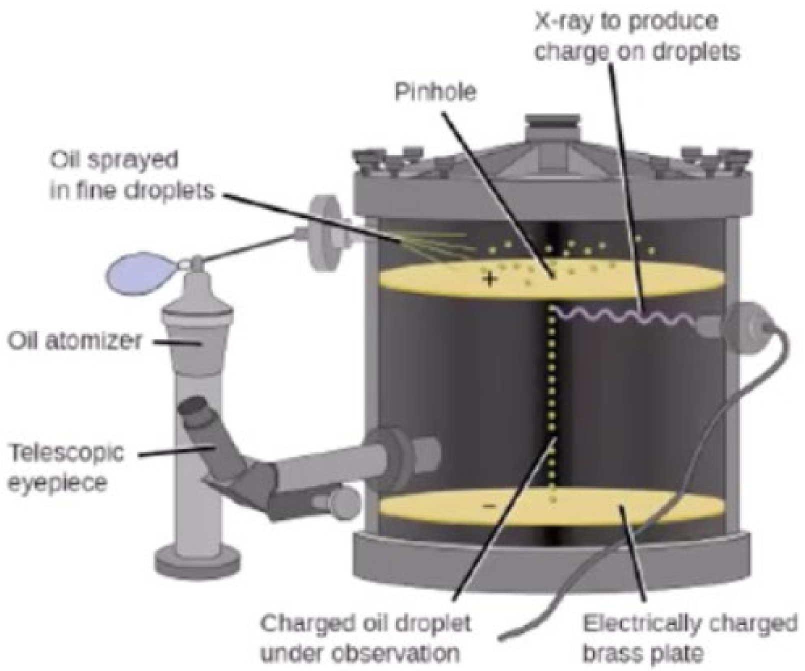


Figure 2.6 (a) J. J. Thomson produced a visible beam in a cathode ray tube. (b) This is an early cathode ray tube, invented in 1897 by Ferdinand Braun. (c) In the cathode ray, the beam (shown in yellow) comes from the cathode and is accelerated past the anode toward a fluorescent scale at the end of the tube. Simultaneous deflections by applied

Oil Drop Experiment



Oil drop	Charge in coulombs (C)
A	4.8×10^{-19} C
B	3.2×10^{-19} C
C	6.4×10^{-19} C
D	1.6×10^{-19} C
E	4.8×10^{-19} C

Figure 2.7 Millikan's experiment measured the charge of individual oil drops. The tabulated data are examples of a few possible values.

