CHEM 200/202

Professor Theresa Carlson
Office: GMCS-213B

All emails are to be sent to:
chem200@sdsu.edu

My office hours will be held on zoom via MSLC on **Mondays & Wednesday from 8:00 am to 10:00 am** or by appointment

HOW THE CLASS WILL WORK

Email (for all needs): *chem200@sdsu.edu*
Website: https://sdsuchem200.sdsu.edu/ (Website is meant for waitlisters and has everything except: grades and Turnitin. For the previous two items please find on Canvas when you are enrolled. **The CHEM 200 Website will close after Exam 1**)

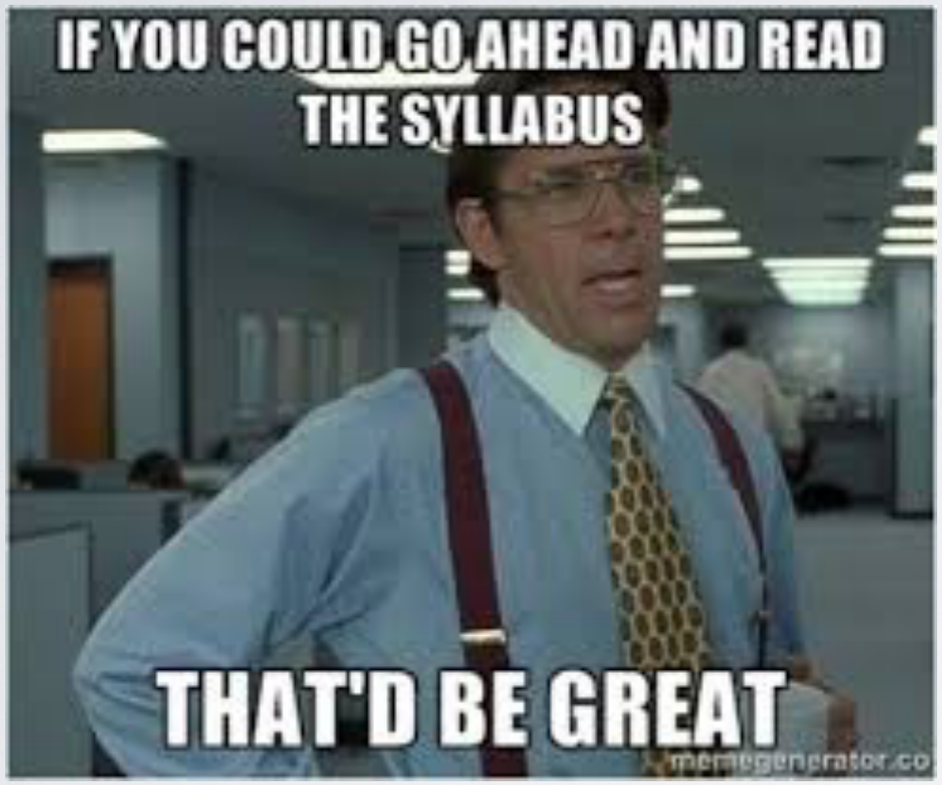
Instructor: Prof. Theresa Carlson, M.A.
Lecture: 12:00 PM – 12:50 PM MWF in HT-140
Help Room (Zoom): 8:00 AM - 10:00 AM Mondays & Wednesdays **Zoom *via* https://mlc.sdsu.edu/**

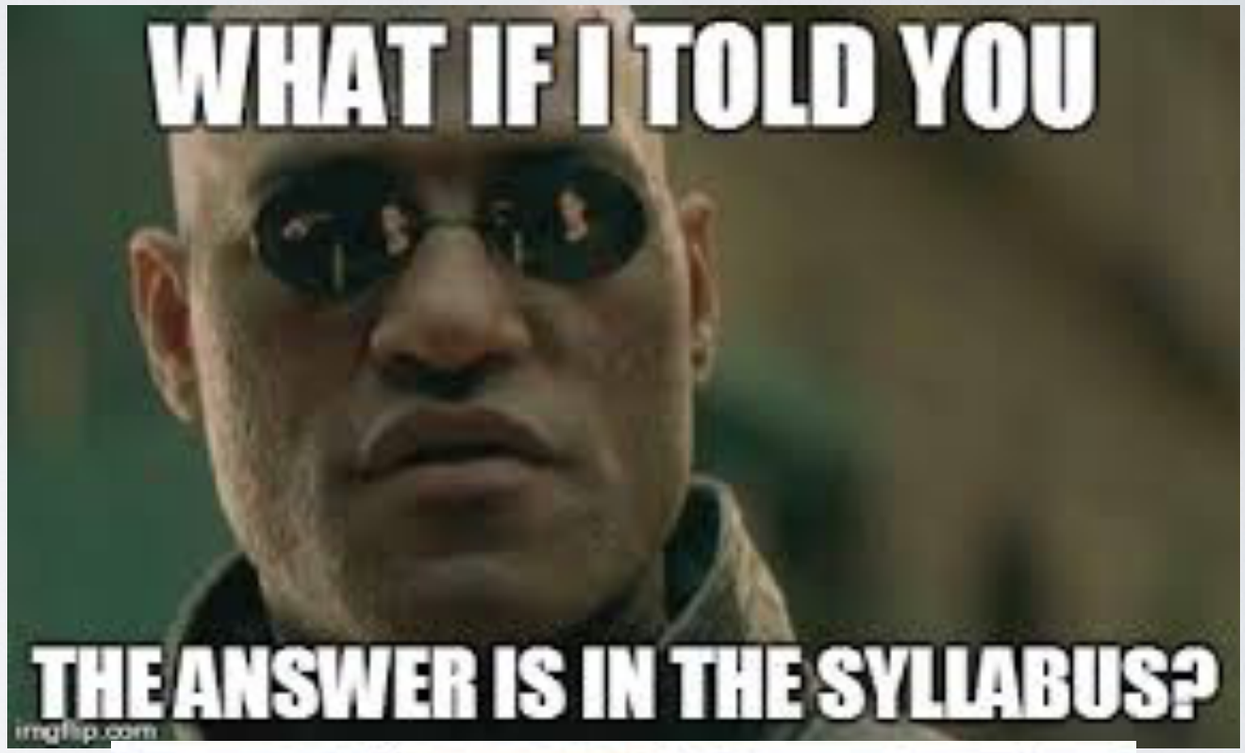
Lab Coordinator: Megan Bowles, M.A.
Help Room (Zoom): 9:00 AM - 11:00 AM Tuesdays **Zoom *via* https://mlc.sdsu.edu/**

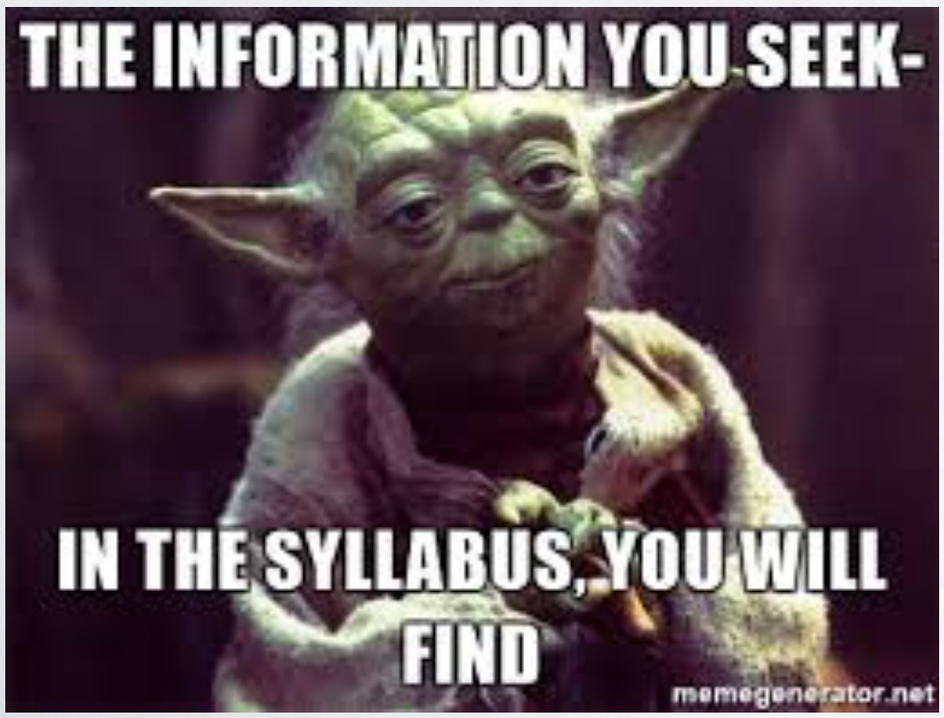
Mode of Instruction: Face-to-Face. Lectures will be recorded using Course Capture/Mediasite and available on Canvas. Attendance is strongly encouraged. There will be 40 points out of 43 points for lecture participation. Labs sessions are in-person as well.

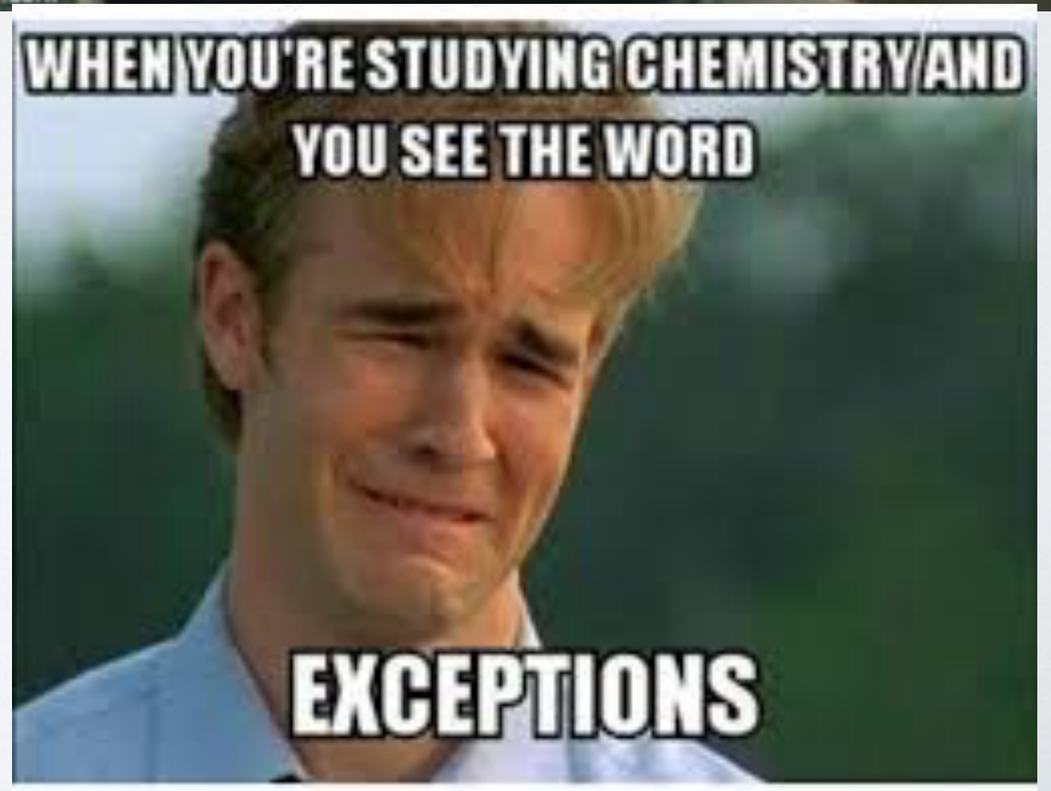
Exams will take place online via OWL.

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.

