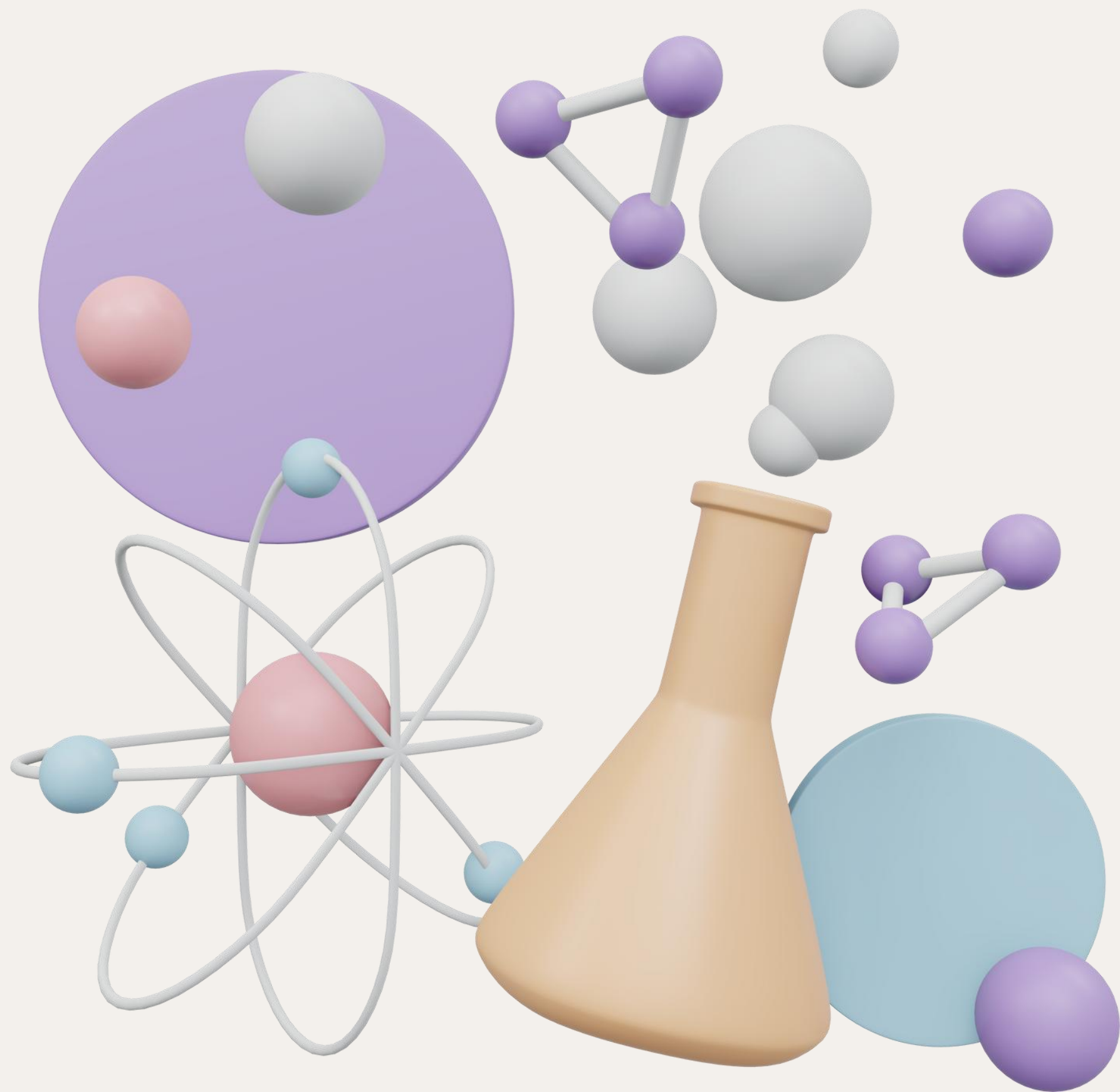
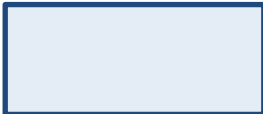
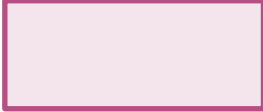




Unit 3: Classification and Measurement of Matter

MATTER MAP

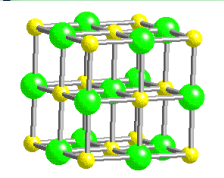
 Pure Substance
 Mixture

[START HERE](#)

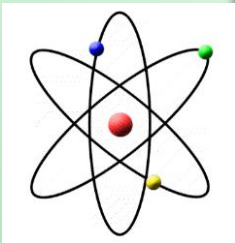
Elements



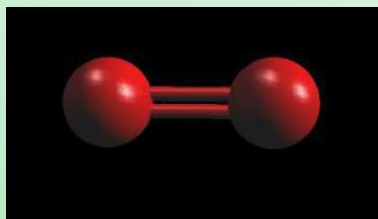
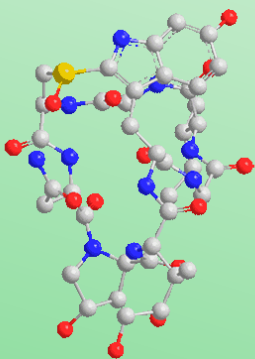
Compounds



Atoms



Molecules



Mixtures



Homogeneous



Heterogeneous



Colloid



Solution



Suspension



WHY CLASSIFY MATTER?

There are so many different types of matter...it can get confusing!

Classifying matter helps us understand it better:

- Helps us understand similarities and differences
- Allows us to make predictions as to how matter will behave
- Can help us connect observations to the particle level

At the **BROADEST LEVEL**, matter is classified into 2 categories:

- Made of only one type of substance
- Substance has only one chemical identity
- Proportions of the substance are fixed
- Cannot be separated into simpler substances by physical means

Pure
Substances

Mixtures

- Made of two or more types of substances
- Each substance retains its chemical identity
- Proportions of the substances are not fixed
- Can be separated into simpler substances by physical means

PHYSICAL Properties

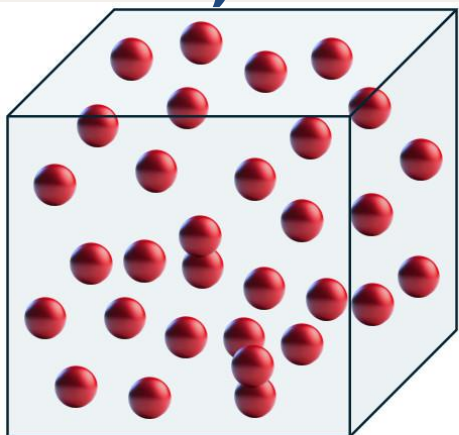
Descriptions are
an important part
of classification

CHEMICAL Properties

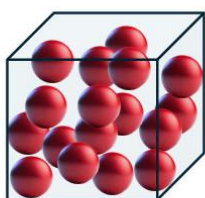
Can be determined **WITHOUT** performing
any chemical reactions.

Can only be determined by
performing chemical reactions.