Determined the magnitude of the elemental charge

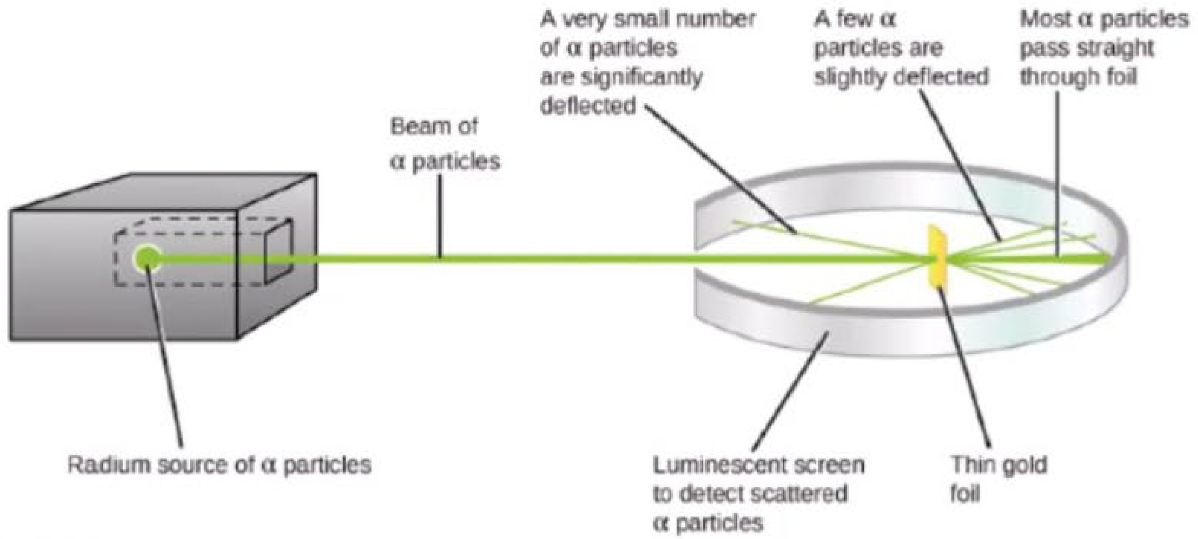


Figure 2.9 Geiger and Rutherford fired α particles at a piece of gold foil and detected where those particles went, as shown in this schematic diagram of their experiment. Most of the particles passed straight through the foil, but a few were deflected slightly and a very small number were significantly deflected.

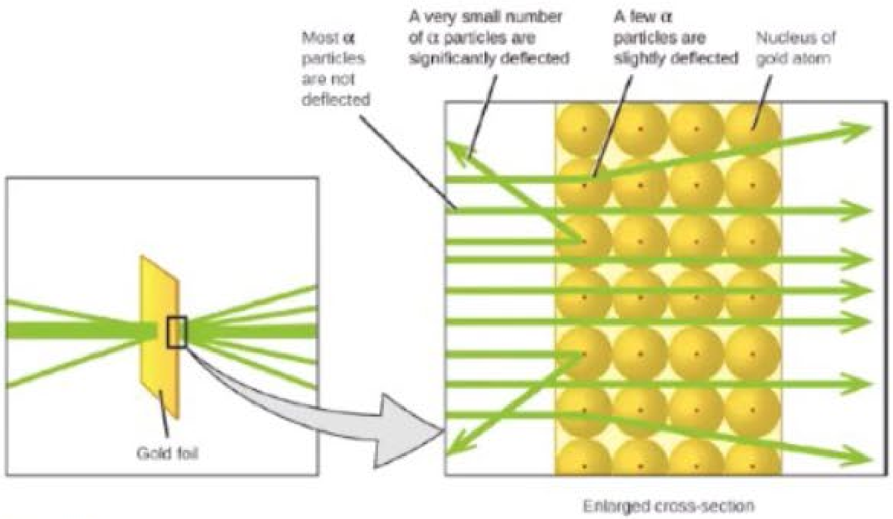
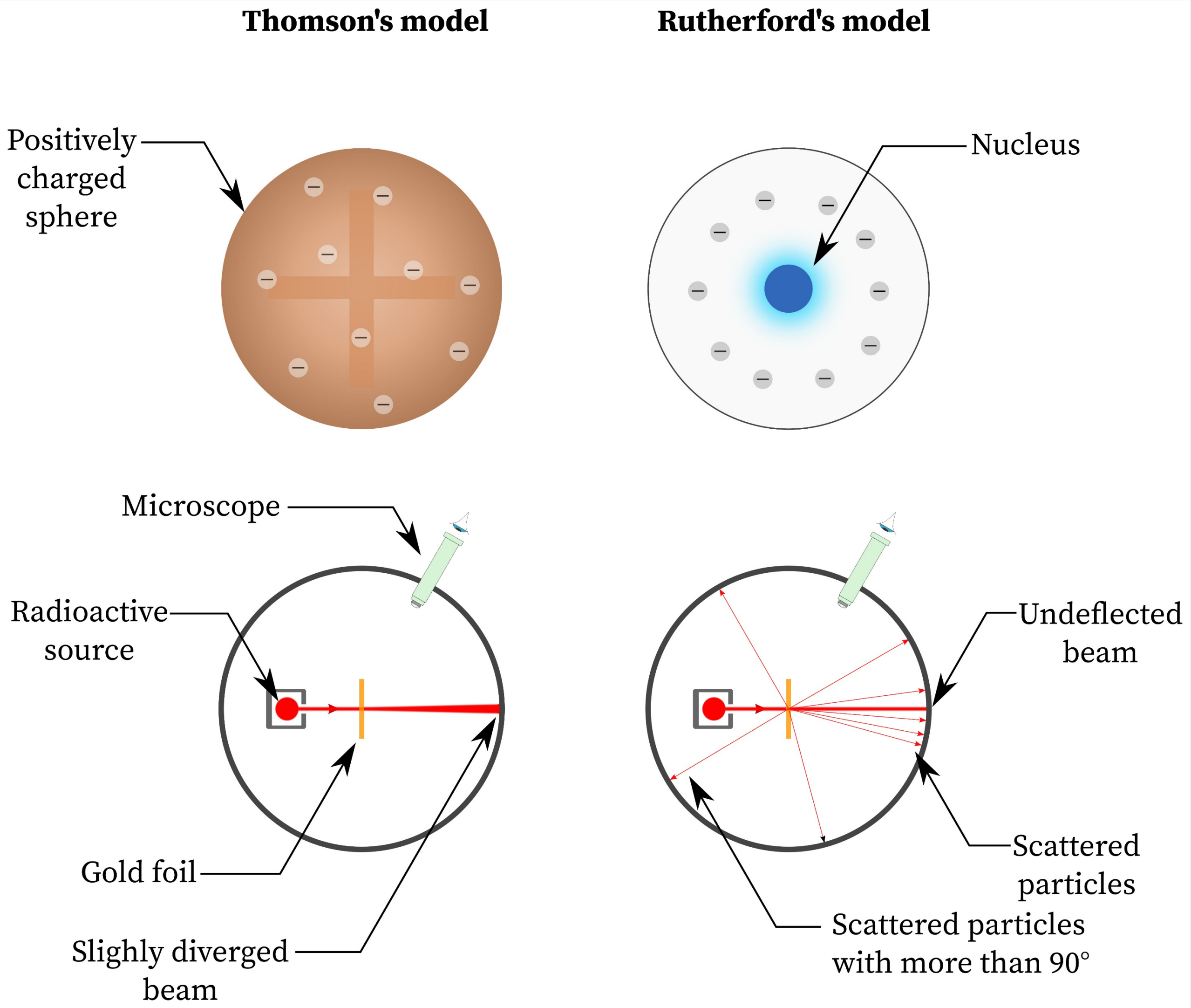