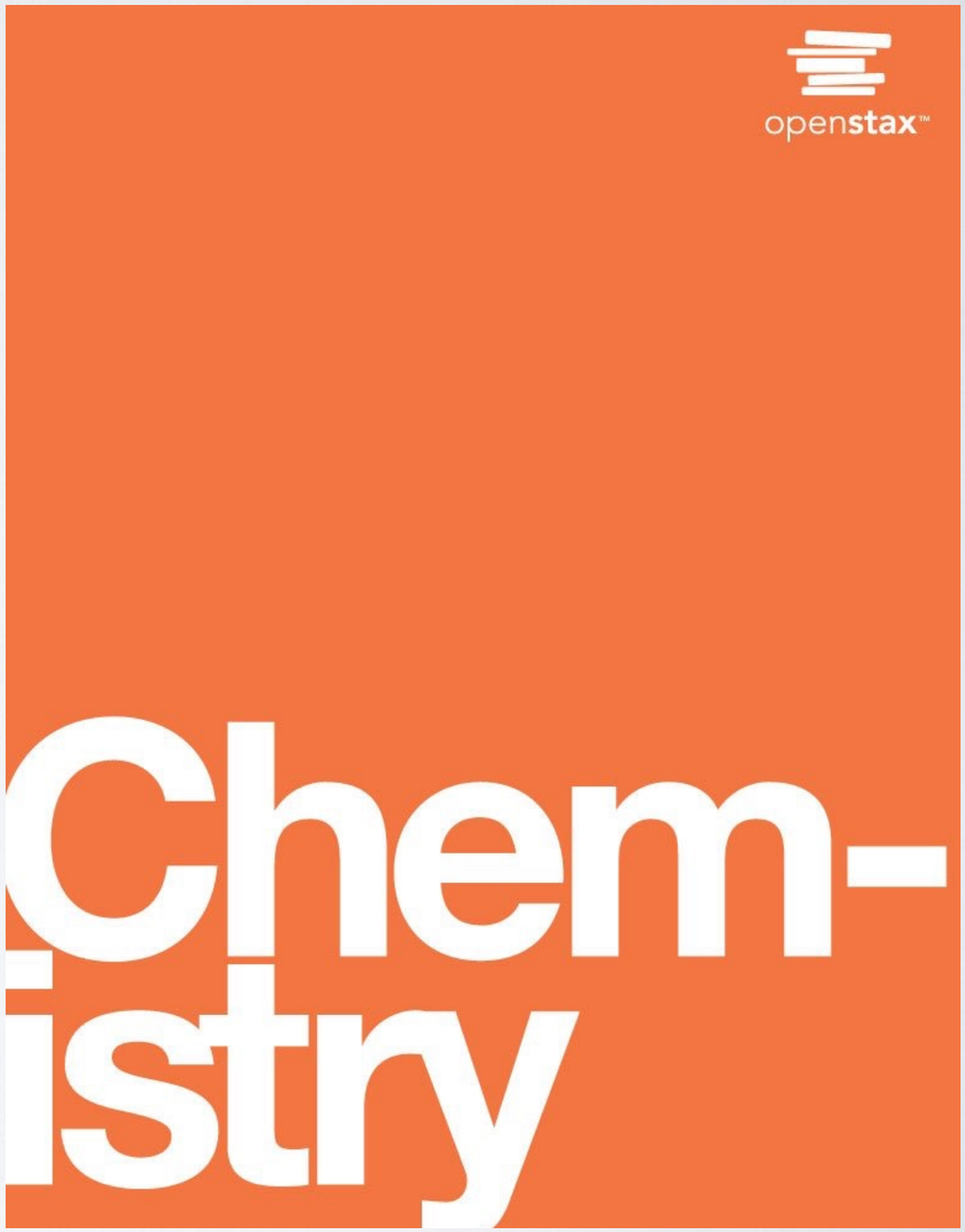
THE MATH AND SCIENCE LEARNING CENTER (MSLC)

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.

TEXTBOOK

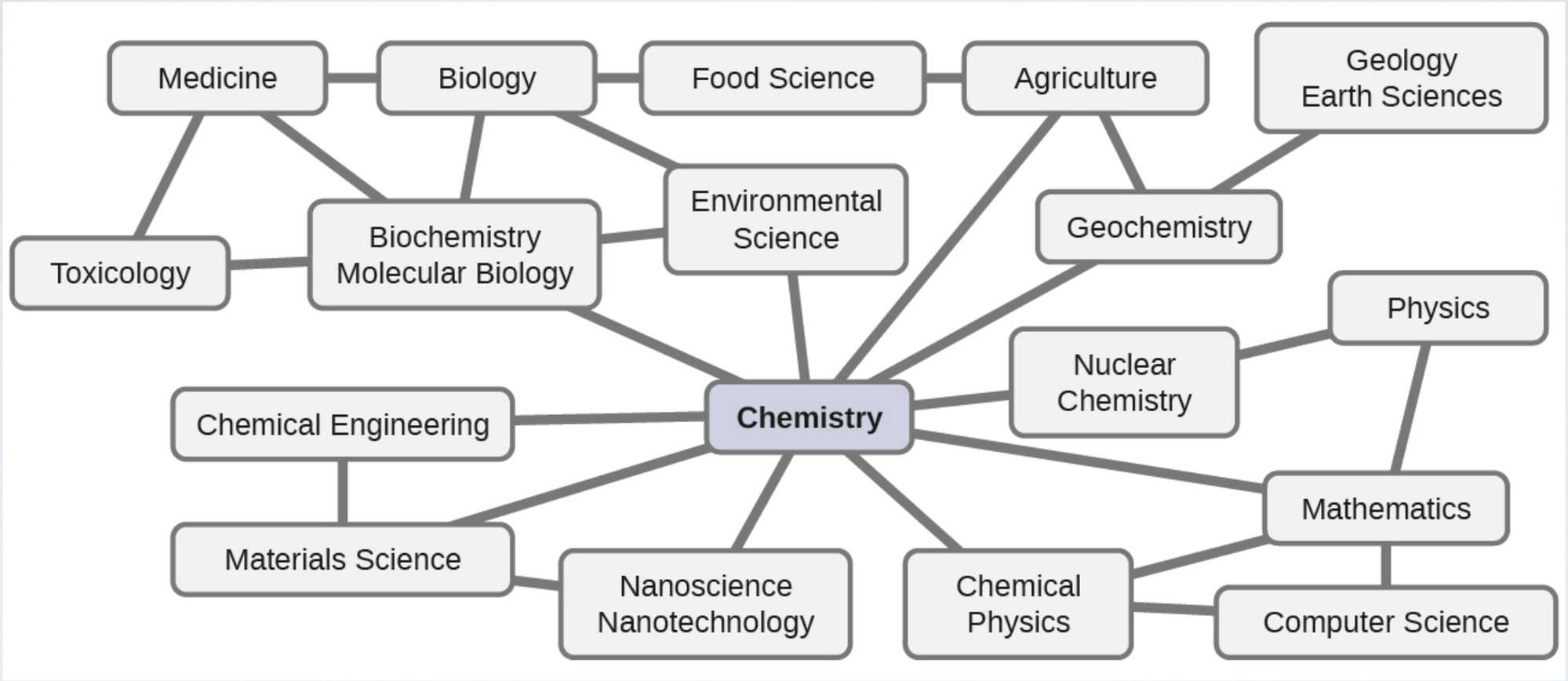
- **Openstax Chemistry**
- **PDF is Free!***
- **Redshelf (in Canvas) is an interactive ebook for FREE!**
- Free for Kindle
- Available from iBooks ($4.99)



LECTURE OBJECTIVES

- Chapter 1.1 Chemistry in Context & The Scientific Method.
- Chapter 1.2 Phases and Classification of Matter
- Chapter 1.3 Physical and Chemical Properties
- Chapter 1.4 Measurement - SI Units, Prefixes
- Chapter 1.5 Measurement Uncertainty - Accuracy/Precision & Sig. Figs.
- Chapter 1.6 Mathematical Treatment of Measurement Results

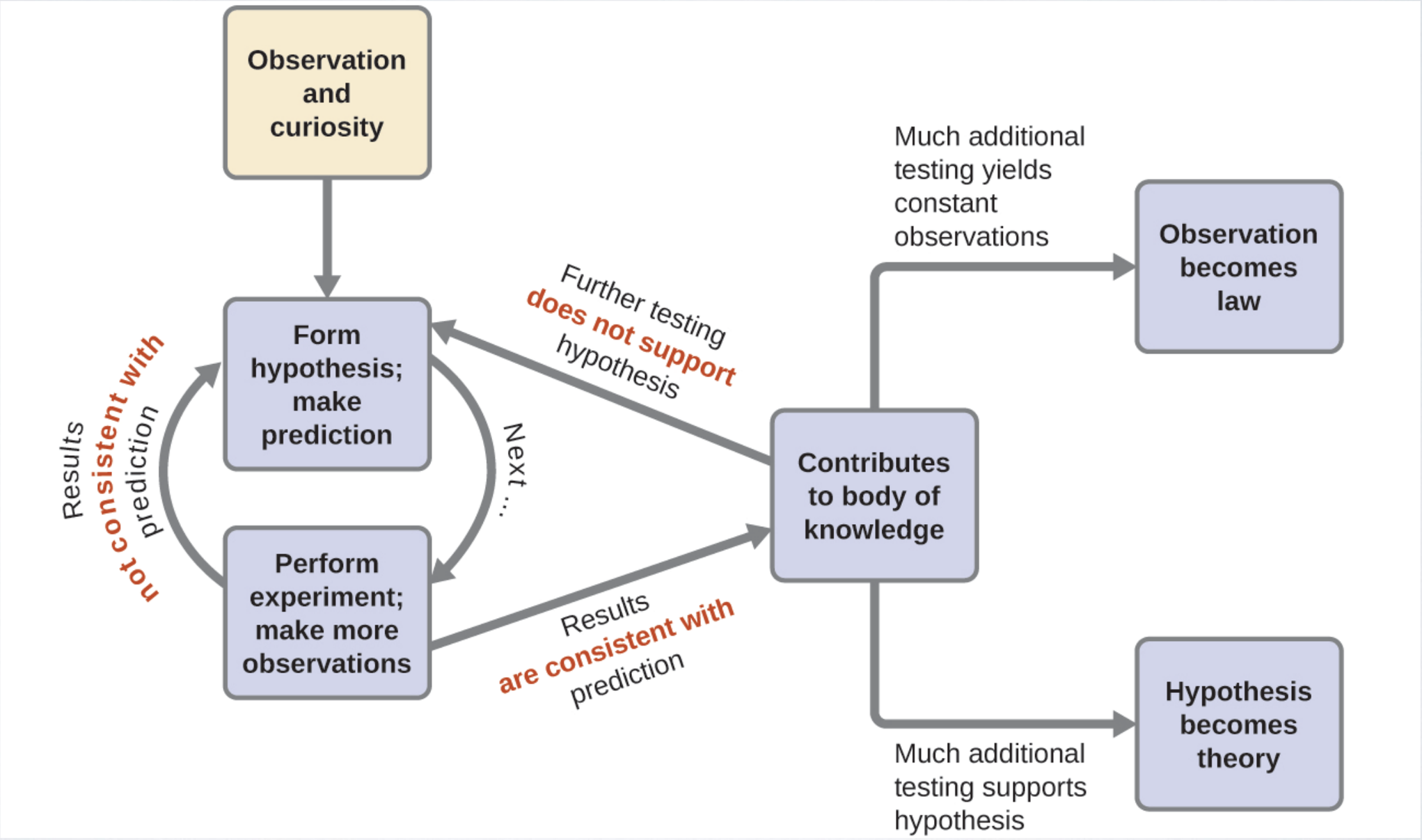
CHEMISTRY - THE CENTRAL SCIENCE



CHEMISTRY DEFINITION

- The study of the composition, properties, and interactions of MATTER.

THE SCIENTIFIC METHOD



THE SCIENTIFIC METHOD

From the perspective of a cat.

- Observation: Owners will pick things up and put the item back.
- Hypothesis: If I knock something off the table my owners will pick it up.
- Experiment: The https://www.litter-robot.com/blog/why-do-cats-knock-things-off-tables/ re goes the cup!
- Model (Theory): Owners will always pick up things that I knock off the table.
- Further Experiments: Repeat experiment with spoon, bowl, fork…
- New Model (Theory): Owners don't pick up and put back fork..next item!