Mass, Volume, Density

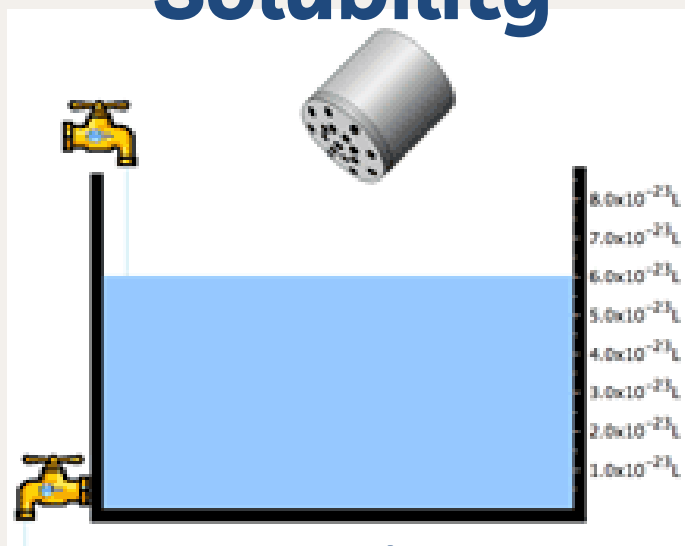


More Mass
More Volume
Lower Density



Less Mass
Less Volume
Higher Density

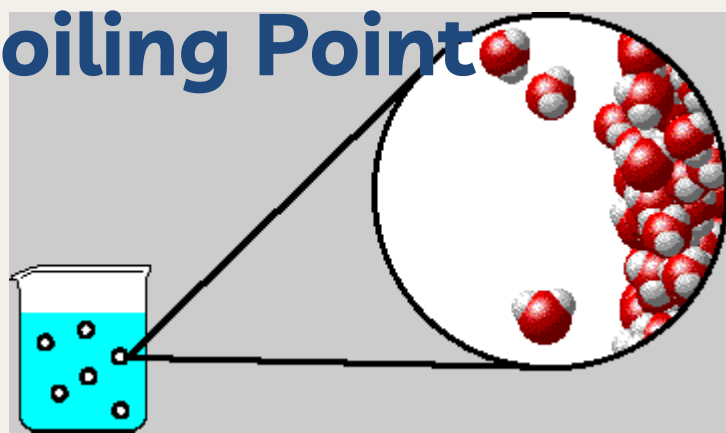
Solubility



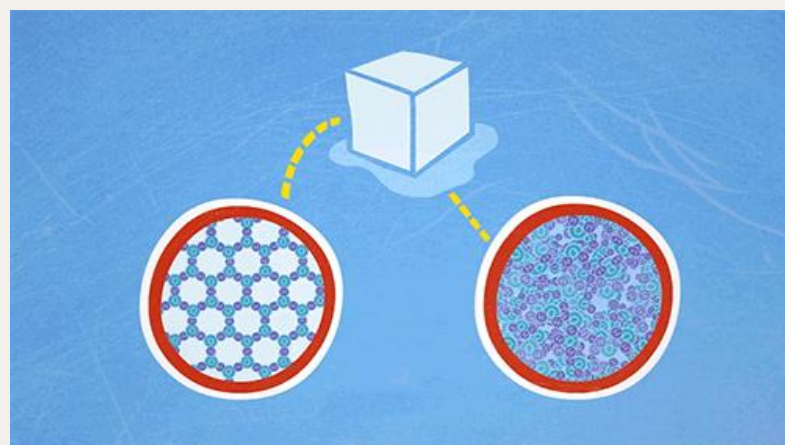
Magnetism



Boiling Point



Melting Point



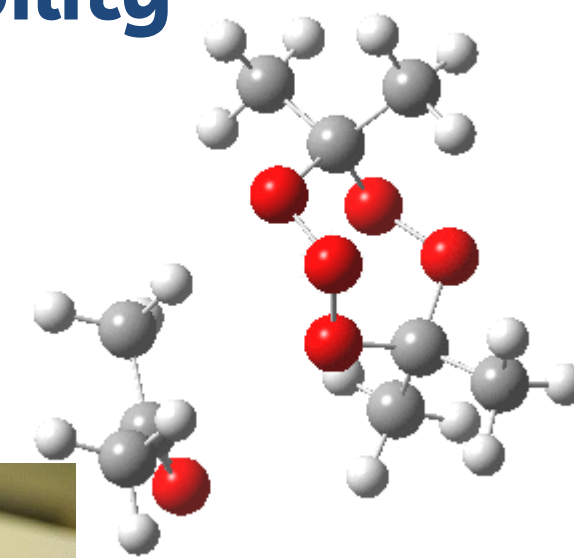
Reactivity



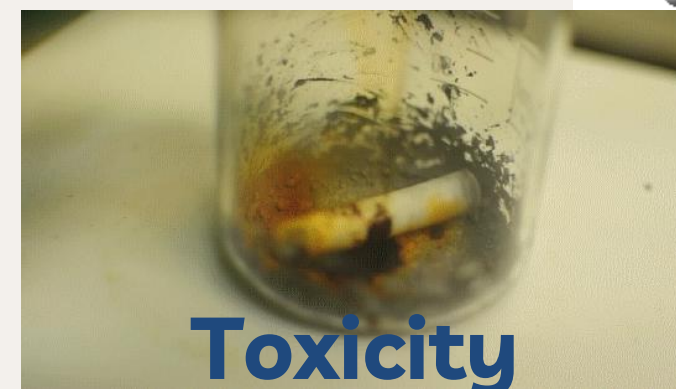
Oxidation



Stability



Toxicity



REACTIONS AND FORCES



BACK TO
MATTER MAP

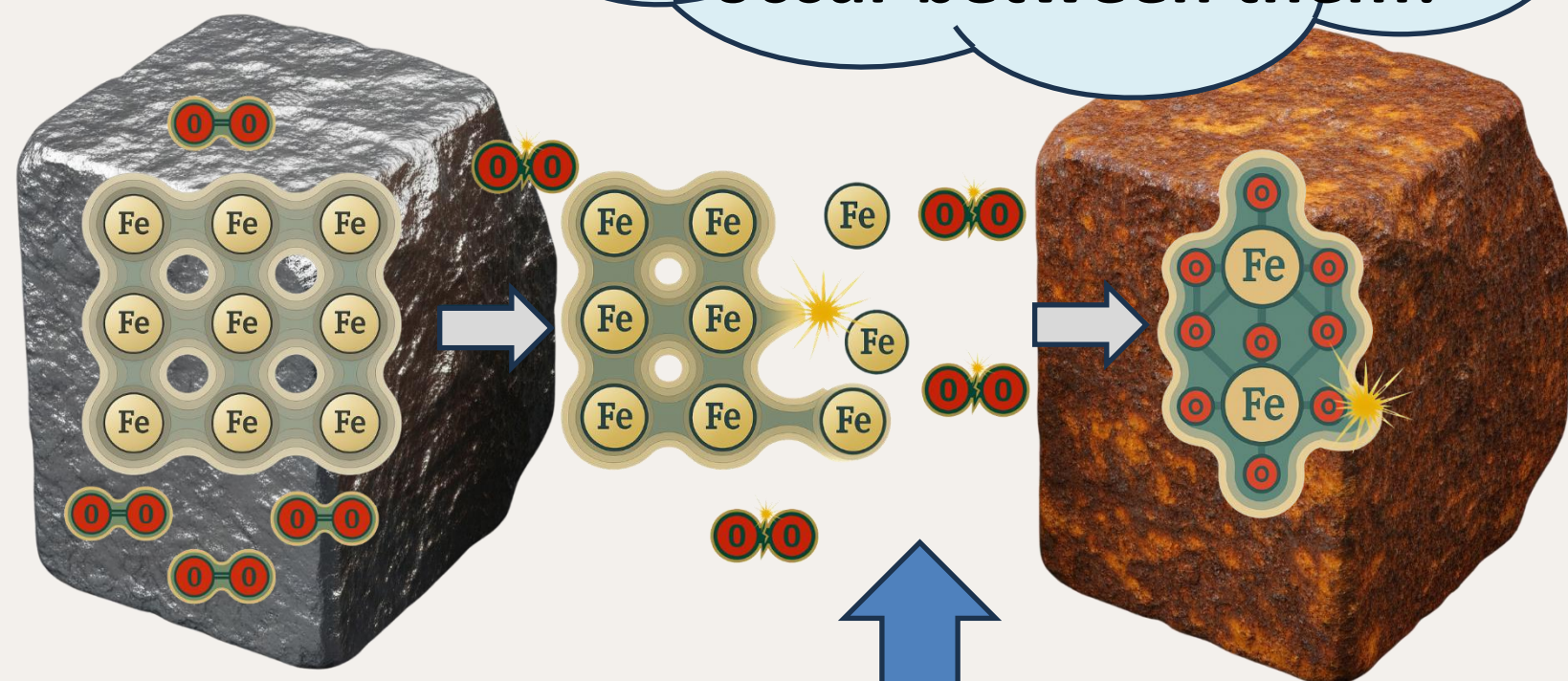
Remember, physical reactions do not involve changing the composition of the substance, while chemical reactions do!

Click image to review

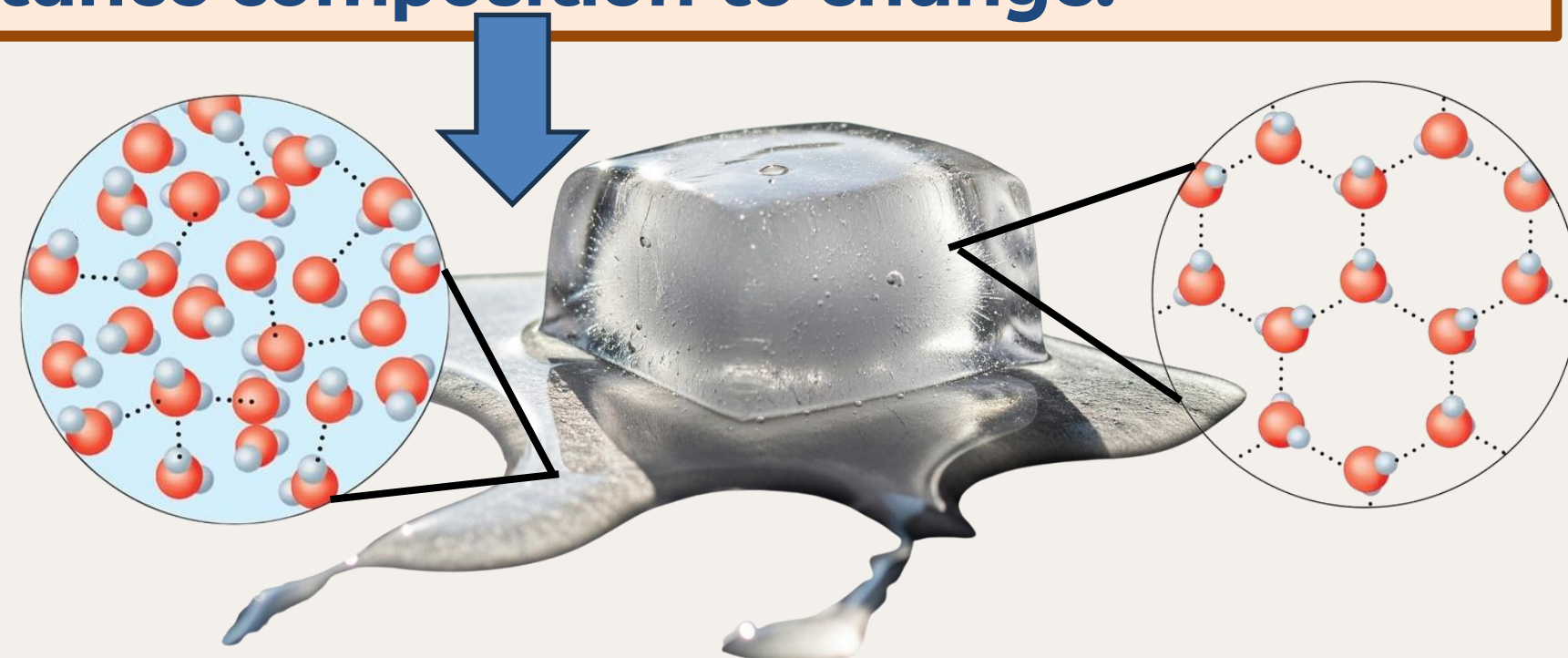
Forces govern all properties of atoms and reactions that occur between them!

I hate to admit it, but most of the reasons behind the behavior of matter has to do with **FORCES** (yes, physics!).