Figure 2.10 The α particles are deflected only when they collide with or pass close to the much heavier, positively charged gold nucleus. Because the nucleus is very small compared to the size of an atom, very few α particles are deflected. Most pass through the relatively large region occupied by electrons, which are too light to deflect the rapidly moving particles.

Gold Foil Experiment

Discovery of the Nucleus


Thomson's model
Rutherford's model
Positively charged sphere
Nucleus
Microscope
Radioactive source
Gold foil
Slighly diverged beam
Undeflected beam
Scattered particles
Scattered particles with more than 90°

The Subatomic Particles

Properties of Subatomic Particles

Name	Location	Charge (C)	Unit Charge	Mass (amu)	Mass (g)
electron	outside nucleus	-1.602×10^{-19}	1−	0.00055	0.00091×10^{-24}
proton	nucleus	1.602×10^{-19}	1+	1.00727	1.67262×10^{-24}
neutron	nucleus	0	0	1.00866	1.67493×10^{-24}

Table 2.2

Isotopes

Nuclear Compositions of Atoms of the Very Light Elements

Element	Symbol	Atomic Number	Number of Protons	Number of Neutrons	Mass (amu)	% Natural Abundance
	${}^{2}_{1}H$ (deuterium)	1	1	1	2.0141	0.0115
	${}^{3}_{1}H$ (tritium)	1	1	2	3.01605	— (trace)
helium	${}^{3}_{2}He$	2	2	1	3.01603	0.00013
	${}^{4}_{2}He$	2	2	2	4.0026	100
lithium	${}^{6}_{3}Li$	3	3	3	6.0151	7.59
	${}^{7}_{3}Li$	3	3	4	7.0160	92.41
beryllium	${}^{9}_{4}Be$	4	4	5	9.0122	100
boron	${}^{10}_{5}B$	5	5	5	10.0129	19.9
	${}^{11}_{5}B$	5	5	6	11.0093	80.1
carbon	${}^{12}_{6}C$	6	6	6	12.0000	98.89
	${}^{13}_{6}C$	6	6	7	13.0034	1.11
	${}^{14}_{6}C$	6	6	8	14.0032	— (trace)
nitrogen	${}^{14}_{7}N$	7	7	7	14.0031	99.63
	${}^{15}_{7}N$	7	7	8	15.0001	0.37
oxygen	${}^{16}_{8}O$	8	8	8	15.9949	99.757
	${}^{17}_{8}O$	8	8	9	16.9991	0.038
	${}^{18}_{8}O$	8	8	10	17.9992	0.205
fluorine	${}^{19}_{9}F$	9	9	10	18.9984	100
neon	${}^{20}_{10}Ne$	10	10	10	19.9924	90.48
	${}^{21}_{10}Ne$	10	10	11	20.9938	0.27
	${}^{22}_{10}Ne$	10	10	12	21.9914	9.25