THE SCIENTIFIC METHOD

From the perspective of a scientist

- Observation: Are reliable measurements.
- Hypothesis: A proposal to explain the results of the measurements (this may be revised).
- Experiment: The hypothesis is tested.
- Model (Theory): Assumptions are used to make a theory that explain the data from the experiments.
- Further Experiments: New experiments are tested to see if the model continues to hold true, or if it needs to be modified. If it holds true the theory may become a Scientific Law.

DEFINITIONS

- Matter: anything that has mass and volume - a chair, a book, a molecule, you and me

- Composition: the simpler substance(s) and amounts that make up matter (e.g. air ~ 78% N_2, 21% O_2, 0.9% Ar, 0.04% CO_2,...)

- Properties: the physical and chemical characteristics that make each substance unique.

DOMAINS OF CHEMISTRY

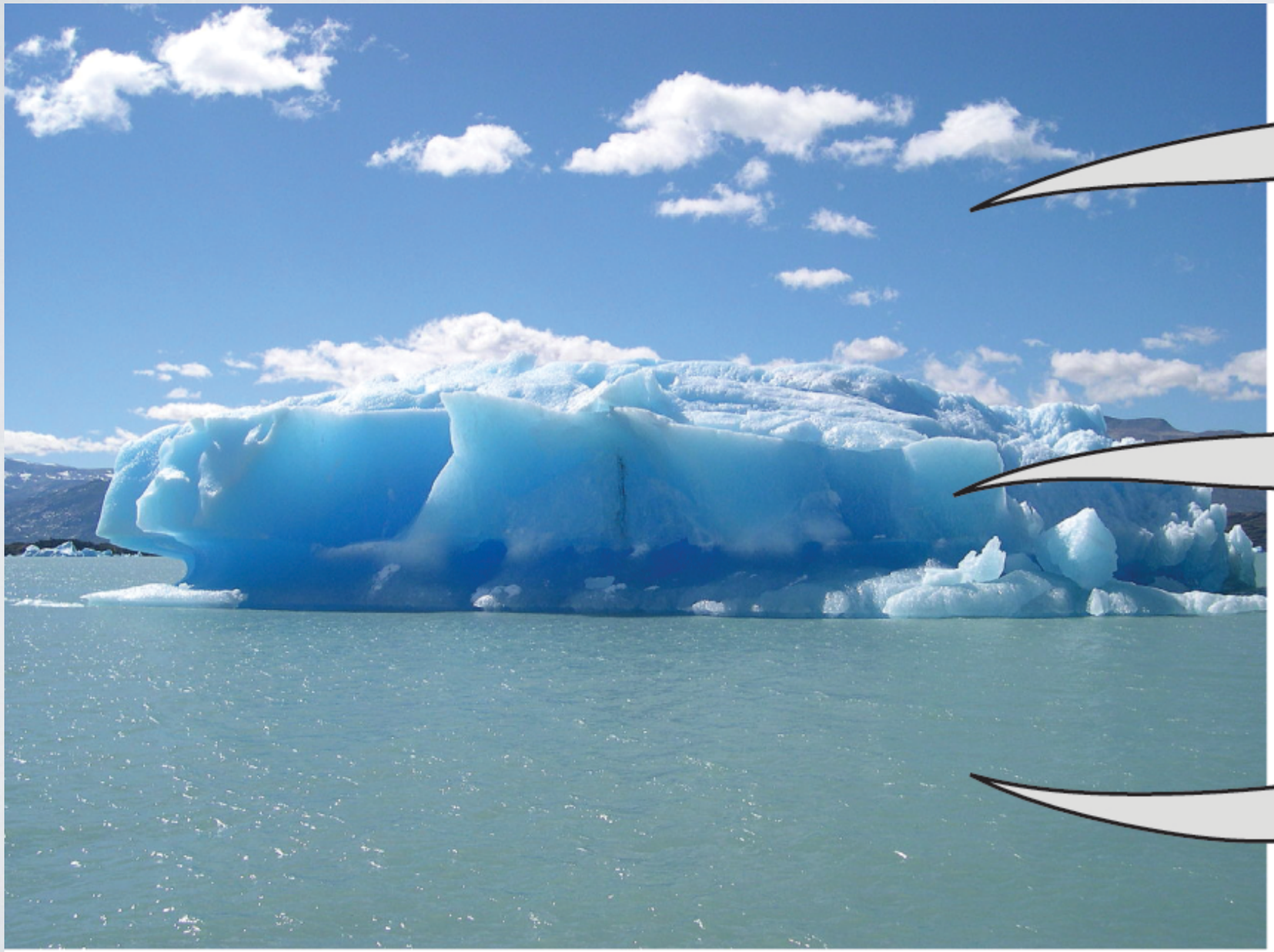
- Macroscopic- it is the realm of everyday things that are large enough to be sensed directly by human sight or touch. Macro means large in Greek.
    - Example: Blade of Grass
- Microscopic- it is almost always visited in the imagination. Micro means small in Greek.
    - Example: a Human skin cell
- Particulate- is too small to be seen with the most powerful optical microscope.
    - A helium atom
- Symbolic- specialized language used to represent components of the macroscopic and microscopic domain.

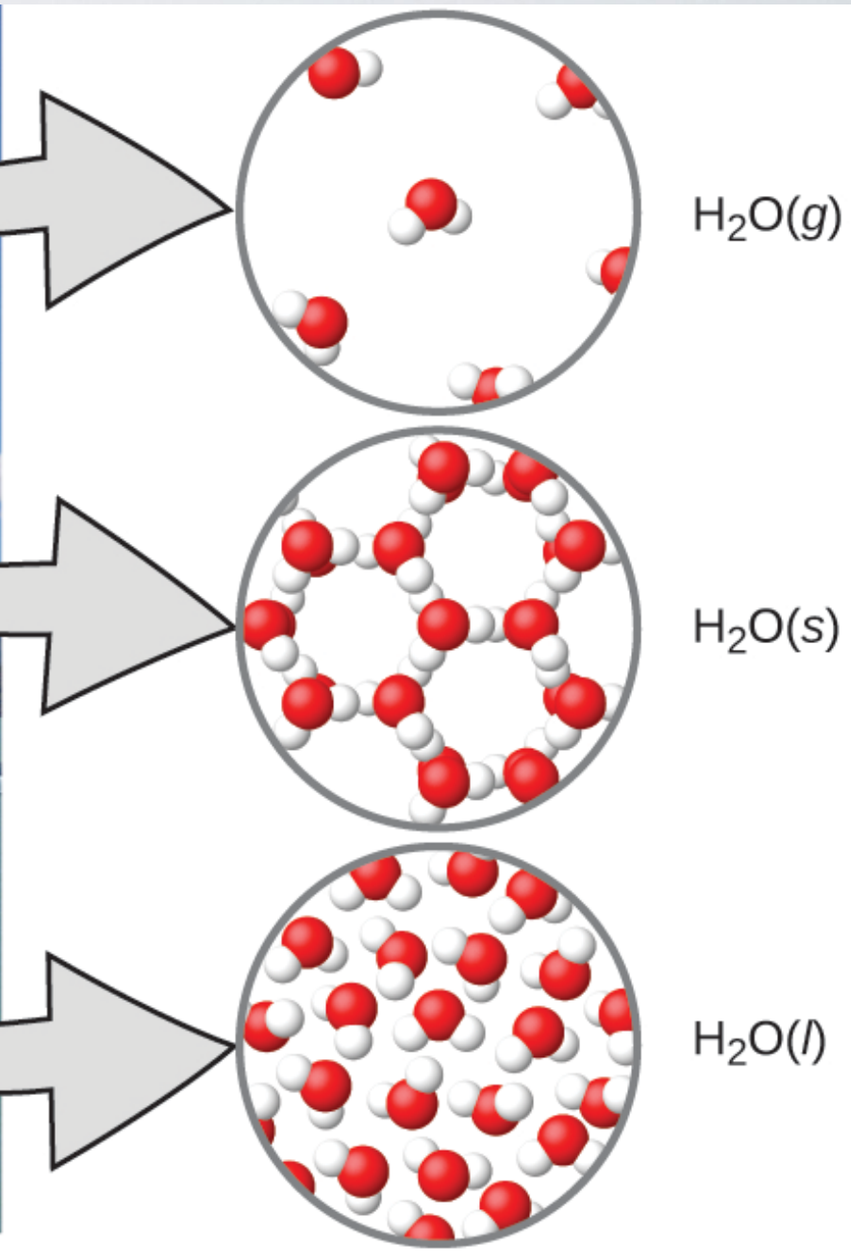
MACROSCOPIC, MICROSCOPIC AND PARTICULATE

Classify each of the following as either macroscopic, microscopic or particulate:

an iron atom	particulate
dry ice	macroscopic
a water molecule	particulate

MATTER EXISTS IN DIFFERENT STATES

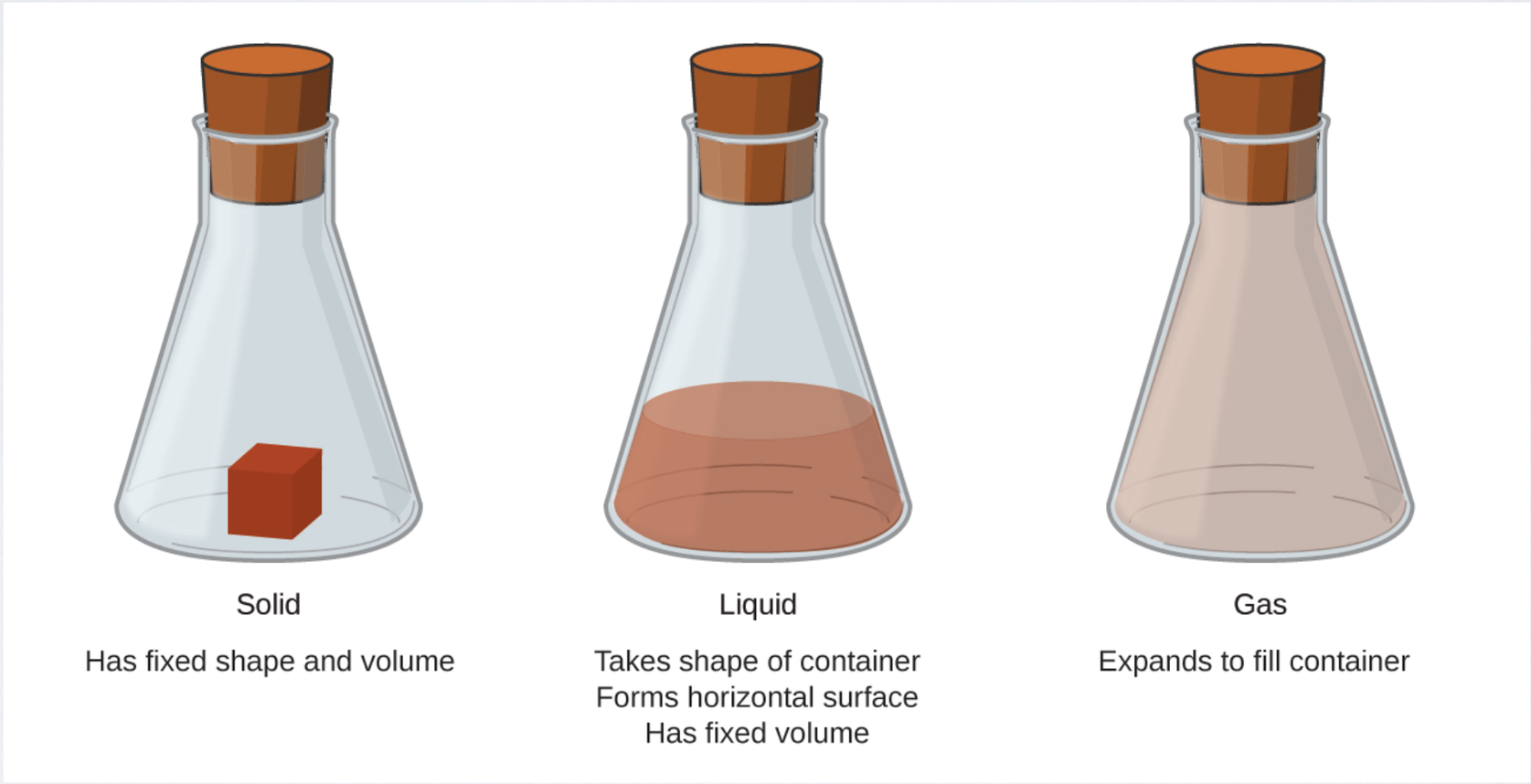




(a) (b) (c)

PHASES & CLASSIFICATION OF MATTER

- Matter: anything that has mass and volume - a chair, a book, a molecule



The three most common states or phases of matter are solid, liquid, and gas.