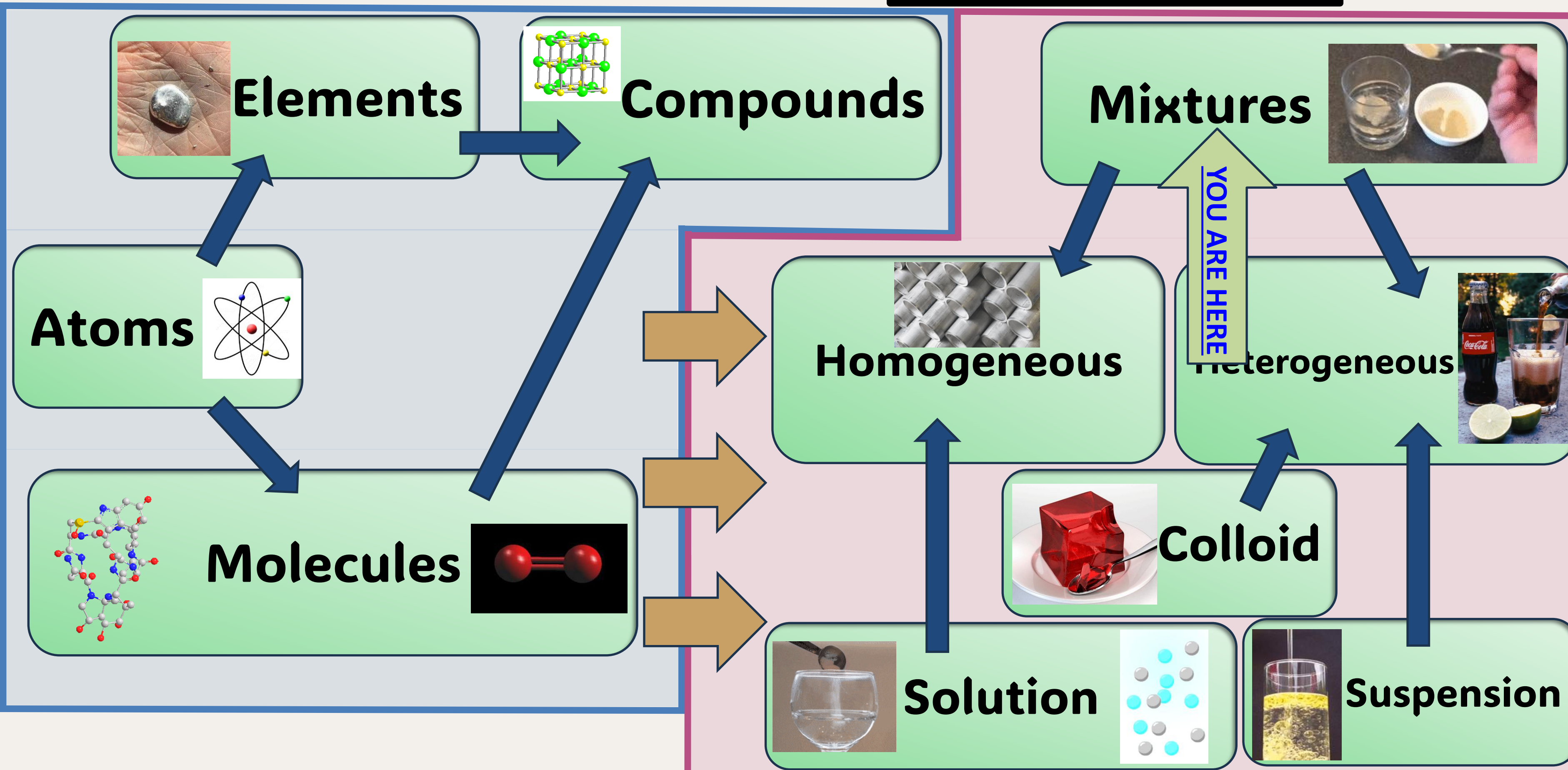
Physical changes involve the making and/or breaking of forces that do not cause the substance composition to change.



Chemical changes involve the making and/or breaking of forces between atoms that causes the substance composition to change.



MATTER MAP



MIXTURES

2 or more different substances combined so that each substance **retains** their chemical composition and can be separated by **physical** means

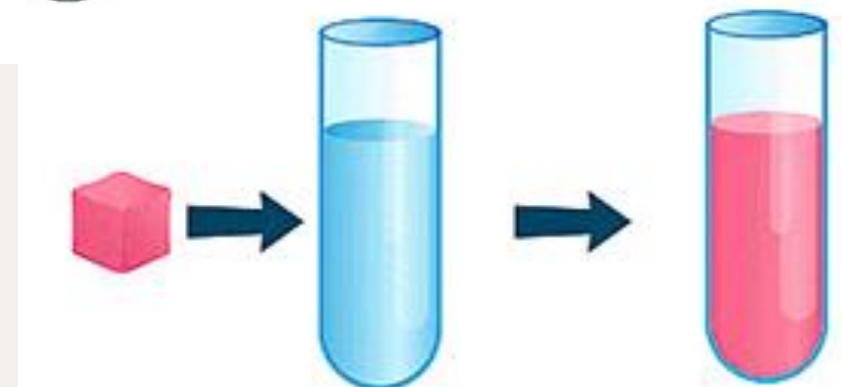
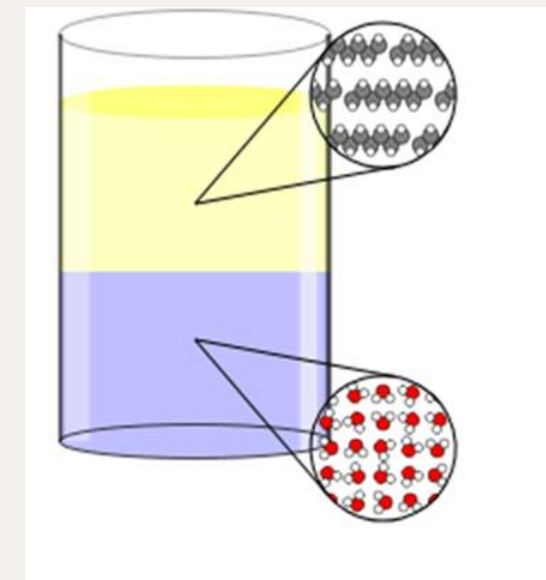
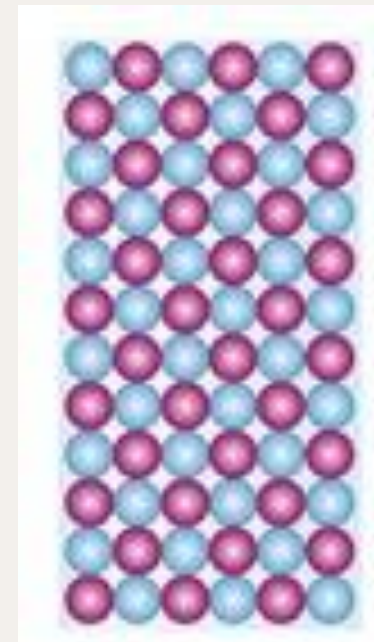
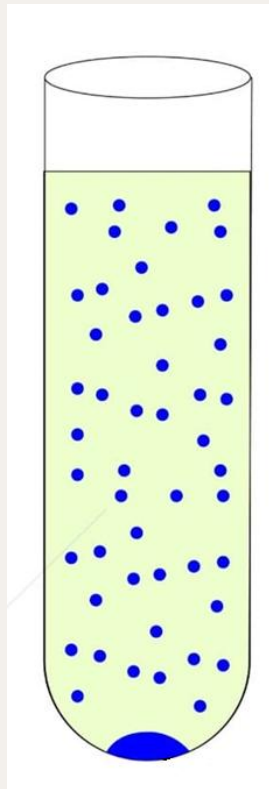
Mixtures can be solids, liquids, gases, or a combination of these

There are still forces that occur between the substances, but they can be broken without altering the composition of the substance (without breaking chemical bonds)

Can vary in particle size

Can vary in particle distribution

Can have uniform OR non-uniform properties



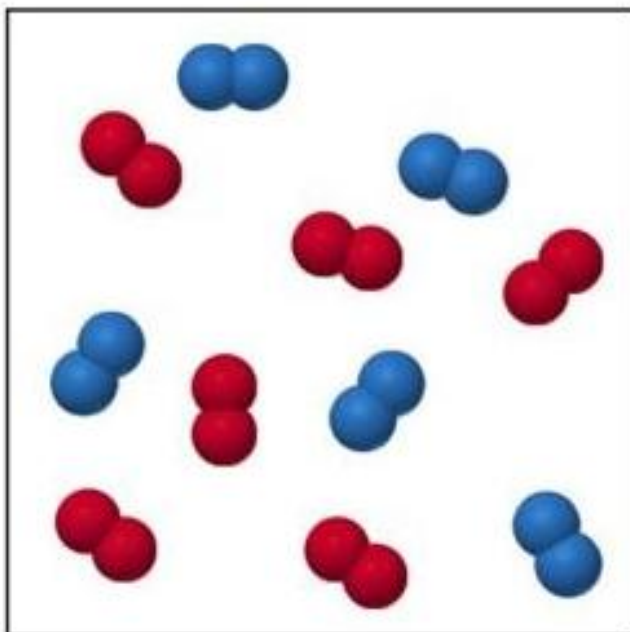
BACK TO
MATTER MAP

PURE SUBSTANCE OR MIXTURE?

Click to Choose

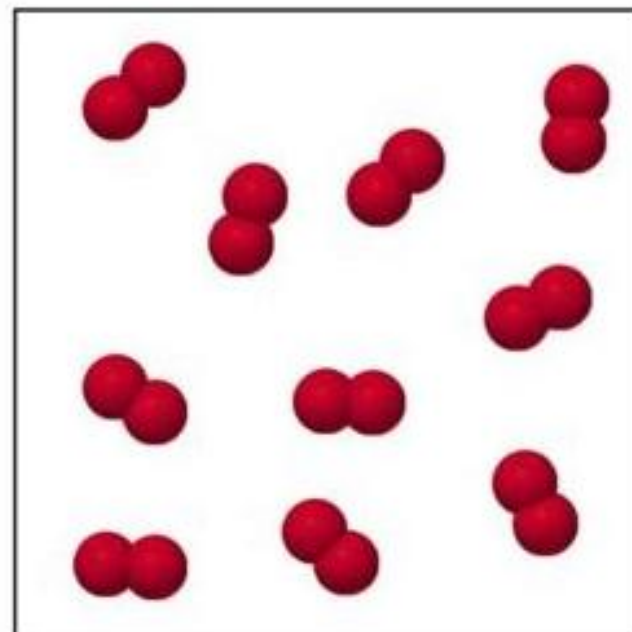
Pure Substance?

Mixture?