Table 2.4

Ions

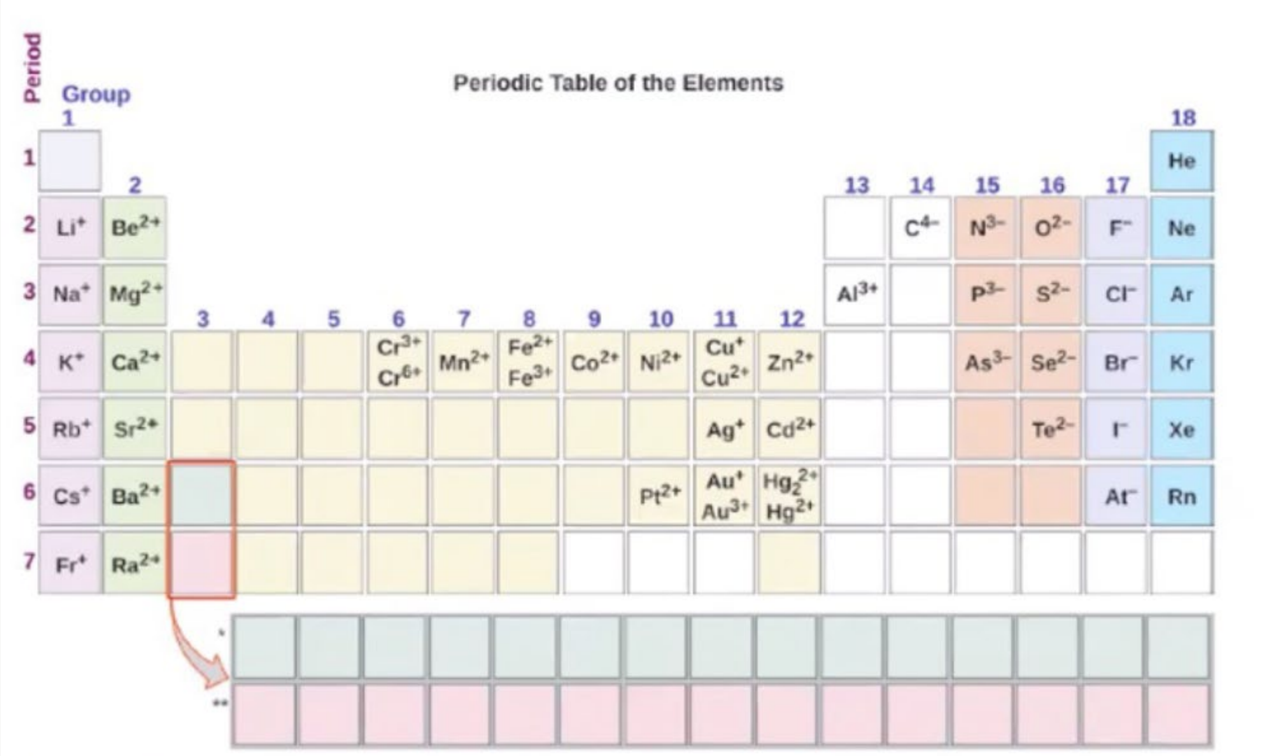