4 STATES OF MATTER

1. Solid- has fixed shape and volume

2. Liquid- takes shape of a container and has fixed volume

3. Gas- expands to fill container and has a varying shape that conforms to the container **but** does not have a surface.

4. Plasma- is a gaseous state of matter that contains appreciable numbers of electrically charged particles.

PLASMA

A plasma torch can be used to cut metal. (credit: “Hypertherm”/Wikimedia Commons)

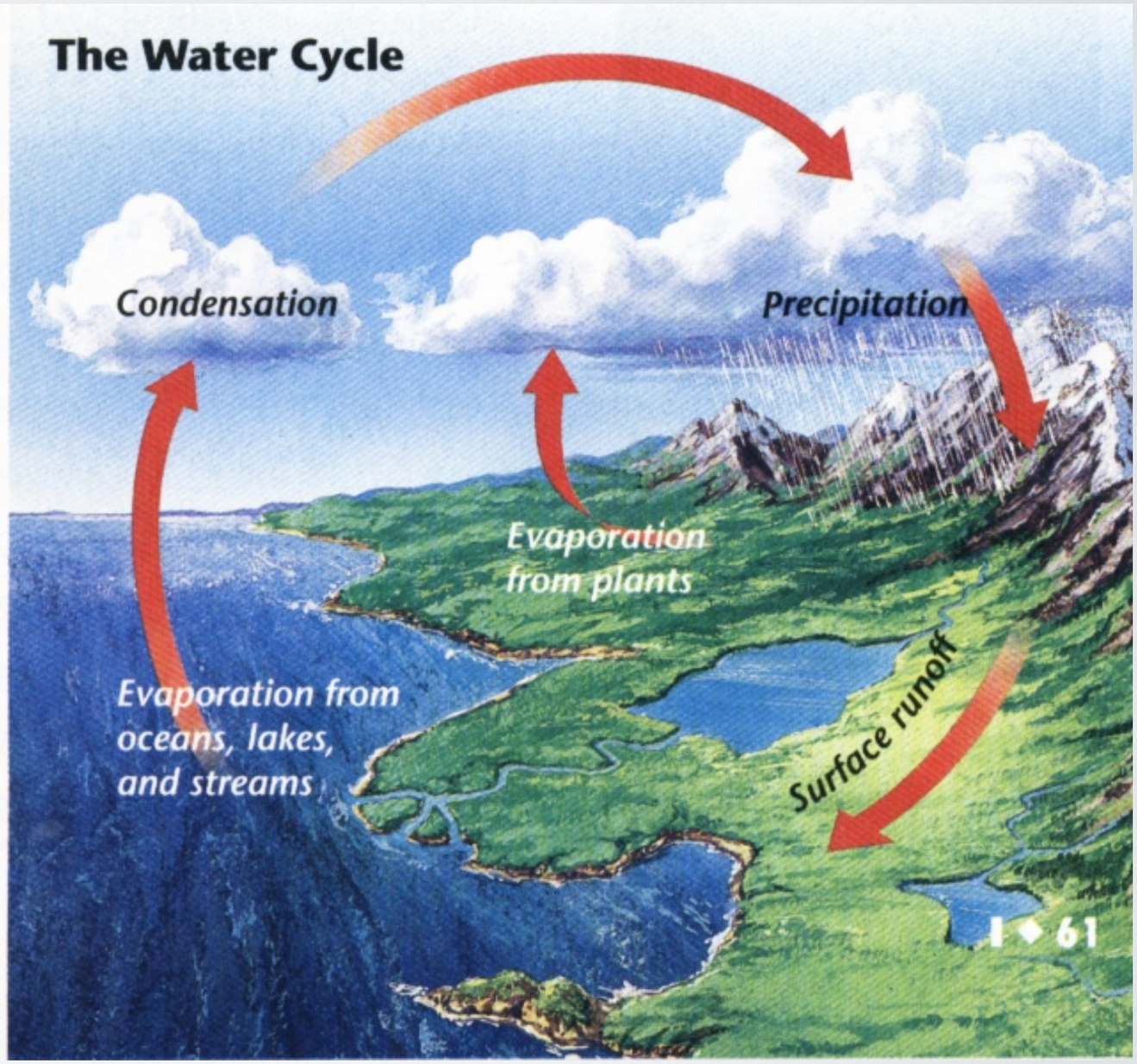
PHYSICAL & CHEMICAL PROPERTIES

- Physical properties: those which identify the substance without interacting with another substance (e.g. color, melting point, density...)

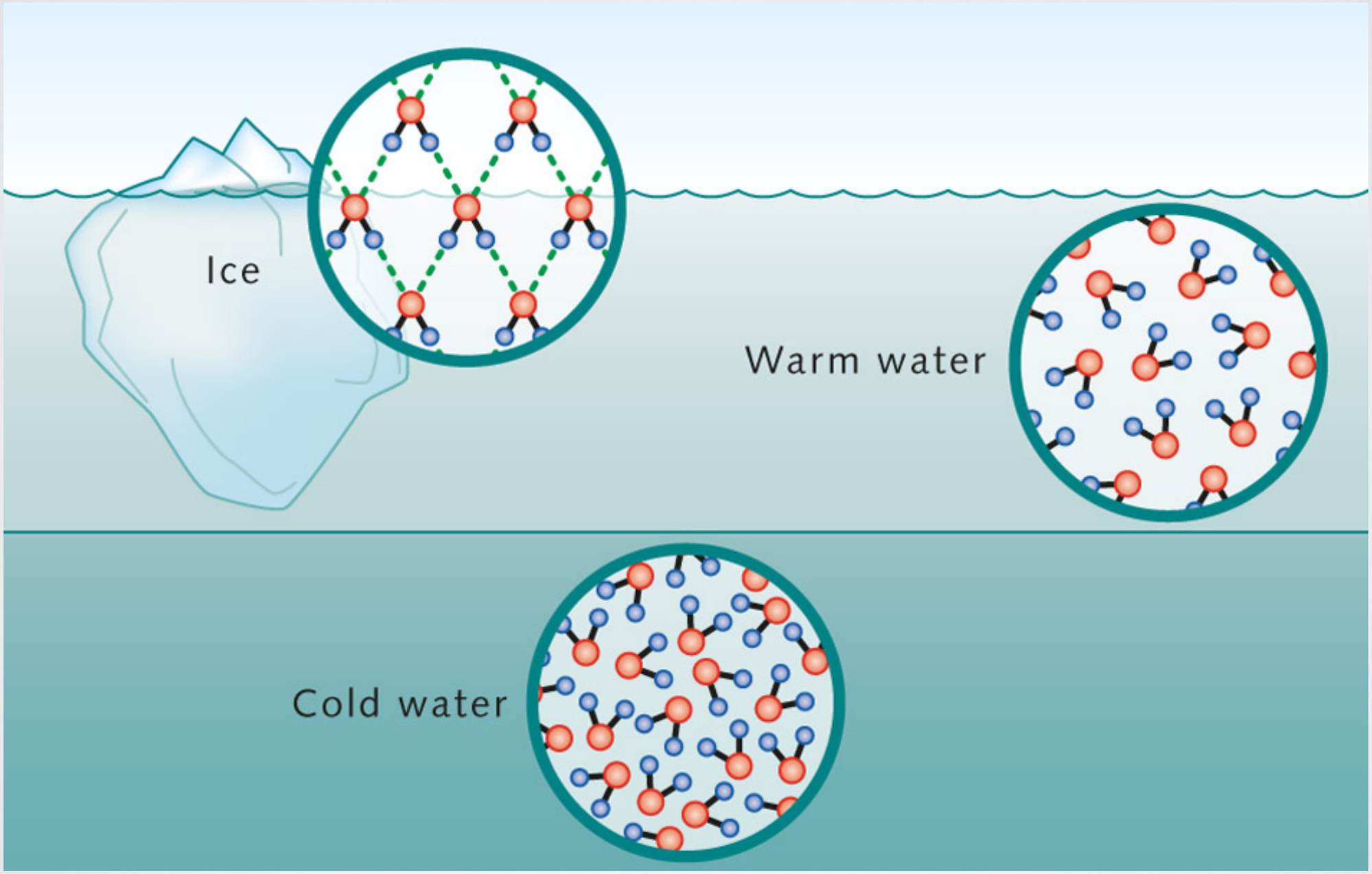
- Chemical properties: those which identify the substance by it's interactions with, or transformations into, other substance(s) (e.g. flammability, corrosiveness, reactivity,...)

PHYSICAL PROPERTIES

Think of water: Water can go from ice to vapor to liquid water without changing it's composition.



WATER IN ITS DIFFERENT STATES

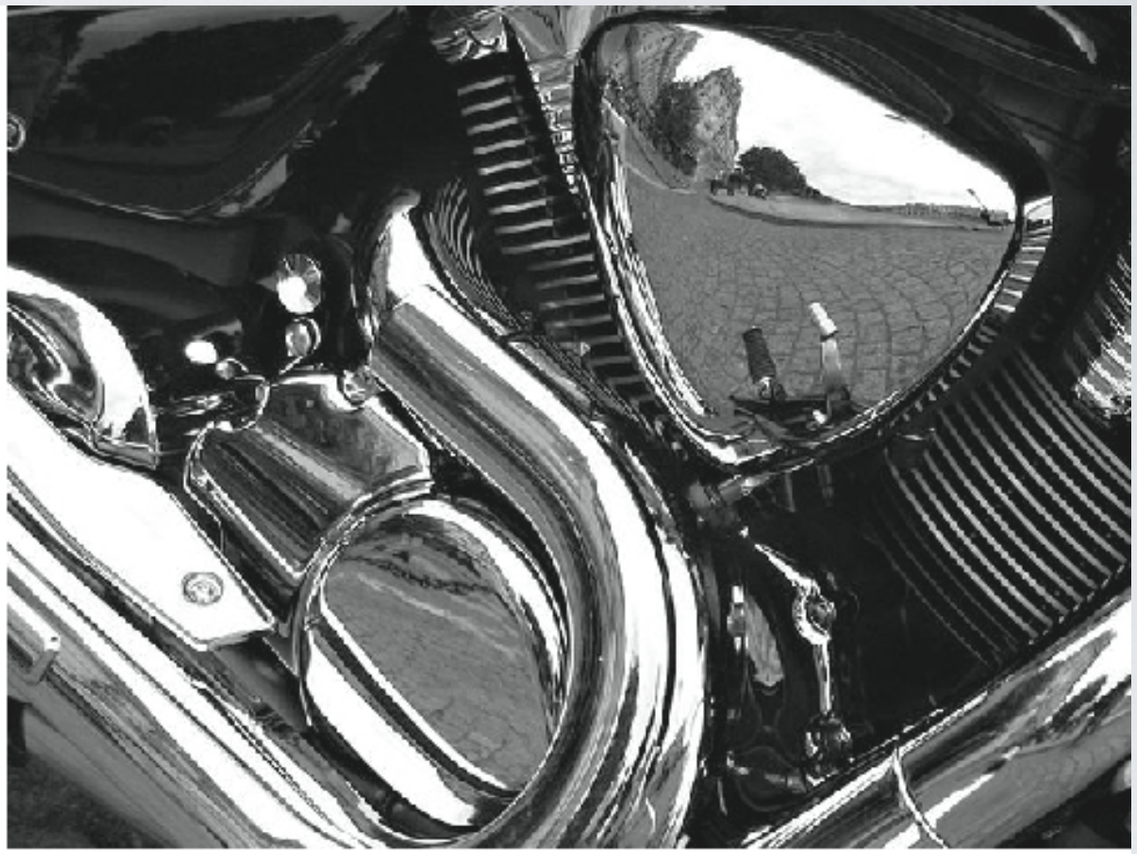


CHEMICAL PROPERTIES

Think of baking a cake: To make a cake you need eggs, water, flour, cake mix, etc. When you heat the cake mixture the composition of the mixtures changes creating a new substance that is nothing similar to the original substance.