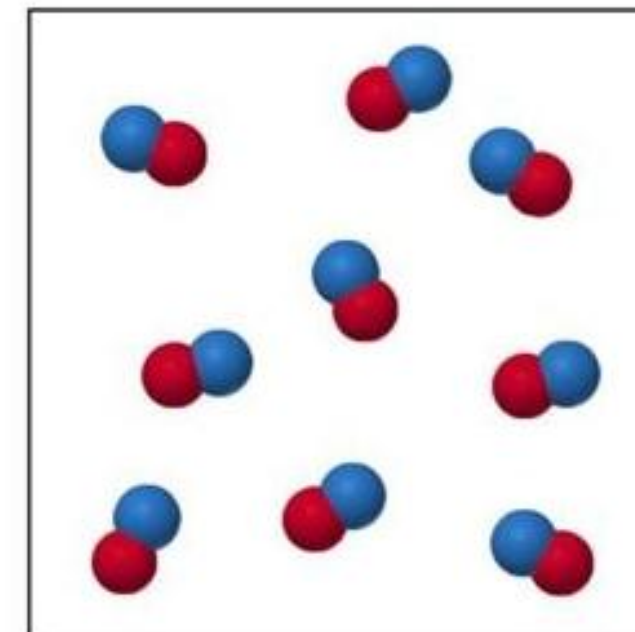
Pure Substance?

Mixture?



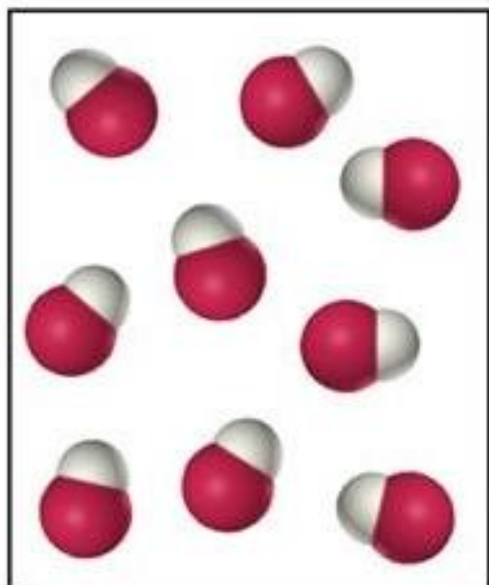
Pure Substance?

Mixture?



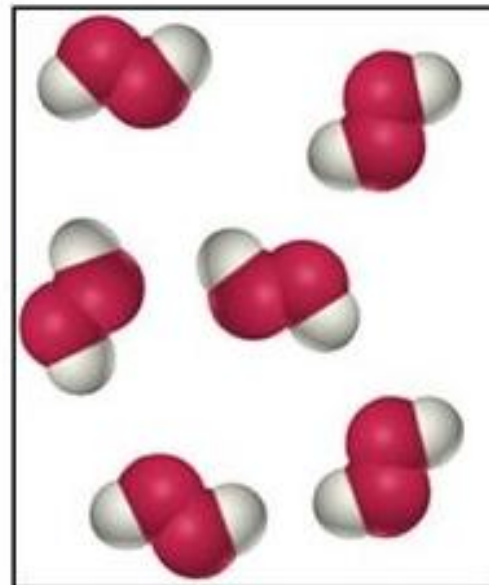
Pure Substance?

Mixture?



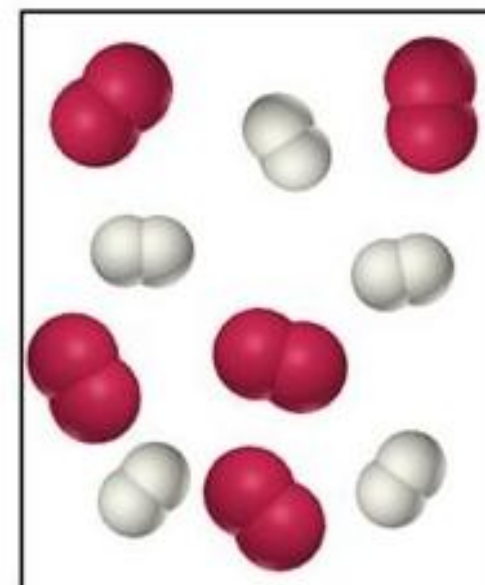
Pure Substance?

Mixture?



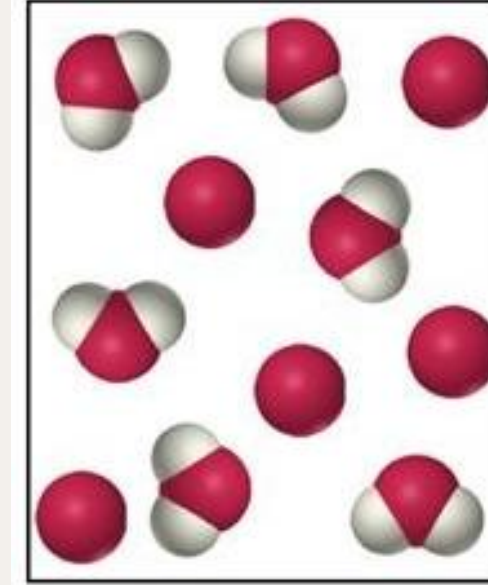
Pure Substance?

Mixture?

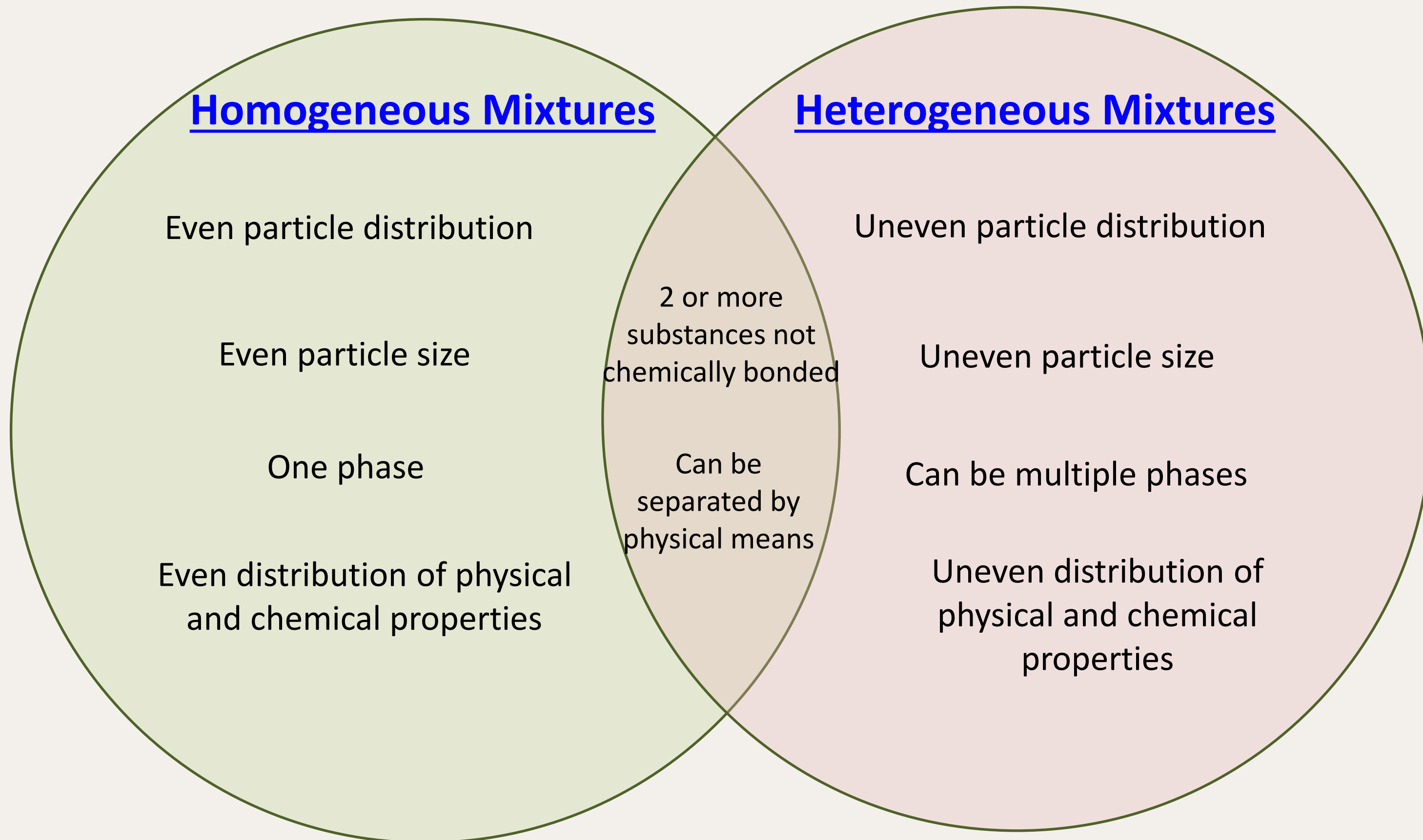


Pure Substance?

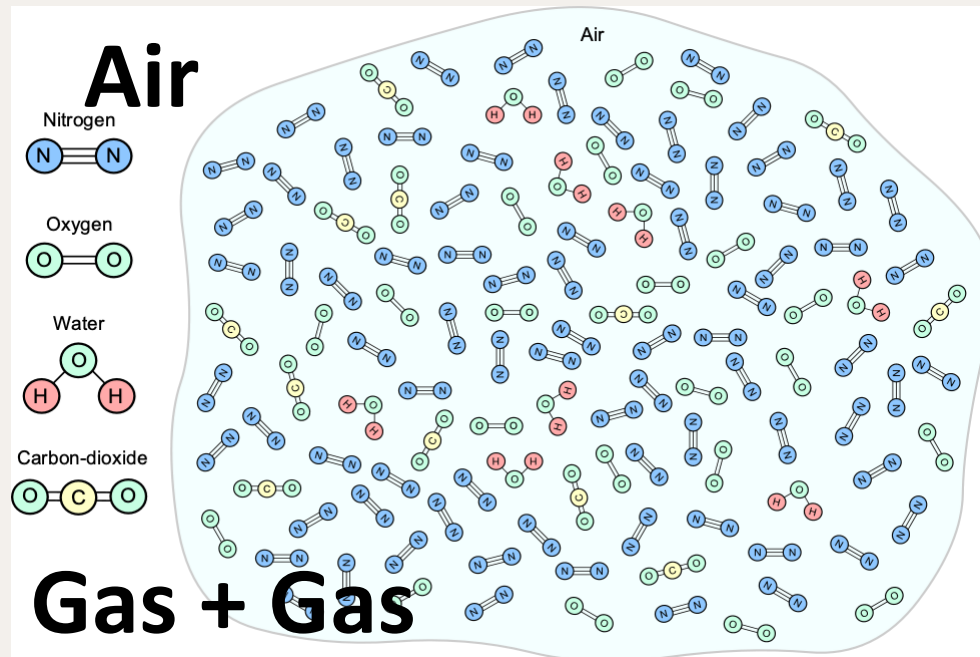
Mixture?