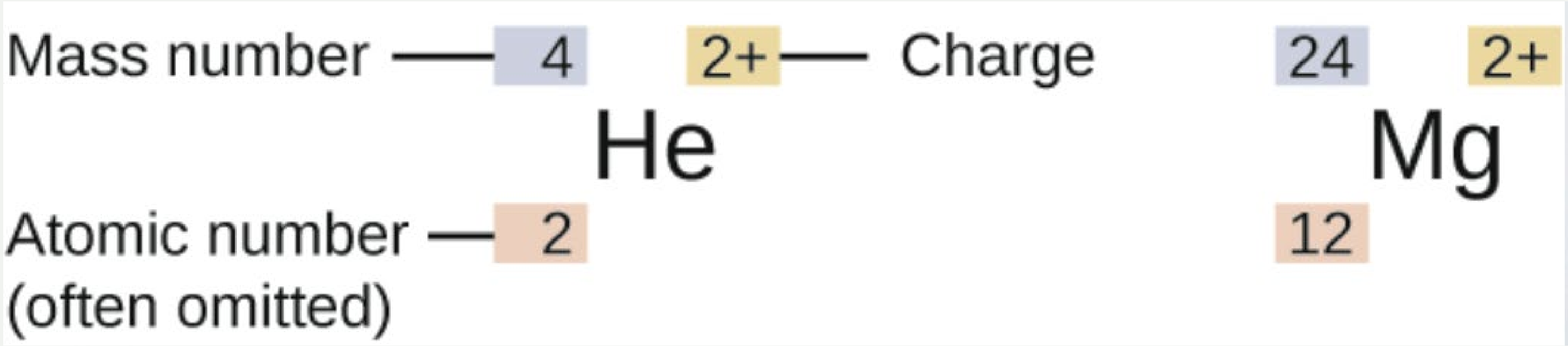
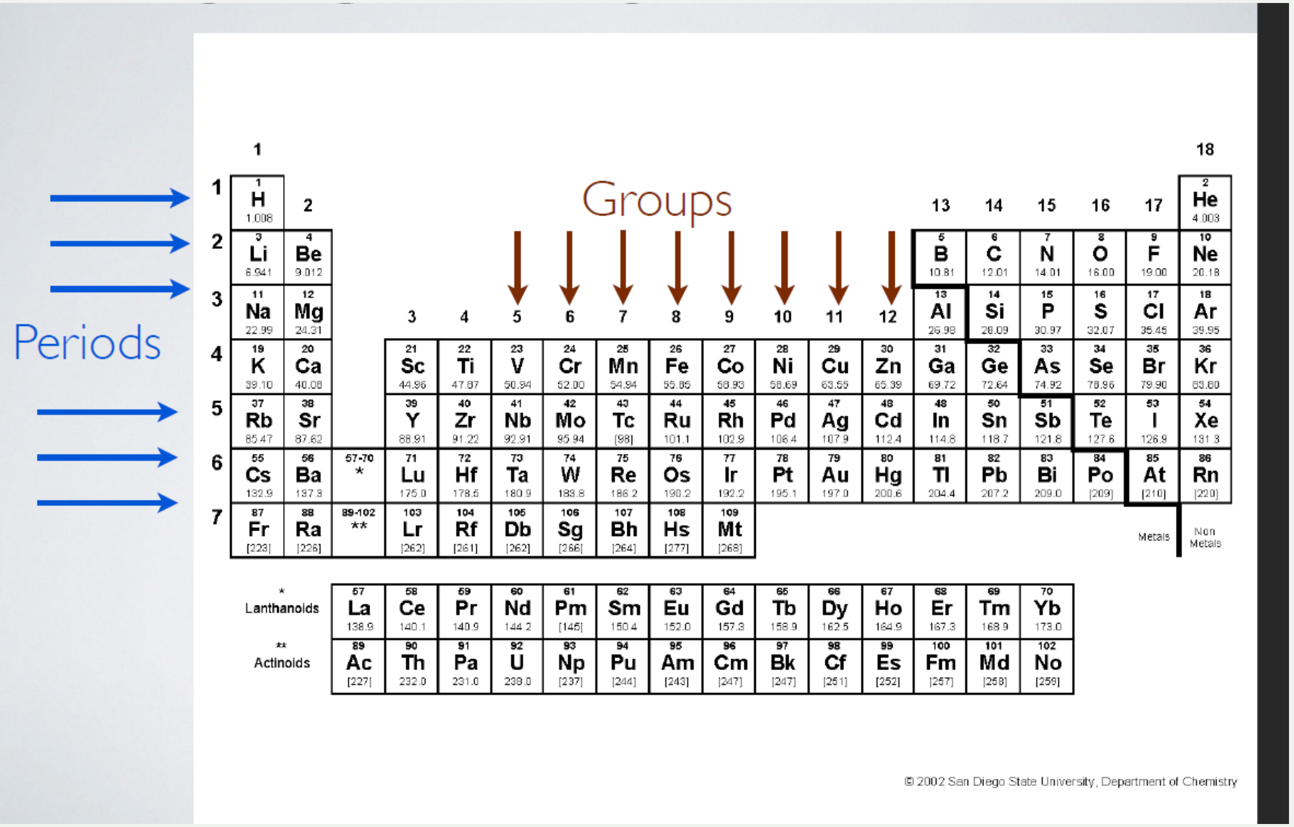