CHEMICAL PROPERTIES

(a)

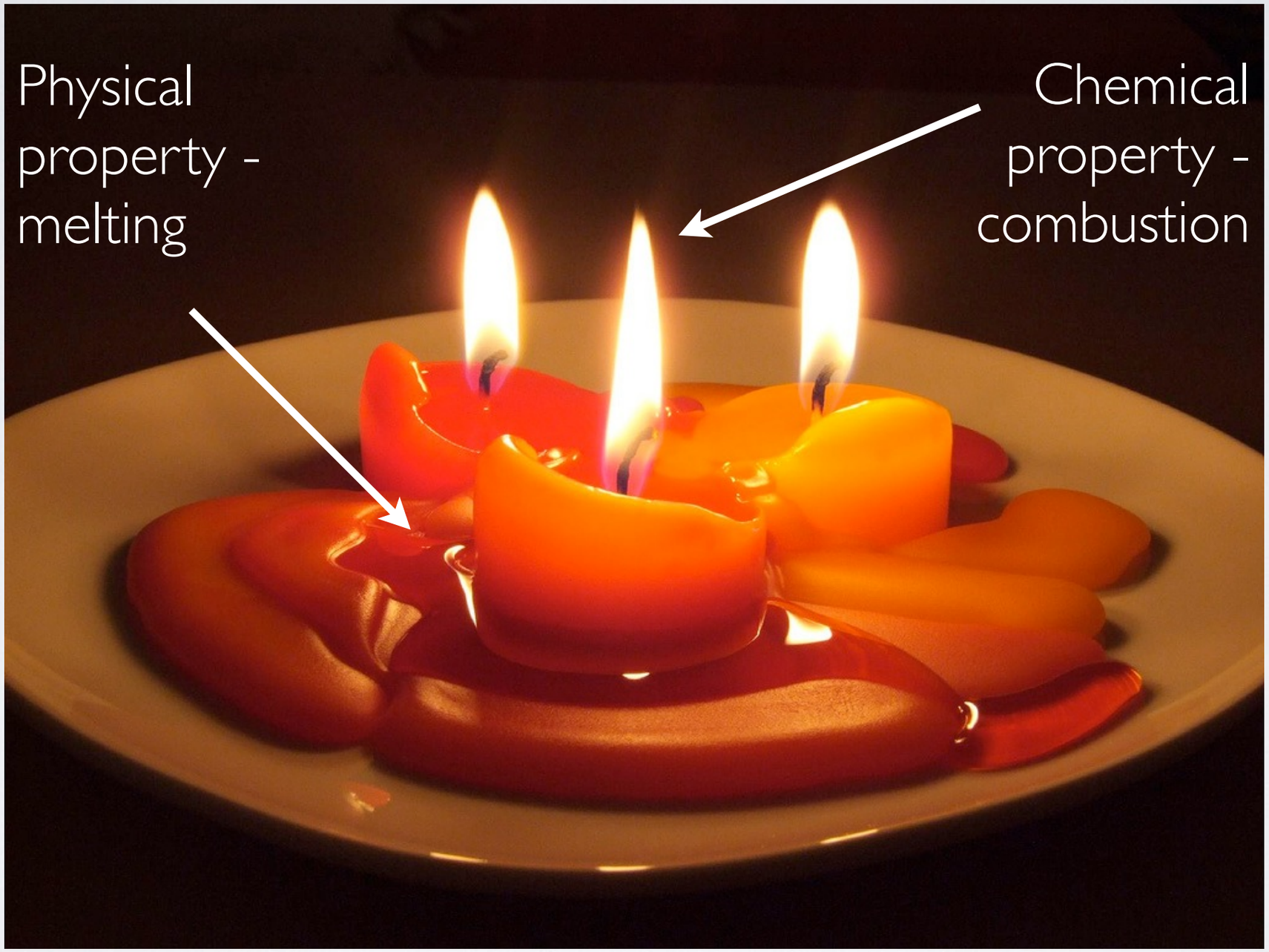


(b)

- (a) Iron (Fe) rusts when exposed to water and oxygen over long periods of time.

- (b) Chromium (Cr) the primary component in chrome does not rust.

PHYSICAL & CHEMICAL PROPERTIES



http://www.flickr.com/photos/peterbecker/262810485/

PHYSICAL & CHEMICAL PROPERTIES QUESTION

Which is a chemical property of copper?

A. Reddish brown color
B. Reacts with nitric acid
C. Melts at 1083°C
D. Conducts electricity

COPPER REACTING WITH NITRIC ACID

$$Cu_{(s)} + 4HNO_{3\ (aq)} \longrightarrow Cu(NO_3)_{2\ (aq)} + 2NO_{2(aq)} + 2H_2O_{(l)}$$

Copper solid becomes aqueous Copper (II) Nitrate, when mixed with Nitric Acid; changing the composition.

CLASSIFY CHEMICAL/PHYSICAL PROPERTIES

Classify each of the following **properties** as chemical or physical:

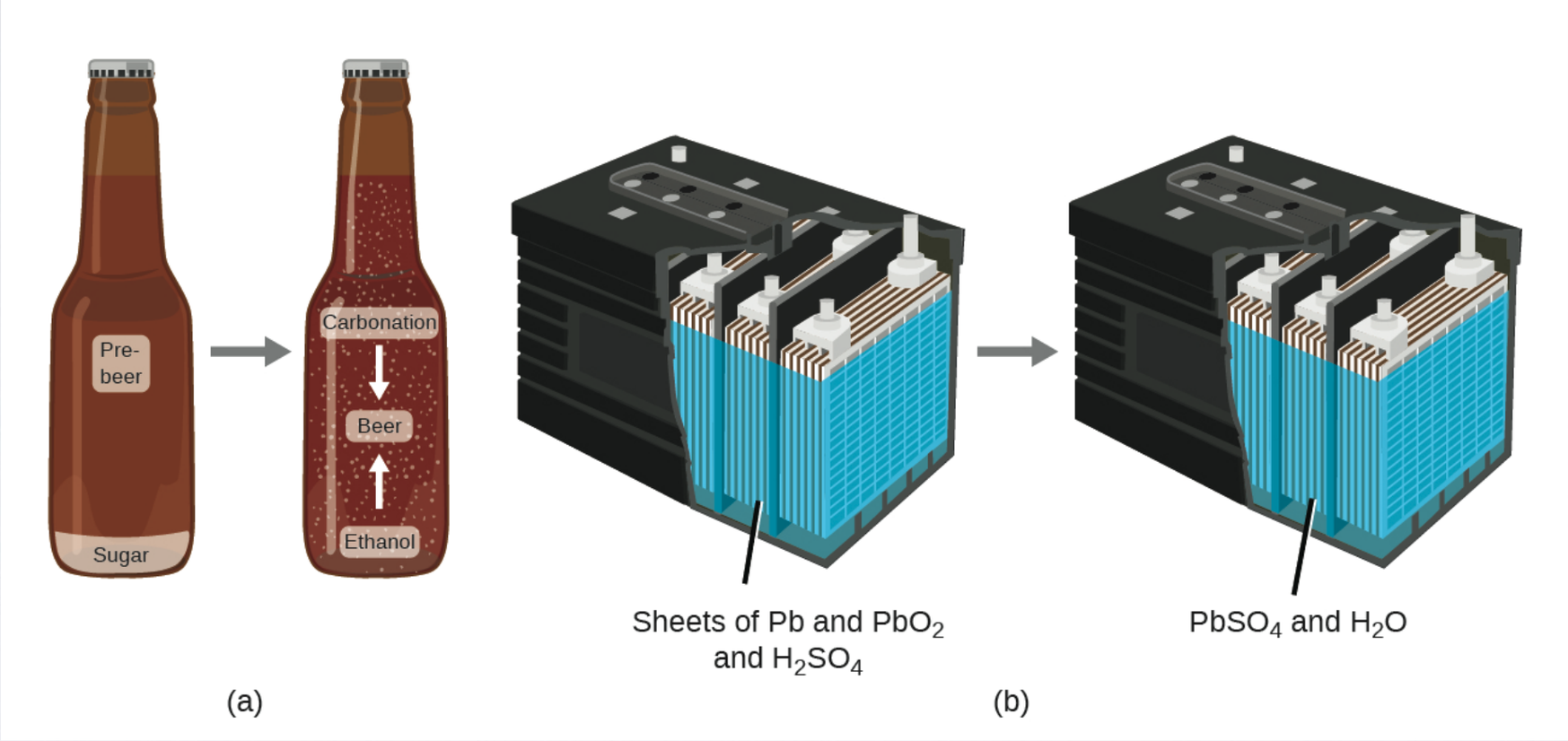
corrosiveness	_____
combustibility	_____
conductivity of a metal	_____

SCAN ME

LAW OF CONSERVATION OF MATTER

- There is no detectable change in the total quantity of matter present when matter converts from one type to another (a chemical change) or changes among solids, liquids, or gaseous (physical change).

LAW OF CONSERVATION OF MATTER



a) The mass of beer precursor materials is the same as the mass of beer produced: Sugar has become alcohol and carbonation.

b) The mass of the lead, lead oxide plates, and sulfuric acid that goes into the production of electricity is exactly equal to the mass of lead sulfate and water that is formed.

Periodic Table of the Elements

Metals

Metalloids

Non-Metals

Transition Metals

	1												13	14	15	16	17	18
1	1 H 1.008	2																2 He 4.003
2	3 Li 6.941	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
3	11 Na 22.99	12 Mg 24.31	3	4	5	6	7	8	9	10	11	12	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
4	19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.64	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
5	37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc [98]	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	48 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
6	55 Cs 132.9	56 Ba 137.3	57-70 *	71 Lu 175.0	72 Hf 178.5	73 Ta 180.9	74 W 183.8	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po [209]	85 At [210]	86 Rn [220]
7	87 Fr [223]	88 Ra [226]	89-102 **	103 Lr [262]	104 Rf [261]	105 Db [262]	106 Sg [266]	107 Bh [264]	108 Hs [277]	109 Mt [268]								

Metals | Non Metals

* Lanthanoids	57 La 138.9	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm [145]	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0
** Actinoids	89 Ac [227]	90 Th 232.0	91 Pa 231.0	92 U 238.0	93 Np [237]	94 Pu [244]	95 Am [243]	96 Cm [247]	97 Bk [247]	98 Cf [251]	99 Es [252]	100 Fm [257]	101 Md [258]	102 No [259]

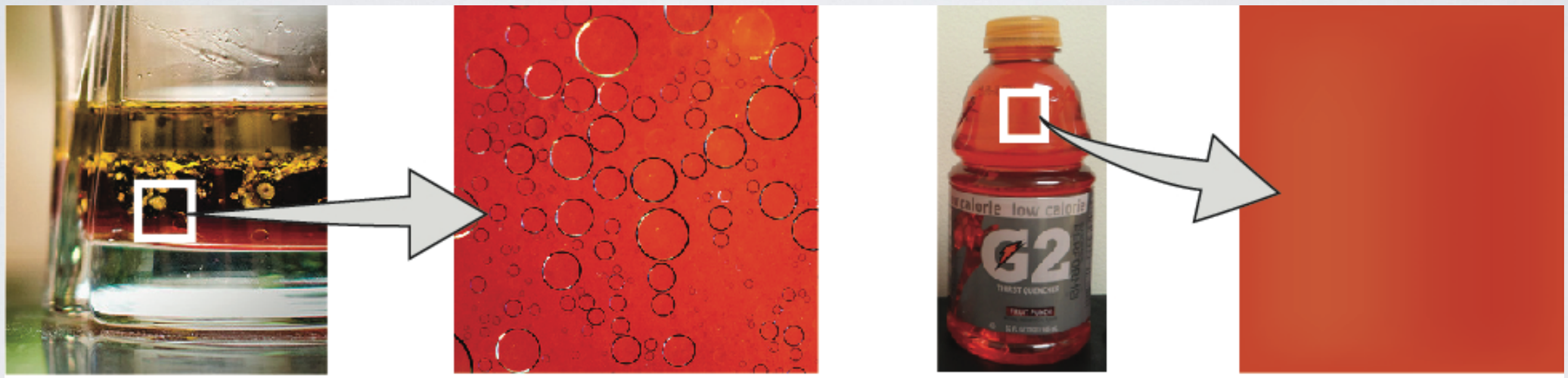
CLASSIFICATION OF MATTER

- Mixture- composed of two or more types of matter that can be present in varying amounts and can be separated by physical changes.