MIXTURES



HOMOGENEOUS MIXTURES



Mixture with a
uniform composition

All solutions are
homogeneous
mixtures but not all
homogeneous
mixtures are
solutions....ponder
that mind-bender!

Solutions

Solutions: solute + solvent



Can be liquid or
solid

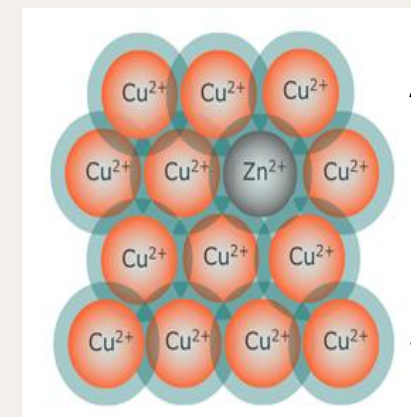
Liquid + Liquid

Solid + Liquid

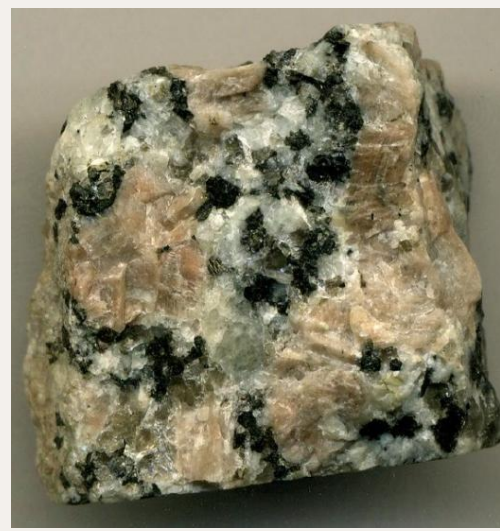


Gas + Liquid

Solid + Solid



HETEROGENEOUS MIXTURES



A solid, liquid or gas in a
“dispersion medium”
Dispersed, NOT dissolved

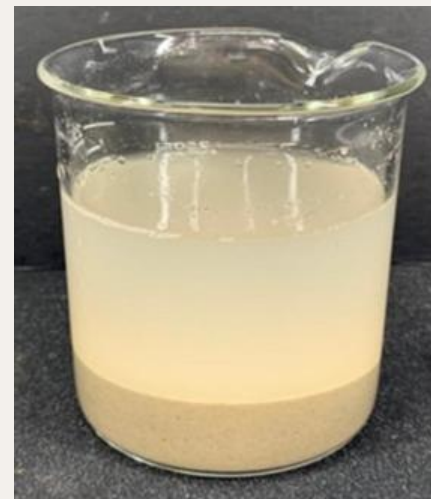
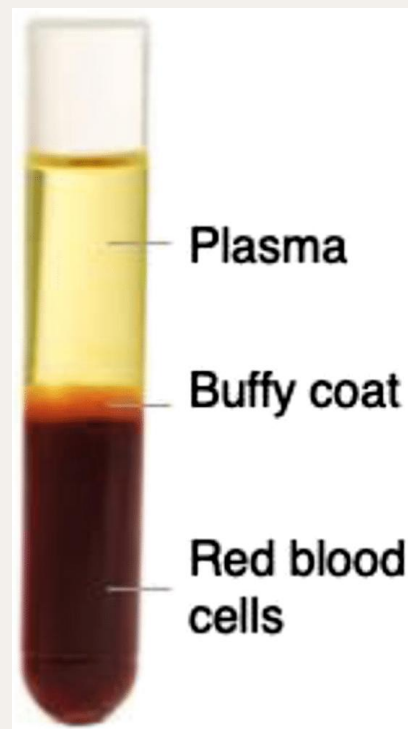
Colloid

Don't settle; can appear
homogenous but have
larger particle sizes

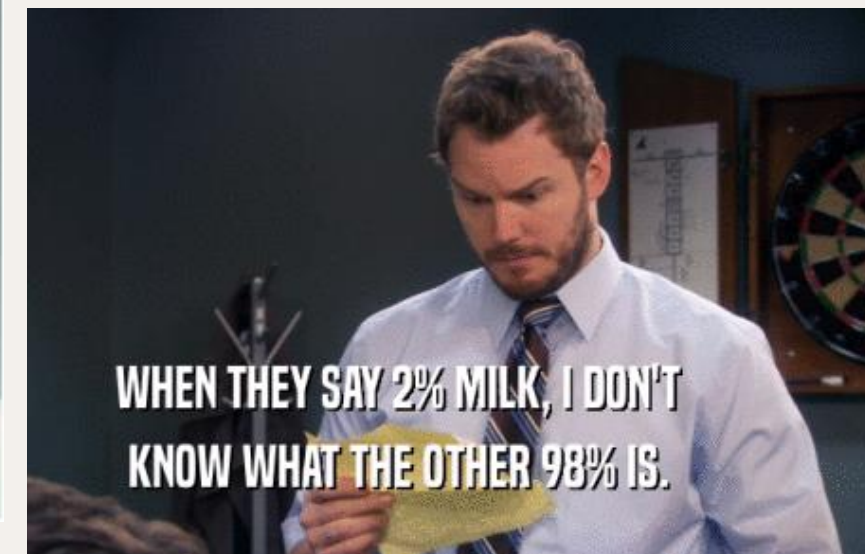
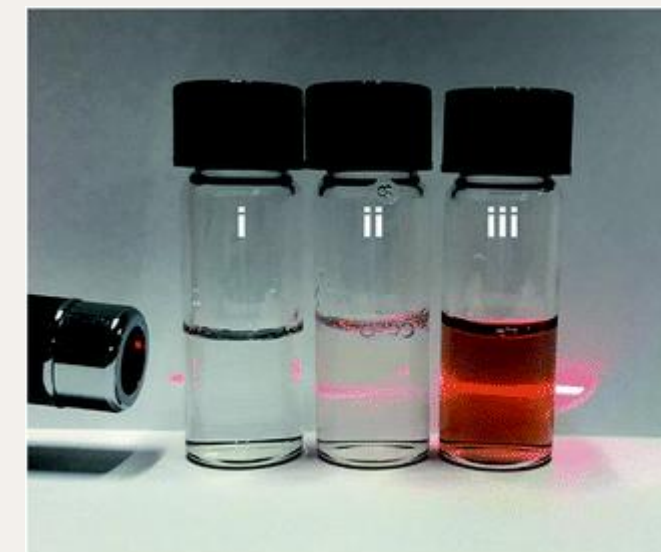
Suspension



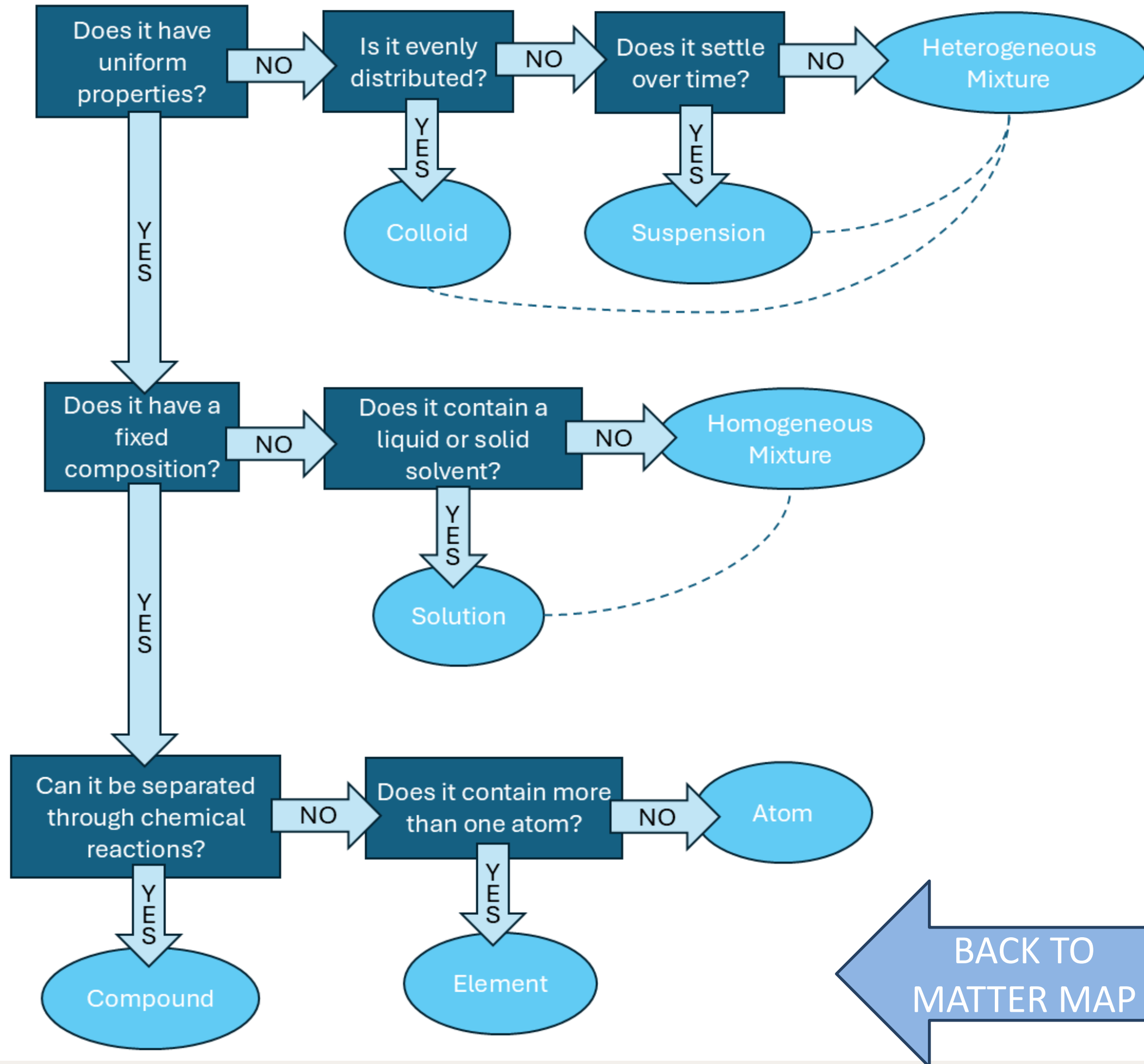
Can test for a colloid
using the Tyndall effect