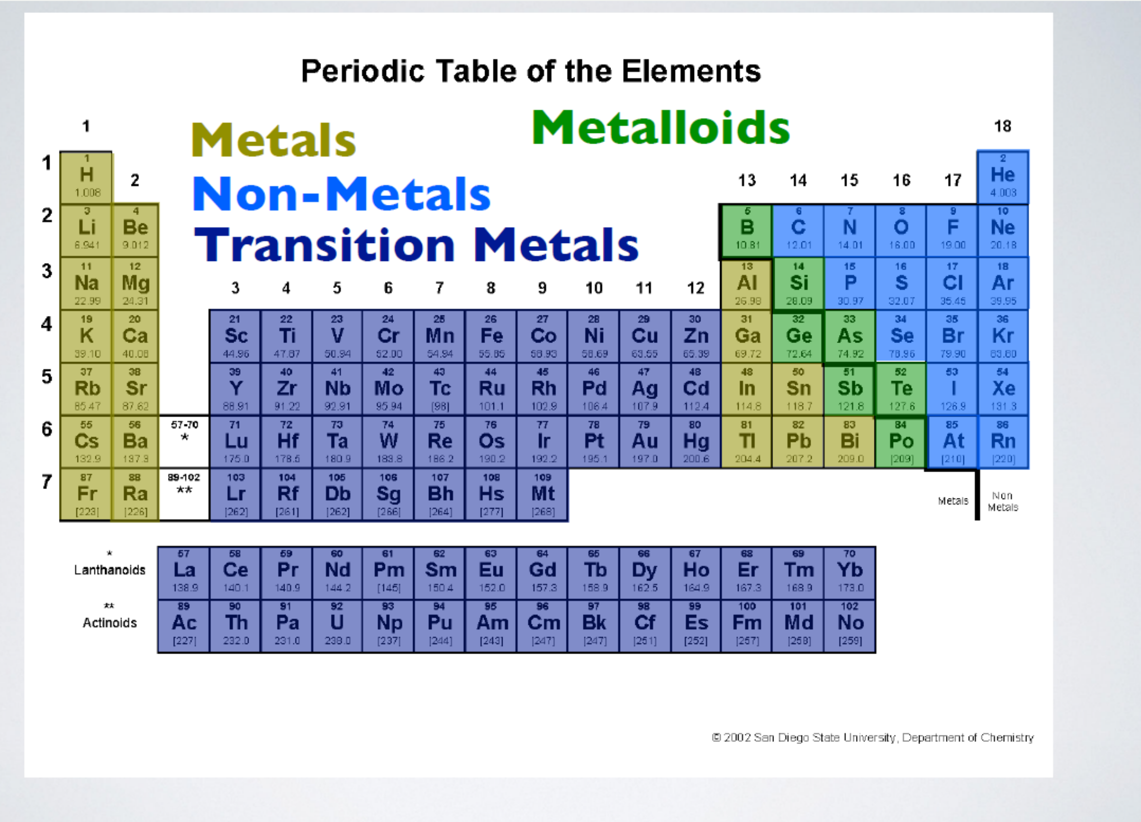
Figure 2.29 Some elements exhibit a regular pattern of ionic charge when they form ions.