- Heterogeneous mixture- has one or more visible boundaries between the components. Ex: rocks and blood

- Homogeneous mixture (solution)- has no visible boundaries because the components are individual atoms, ions, or molecules. ex: sugar dissolved in water.

CLASSIFICATION OF MATTER

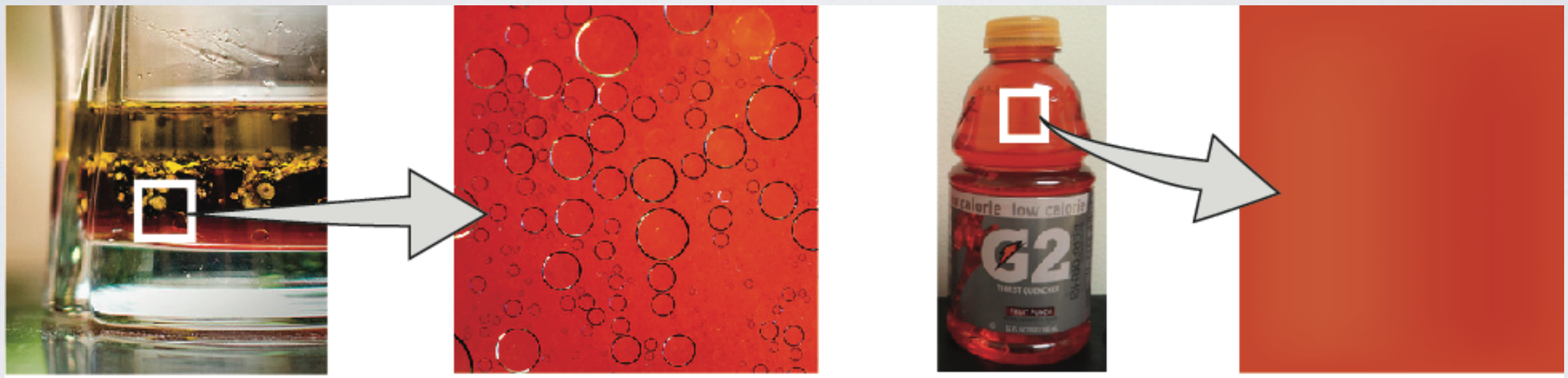


(a) (b)

a) Oil and vinegar salad dressing is a _____ mixture.

b) A commercial sports drink is a _____ mixture.

CLASSIFICATION OF MATTER



(a) (b)

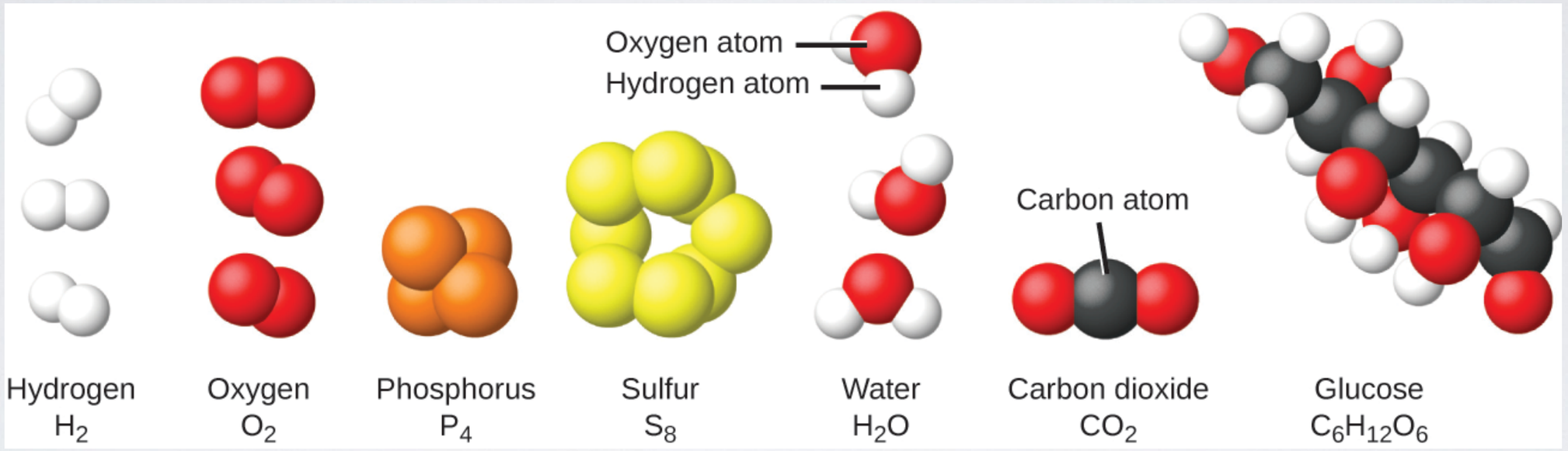
a) Oil and vinegar salad dressing is a **heterogeneous** mixture because its composition is not uniform throughout.

b) A commercial sports drink is a **homogeneous** mixture because its composition is uniform throughout.

CLASSIFICATION OF MATTER

- Pure substance- a constant composition.
  - Elements- pure substances that cannot be broken down into simpler substances by chemical change.
  - Compounds- pure substances that can be broken down by chemical change.

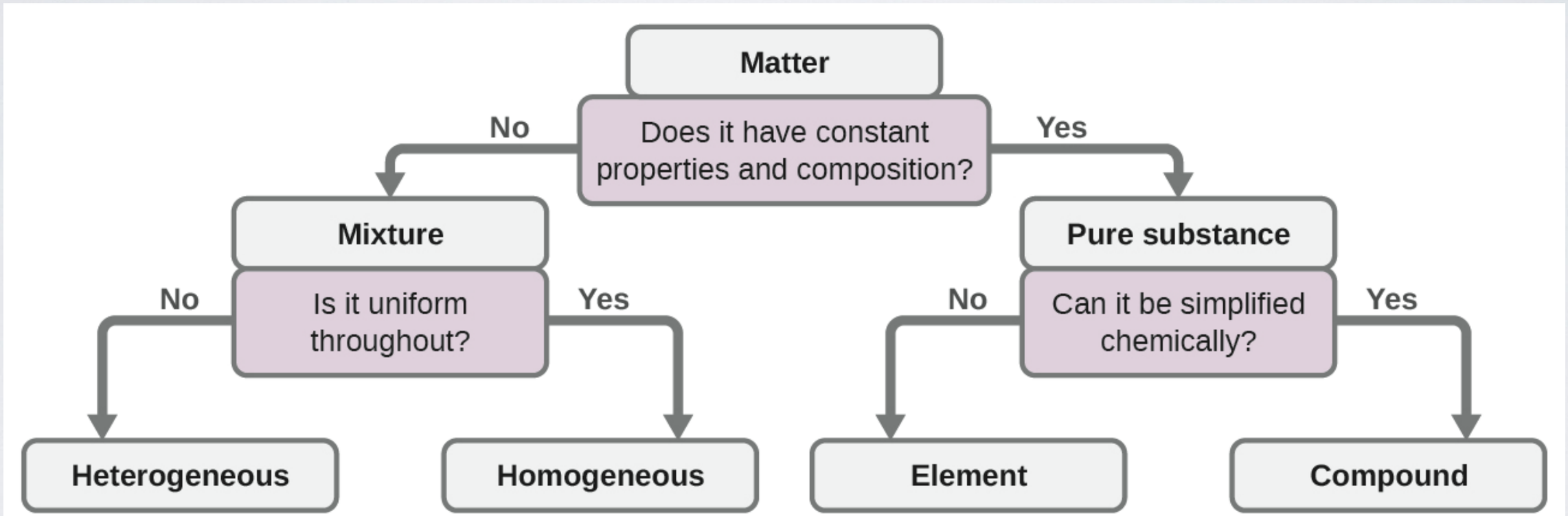
CLASSIFICATION OF MATTER



Elements

Compounds

CLASSIFICATION OF MATTER



MEASUREMENTS

Provides the macroscopic information that is the basis of most of the hypothesis, theories, and laws that describe the behavior of matter and energy in both the macroscopic and microscopic domains of chemistry.

SI UNITS

The rational units of measurement.

Dimension	Unit name	Abbreviation
Mass	kilogram	kg
Length	meter	m
Time	second	s
Temperature	kelvin	K
Electric current	ampere	A
amount of substance	mole	mol
luminous intensity	candela	cd

SCIENTIFIC NOTATION & PREFIXES

Prefix	Symbol	Word	Conventional	Scientific
-	-	one	1	1×10^{0}
deci	d	tenth	0.1	1×10^{-1}
centi	c	hundredth	0.01	1×10^{-2}
milli	m	thousandth	0.001	1×10^{-3}
micro	μ	millionth	0.000001	1×10^{-6}
nano	n	billionth	0.000000001	1×10^{-9}
pico	p	trillionth	0.000000000001	1×10^{-12}
femto	f	quadrillionth	0.000000000000001	1×10^{-15}

SCIENTIFIC NOTATION & PREFIXES

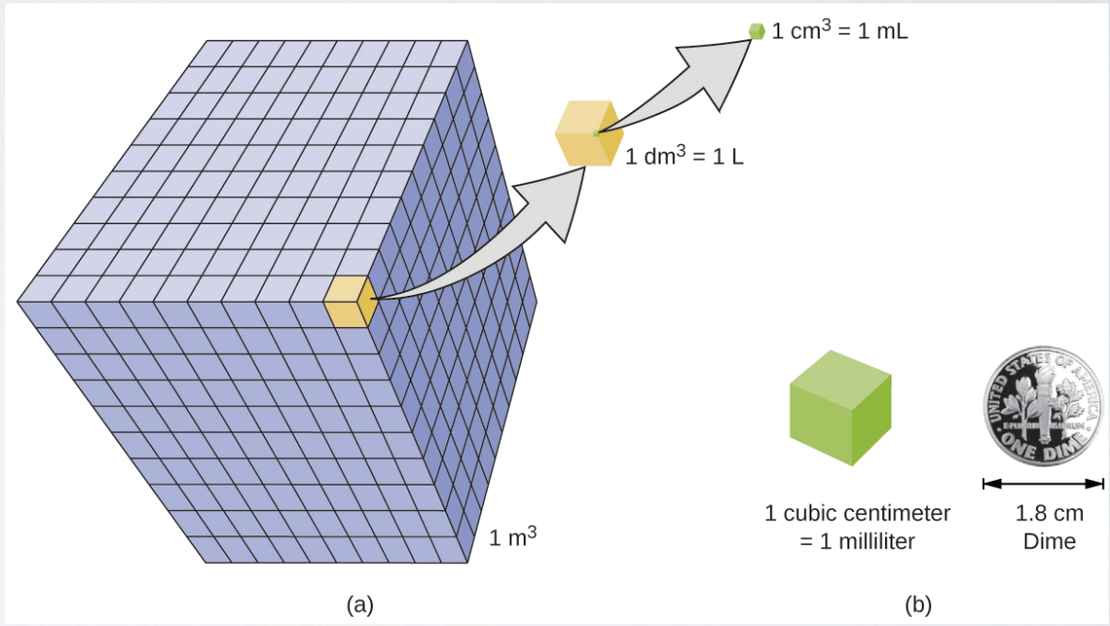
Prefix	Symbol	Word	Conventional	Scientific
tera	T	trillion	1,000,000,000,000	1×10^{12}
giga	G	billion	1,000,000,000	1×10^{9}
mega	M	million	1,000,000	1×10^{6}
kilo	k	thousand	1,000	1×10^{3}
hecto	h	hundred	100	1×10^{2}
deka	da	ten	10	1×10^{1}
-	-	one	1	1×10^{0}