Settle over time

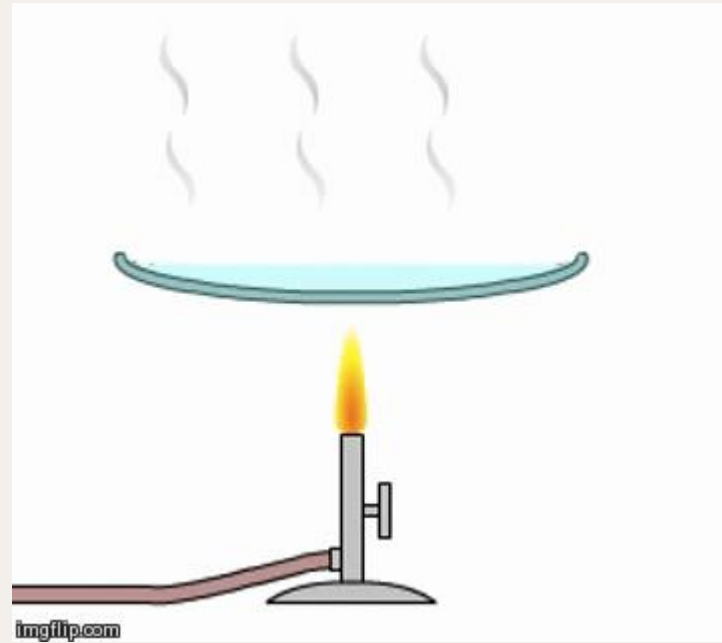


How to Classify Matter

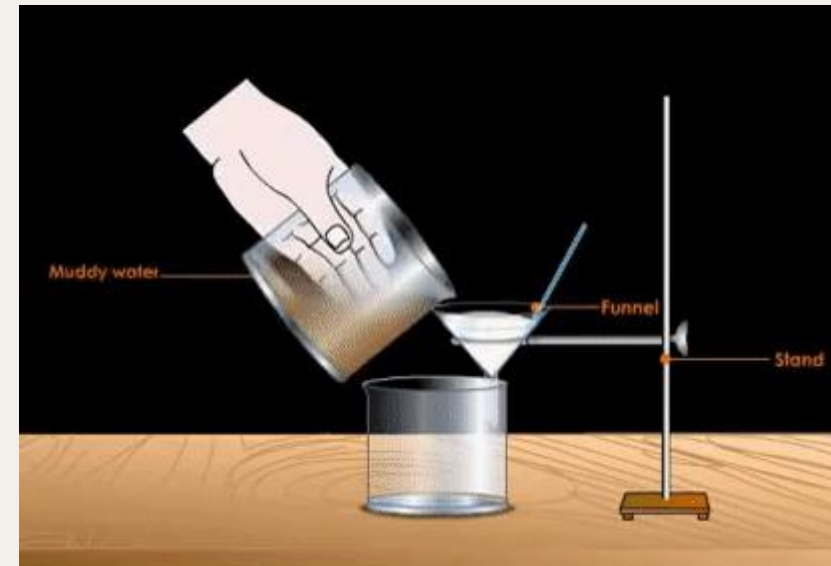


SEPARATION OF MIXTURES

Evaporation



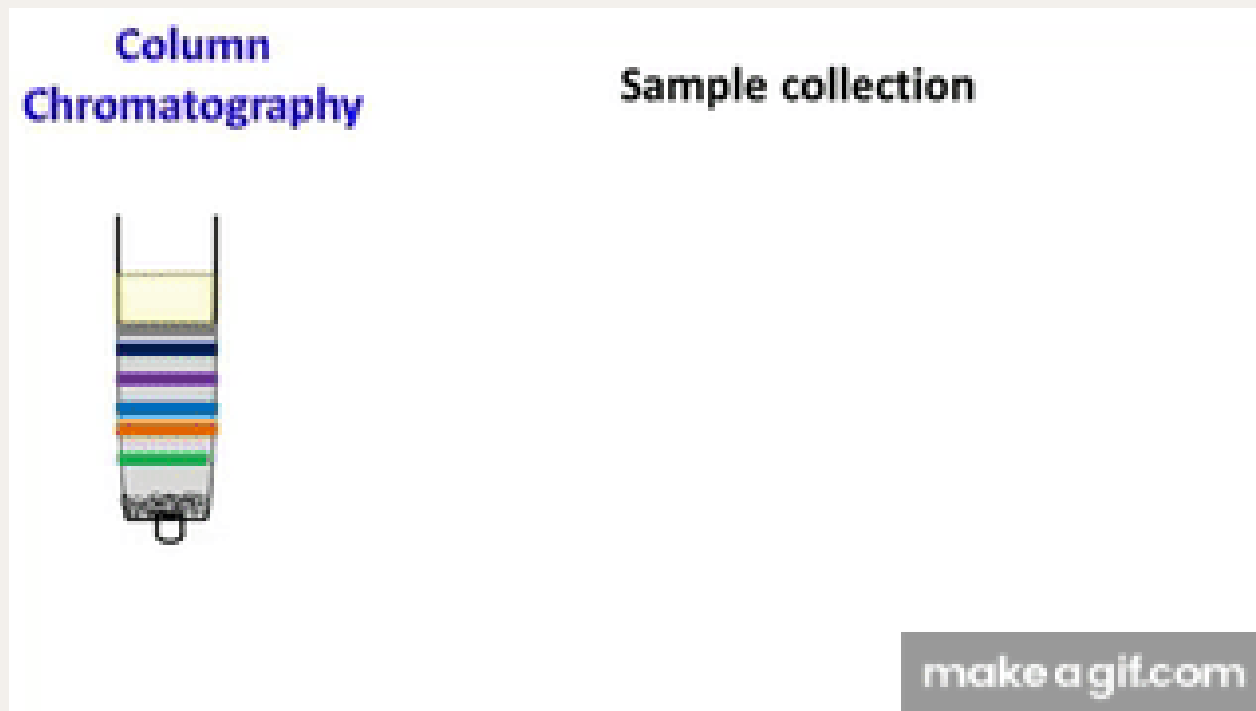
Filtration



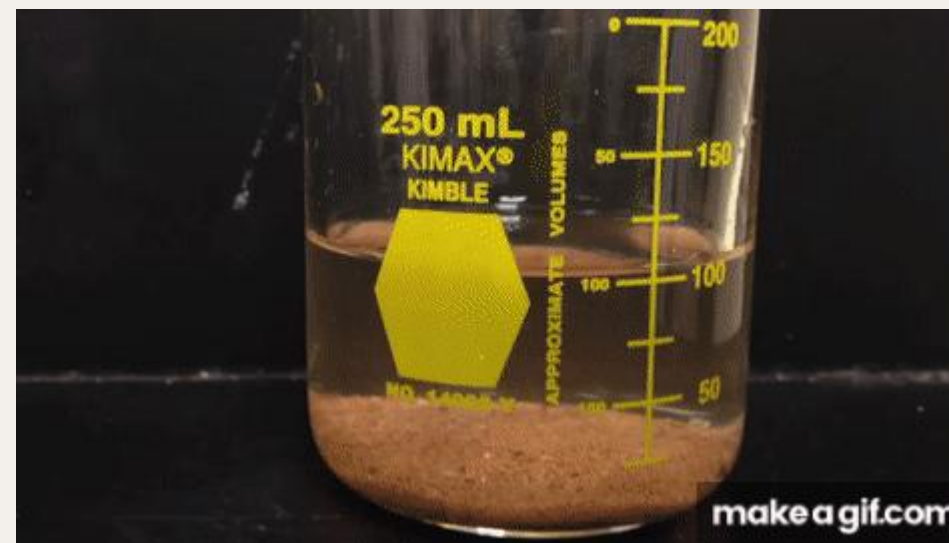
Distillation



Chromatography