Atomic Symbols



The periodic table




Periodic Table of the Elements
Metals
Metalloids
Non-Metals
Transition Metals
Lanthanoids
Actinoids
Metals
Non Metals
© 2002 San Diego State University, Department of Chemistry

Atomic Mass vs. Atomic Weight vs. Mass Number

- Atomic Mass= The mass of a single atom
  - A single ^{12}C atom has an atomic mass of exactly 12 amu (defined)
  - A single ^{13}C atom has an atomic mass of 13.003355 amu (to 8 sig figs)
  - A single ^{16}O atom has an atomic mass of 15.994914 amu (to 8 sig figs)
- Atomic Weight (Average Atomic Mass)= The average mass of the isotopes
  - Carbon has an Average Atomic Mass of 12.011 amu
  - Oxygen has an Average Atomic Mass of 15.999 amu
- Mass Number = Number of Protons + Number of Neutrons
  - ^{12}C has 6 protons and 6 neutrons
  - ^{13}C has 6 protons and 7 neutrons

How many protons, neutrons and electrons?

$$^{16}_{8}O^{-2}$$

Mass Spectrometry

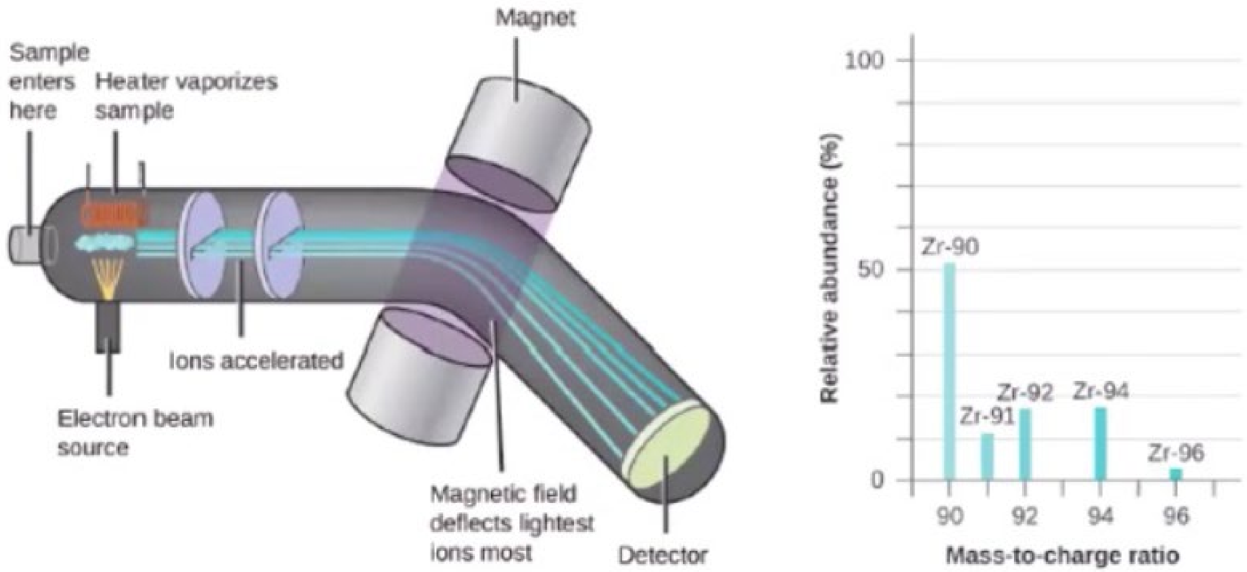


Figure 2.15 Analysis of zirconium in a mass spectrometer produces a mass spectrum with peaks showing the different isotopes of Zr.

Calculating Average Atomic Mass

<u>Isotopes of Silicon</u>:	<u>Percent Abundance</u>:	<u>Atomic Mass</u>:
Silicon-28	92.23%	27.97693 amu
Silicon-29	4.68%	28.97649 amu
Silicon-30	3.09%	29.97377 amu

27.97693 amu (0.9223) + 28.97649 amu (0.0468) + 29.97377 amu (0.0309) = 28.09 amu

Finding Percent Abundance

- The average mass for lithium (Li) is 6.94 g/mol. The isotopes of lithium are ^{6}Li and ^{7}Li with respective masses of 6.0151 amu and 7.0160 amu.

- Given this information, what is the abundance of each of the isotopes?