DENSITY

Density is the measurement of mass over volume

Density = mass / volume

$cm^3 = mL$



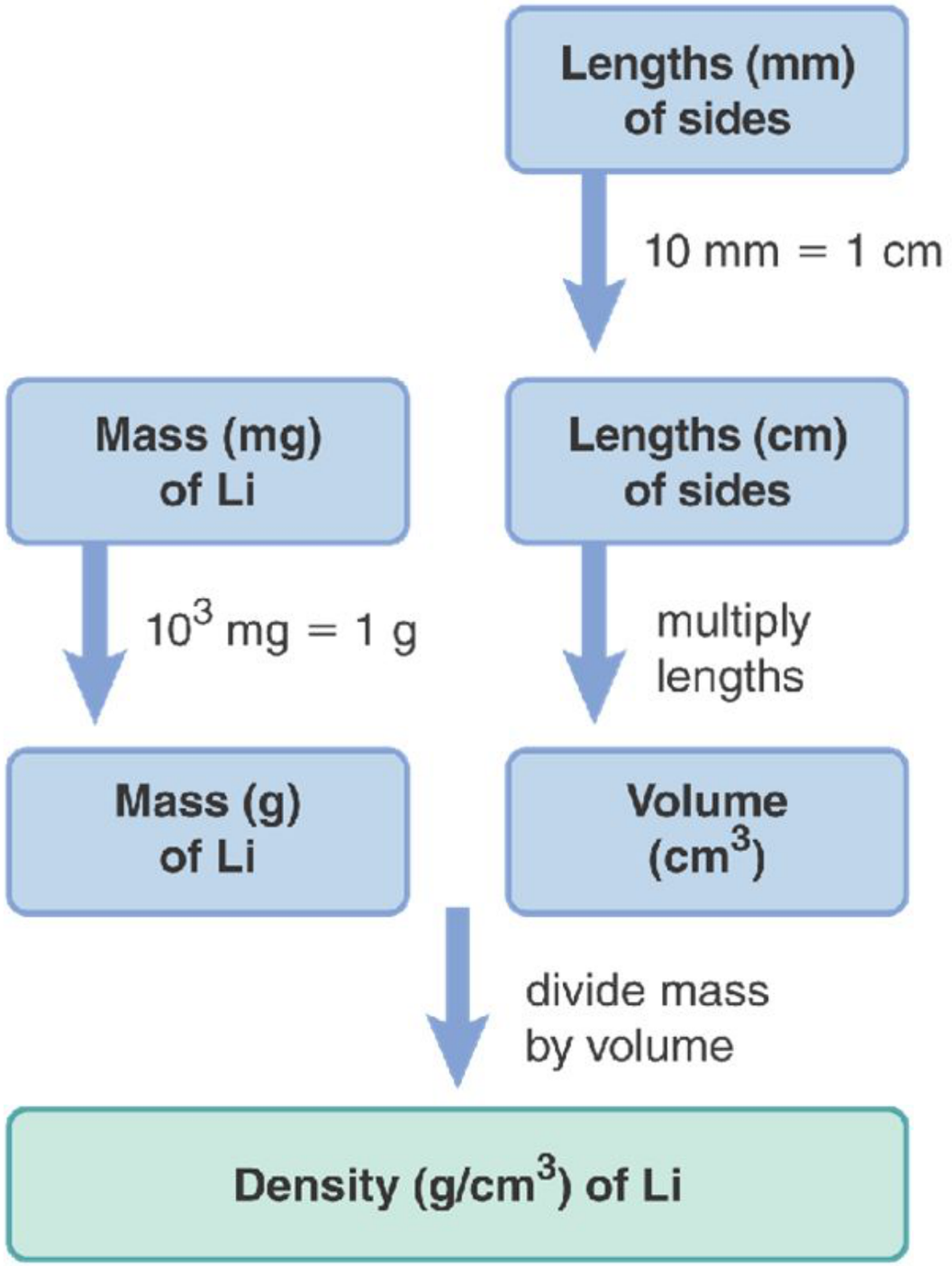
DENSITIES OF COMMON SUBSTANCES

Substance	Physical State	Density (g/cm^3)
Hydrogen	Gas	8.9×10^{-5}
Oxygen	Gas	1.4×10^{-3}
Ethanol	Liquid	0.789
Water	Liquid	1
Table Salt	Solid	2.16
Aluminum	Solid	2.7
Lead	Solid	11.3
Gold	Solid	19.3

QUESTION

Lithium, a soft, gray solid with the lowest density of any metal, is a key component of advanced batteries, such as the one in your laptop. A slab of lithium weighs 1.49×10^4 mg and has sides that are 20.9 mm by 11.1 mm by 11.9 mm. Find the density of lithium in g/cm^3.

Road Map


Lengths (mm) of sides
10 mm = 1 cm
Mass (mg) of Li
Lengths (cm) of sides
10^3 mg = 1 g
multiply lengths
Mass (g) of Li
Volume (cm^3)
divide mass by volume
Density (g/cm^3) of Li

QUESTION

Lithium, a soft, gray solid with the lowest density of any metal, is a key component of advanced batteries, such as the one in your laptop. A slab of lithium weighs 1.49×10^4 mg and has sides that are 20.9 mm by 11.1 mm by 11.9 mm. Find the density of lithium in g/cm^3.

5.40 g/cm^3

EXACT NUMBERS

- Exact numbers do not have uncertainty
- These numbers do not impact the number of significant figures in the calculations
  - 60 min = 1 hour
  - 1000 g = 1 kg
  - 4 people

SIGNIFICANT FIGURES

- Significant figures have real meanings - they represent how accurately something was quantified or measured.

- The last number is always the first number that is uncertain.

- Any numbers beyond that one are purely fictional.

- The results of mathematical transformations are limited by the number of significant digits.

MATH & SIGNIFICANT

- Non-zero digits are always significant.
- Any zeros between two significant digits are significant.
- A final zero or trailing zeros in the decimal portion ONLY are significant.
- For more on significant figure rules and practice see chem team website:
- http://bit.ly/1Qw6KBb (case sensitive)

MATH & SIGNIFICANT

- 0 counts as a sig fig when: between numbers and before a decimal place or after numbers to the right of the decimal place.
- Addition & subtraction: the last common decimal place is the least significant figure.
- Multiplication & division: the answer is limited to the number of significant digits of the factor with the fewest significant figures.
- More rules for logarithms and exponents but we won't worry about those.

MATH & SIGNIFICANT FIGURES

Addition & Subtraction

$$\begin{array}{r} 83.5\ \text{mL} \\ +\ 23.28\ \text{mL} \\ \hline 106.78\ \text{mL} \end{array} = 106.8\ \text{mL}$$

$$\begin{array}{r} 865.90\ \text{g} \\ -\ 2.8121\ \text{g} \\ \hline 863.0879\ \text{g} \end{array} = 863.09\ \text{g}$$

Multiplication & Division

$$\begin{array}{rl} 15.6 & \text{cm} \quad \leftarrow \text{3 sig figs} \\ \times\ 6.023 & \text{cm} \quad \leftarrow \text{4 sig figs} \\ \times\ 0.34 & \text{cm} \quad \leftarrow \text{2 sig figs} \\ \hline 31.945992 & \text{cm}^3 \end{array} = 32\ \text{cm}^3$$

$$\begin{array}{rl} 500 & \text{g} \\ \div\ 305.4 & \text{mL} \\ \hline 1.6371971 & \text{g/mL} \end{array}$$

$$= 2\ \text{g/mL}$$

NEW RULES FOR ROUNDING NUMBERS

- Round UP when:
    - The first digit removed is >5
    - If the first digit removed is 5 and the preceding number is odd (e.g. 23.475 becomes 23.48).
- Round DOWN when
    - The first digit removed is <5
    - If the first digit removed is 5 and the preceding number is even (e.g. 23.485 becomes 23.48).

WHICH ANSWER HAS THE RIGHT NUMBER OF SIG. FIGS.?

$$\frac{(4.6981 - 3.482)}{0.0961} = ?$$

A: 12.6545
B: 12.65
C: 12.7
D: 12.6

ERRORS IN MEASUREMENTS

- Random error: ALL measurements have some level of random error, they can be either positive or negative errors.

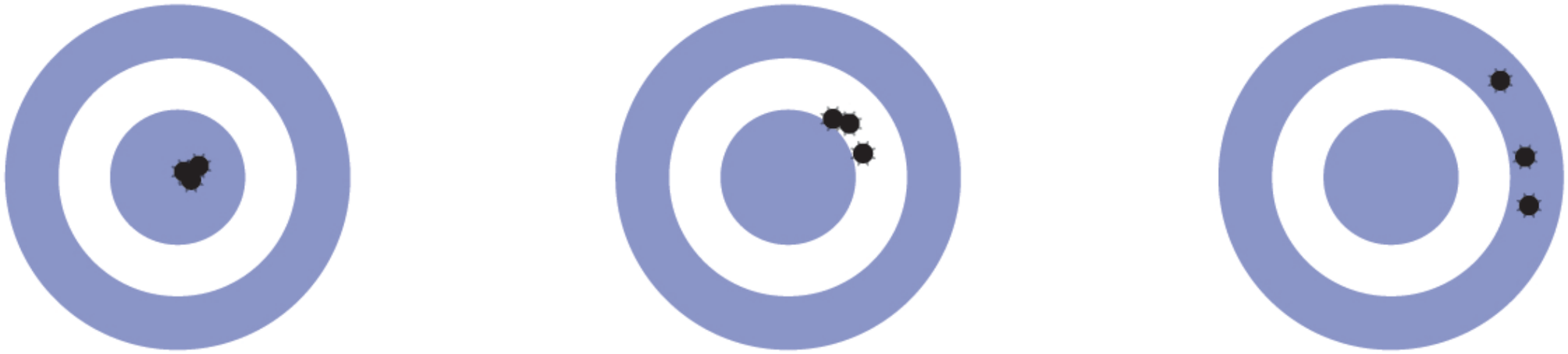
- Systematic error: arise from problems in the measurement procedure, they will be either positive or negative, but not both.

- Systematic errors will also be subject to random error; there will be variations in replicate measurements that have systematic error.

PRECISION & ACCURACY

- Precision relates to how reproducible each measurement is; how close each measurement is to the other measurements.
- Accuracy relates to how close the measured values are to the true value.