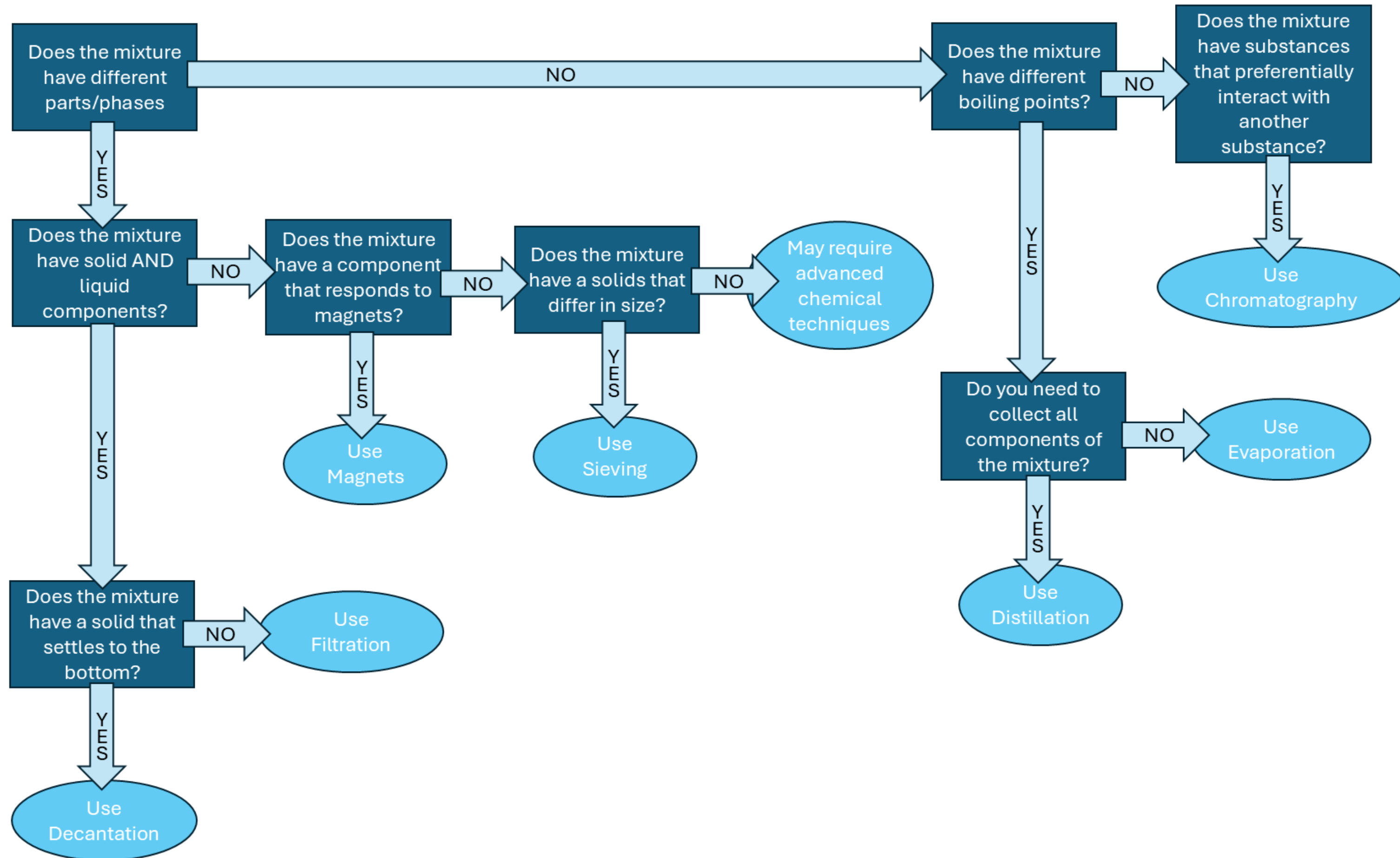
Decanting



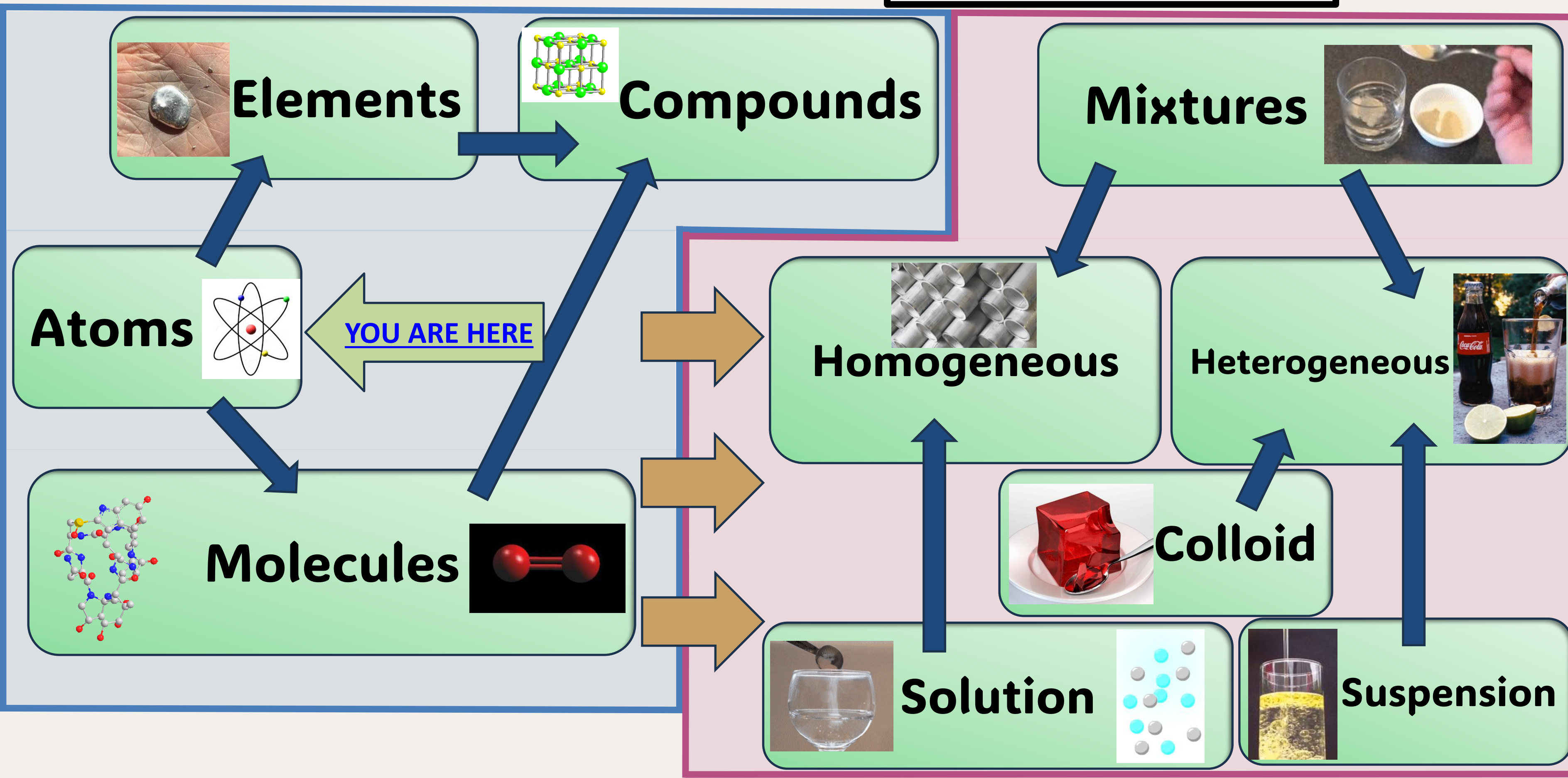
Sieving



How to Separate Mixtures



 Pure Substance
 Mixture

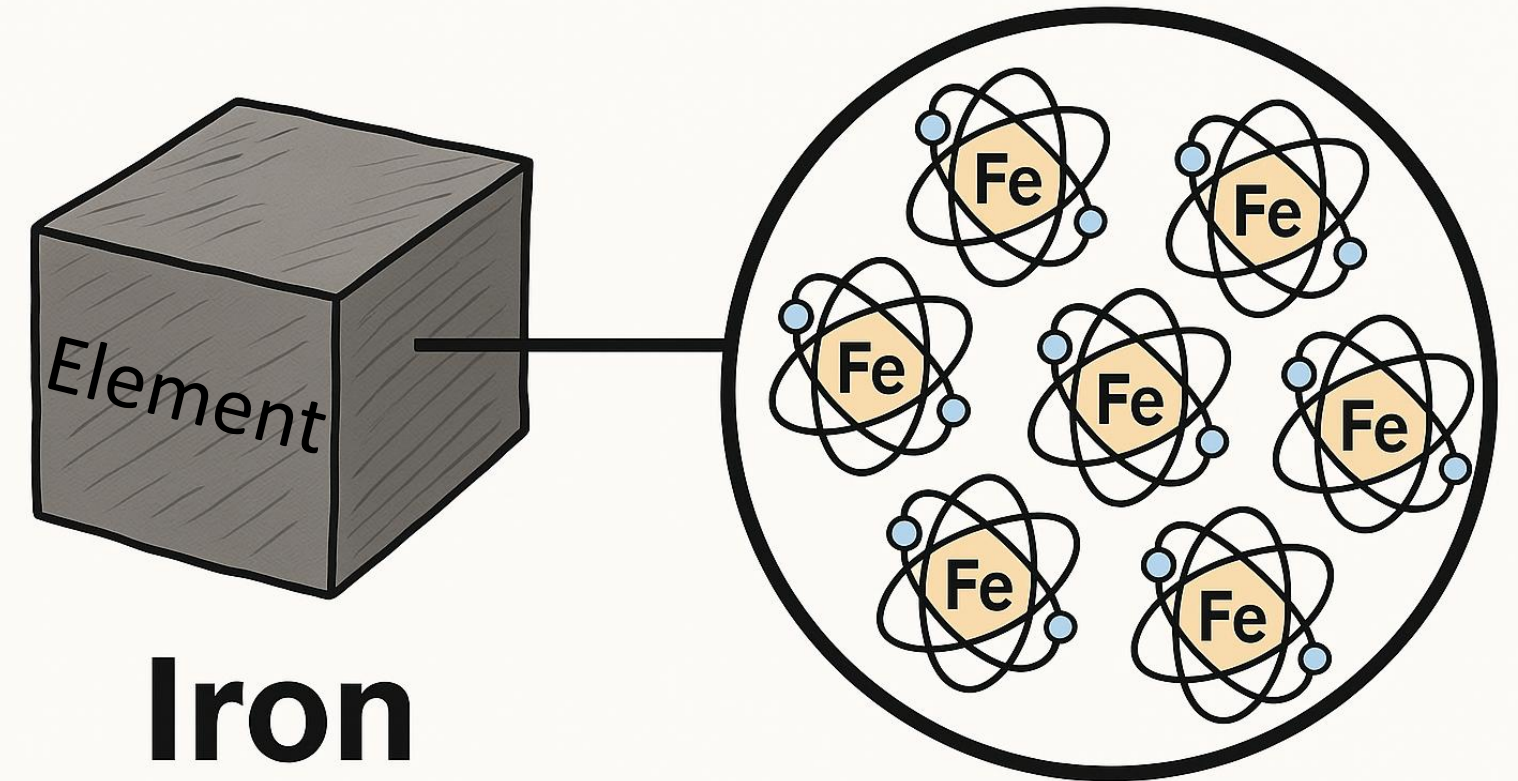
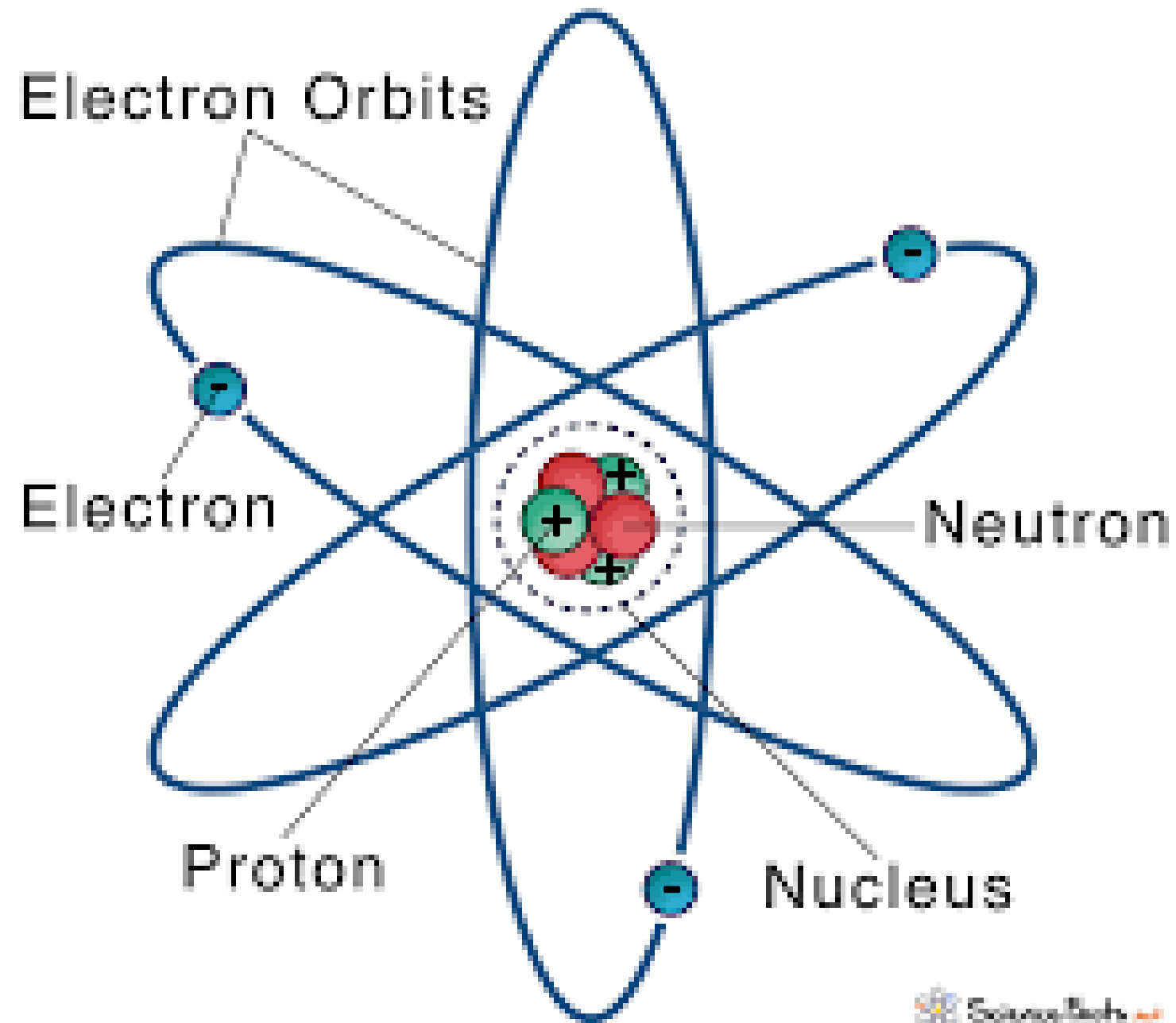


ATOMS

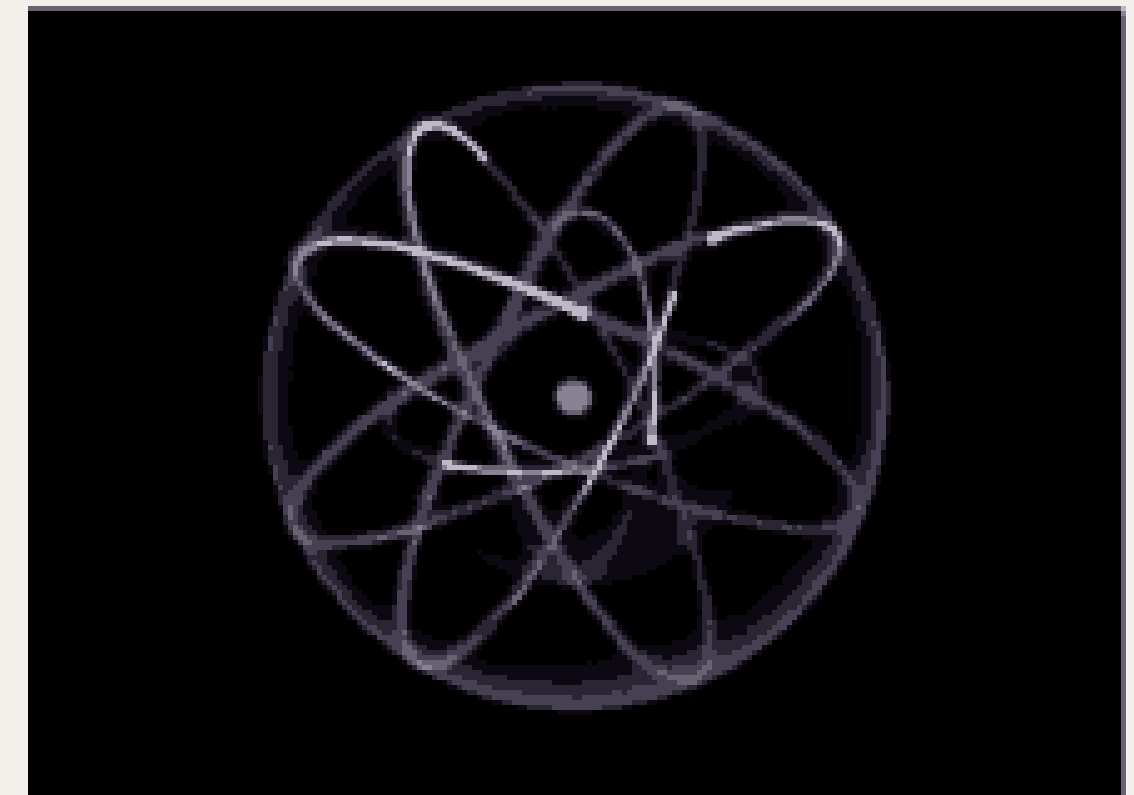
Pure Substance