PRECISION & ACCURACY

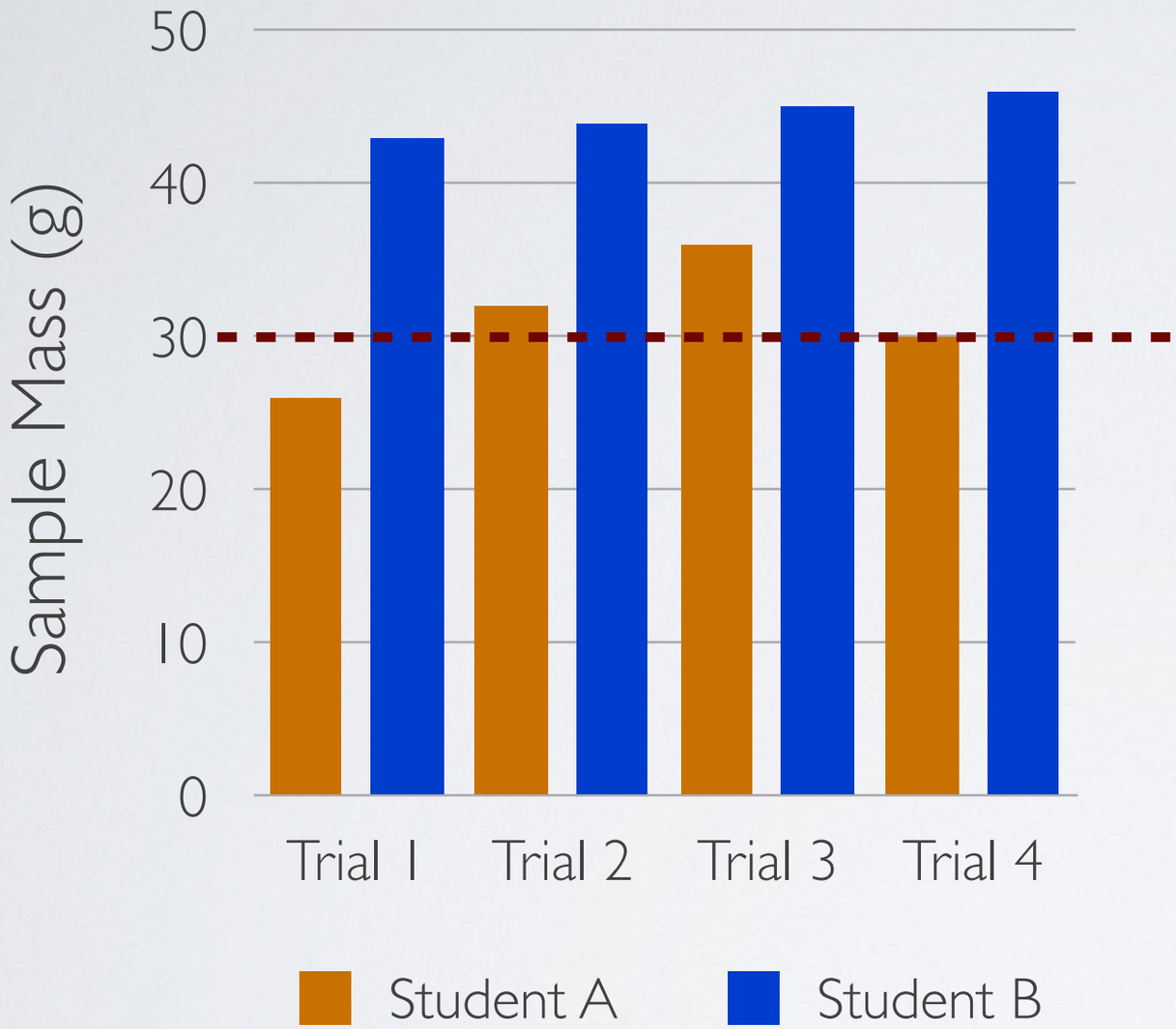


(a) These arrows are close to both the bull's eye and one another, so they are both accurate and precise.

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

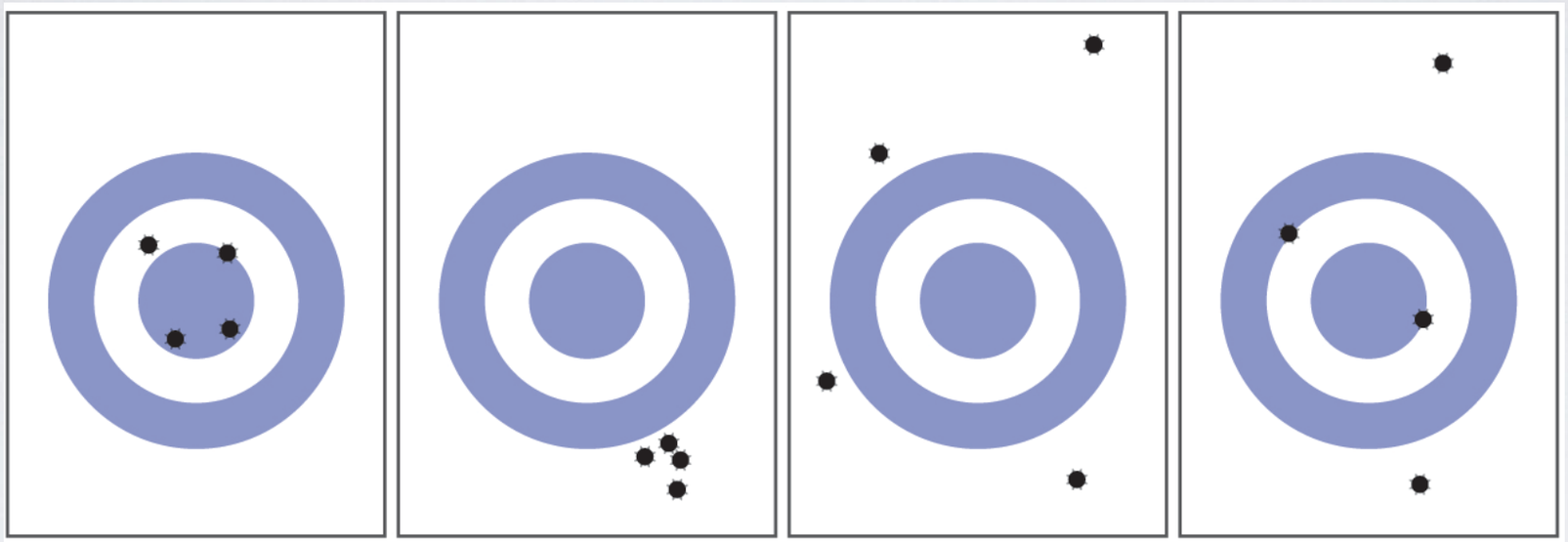
(c) These arrows are neither on target nor close to one another, so they are neither accurate nor precise.

PRECISION & ACCURACY



Systematic error: Student B
Random error: Both Students
Better precision: Student B
Better accuracy: Student A

PRECISION & ACCURACY QUESTION



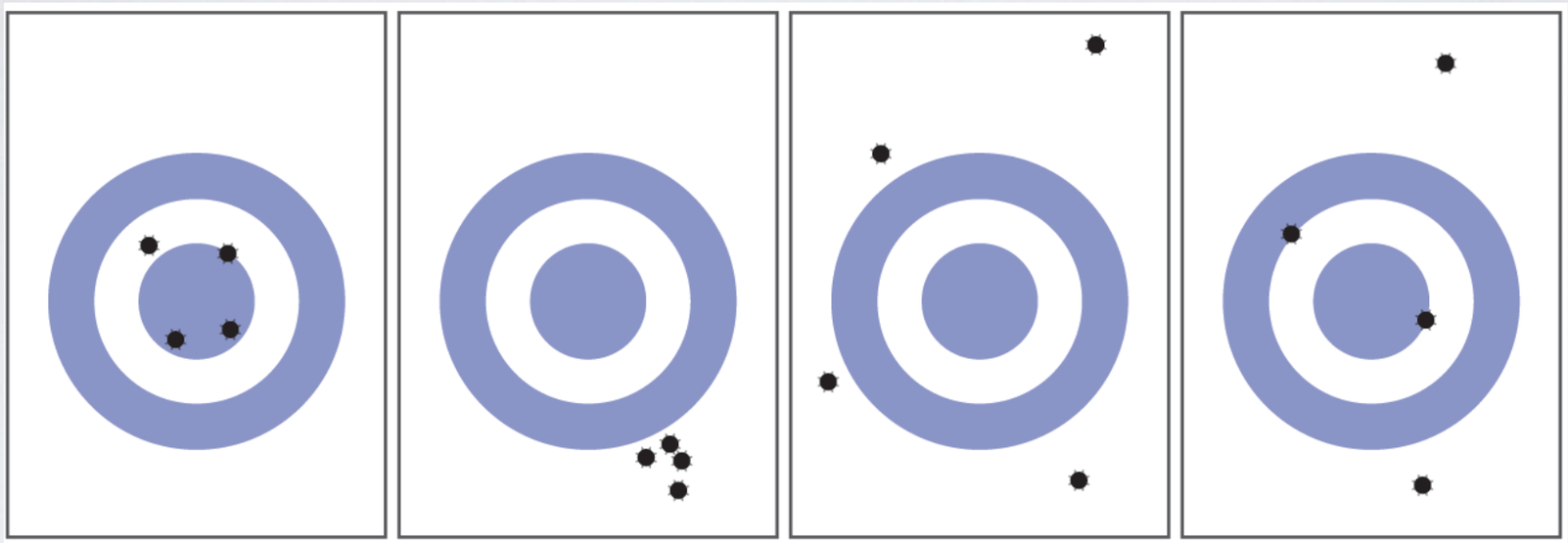
Consider the results of the archery contest shown in this figure.

(a) Which archer is most precise?

(b) Which archer is most accurate?

(c) Who is both least precise and least accurate?

PRECISION & ACCURACY QUESTION



Consider the results of the archery contest shown in this figure.

(a) Which archer is most precise? Archer X

(b) Which archer is most accurate? Archer W

(c) Who is both least precise and least accurate? Archer Y

MEASUREMENT UNCERTAINTY

How long is the red line?

COMMON CONVERSION FACTORS

Length	Volume	Mass
1 m = 1.0936 yd	1 L = 1.0567 qt	1 kg = 2.2046 lb
1 in. = 2.54 cm (exact)	1 qt = 0.94635 L	1 lb = 453.59 g
1 km = 0.62137 mi	1 ft^3 = 28.317 L	1 (avoirdupois) oz = 28.349 g
1 mi = 1609.3 m	1 tbsp = 14.787 mL	1 (troy) oz = 31.103 g

QUESTION

While being driven from Philadelphia to Atlanta, a distance of about 1250 km, a 2014 Lamborghini Aventador Roadster uses 213 L gasoline.

(a) What (average) fuel economy, in miles per gallon, did the Roadster get during this trip?

(b) If gasoline costs $3.80 per gallon, what was the fuel cost for this trip?

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(a) 13.8 mpg

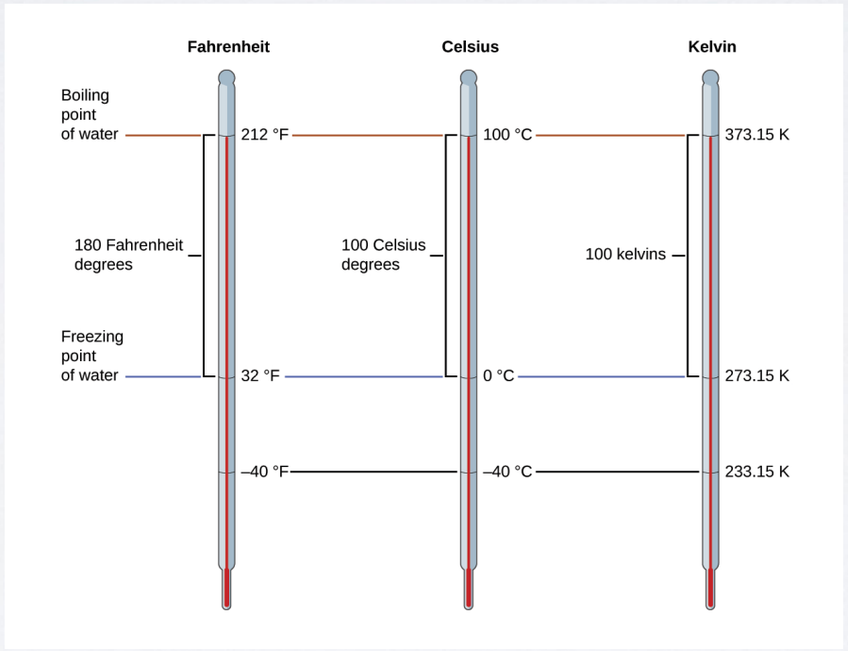
(b) $214

TEMPERATURE SCALES

- **Kelvin (K)** - The "Absolute temperature scale", begins at zero and only has positive values

- **Celsius (°C)** - The principal scientific temperature scale

- **Fahrenheit (°F)** - Not used scientifically, used in some countries for weather reports.



Relative temperatures:

Water freezes at:

32°F

0°C

273.15 K

Water boils at:

212°F

100°C

373.15 K

TEMPERATURE CONVERSIONS

$$T_{°C} = 5/9\ (T_{°F} - 32)$$

$$T_K = T_{°C} + 273.15$$

$$T_{°C} = T_K - 273.15$$

QUESTION

Baking a ready-made pizza calls for an oven temperature of 450 °F. If you are in Europe, and your oven thermometer uses the Celsius scale, what is the setting? What is the kelvin temperature?

QUESTION

Baking a ready-made pizza calls for an oven temperature of 450. °F. If you are in Europe, and your oven thermometer uses the Celsius scale, what is the setting? What is the kelvin temperature?

232 °C

505 K