the smallest unit of an element that retains the chemical properties of that element

Atom



If any piece of a block of iron is removed, it will behave chemically in the same way (they all have the same electron structure).

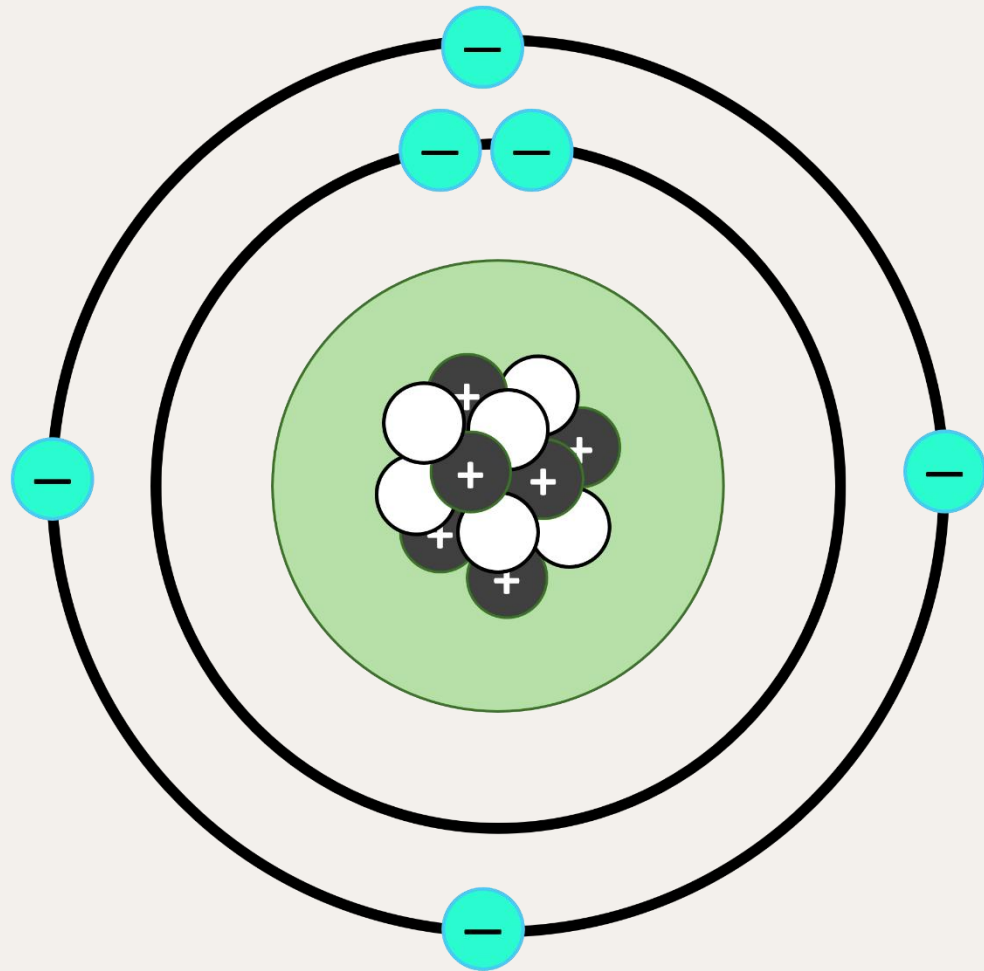


Made of subatomic particles: protons, neutrons, and electrons

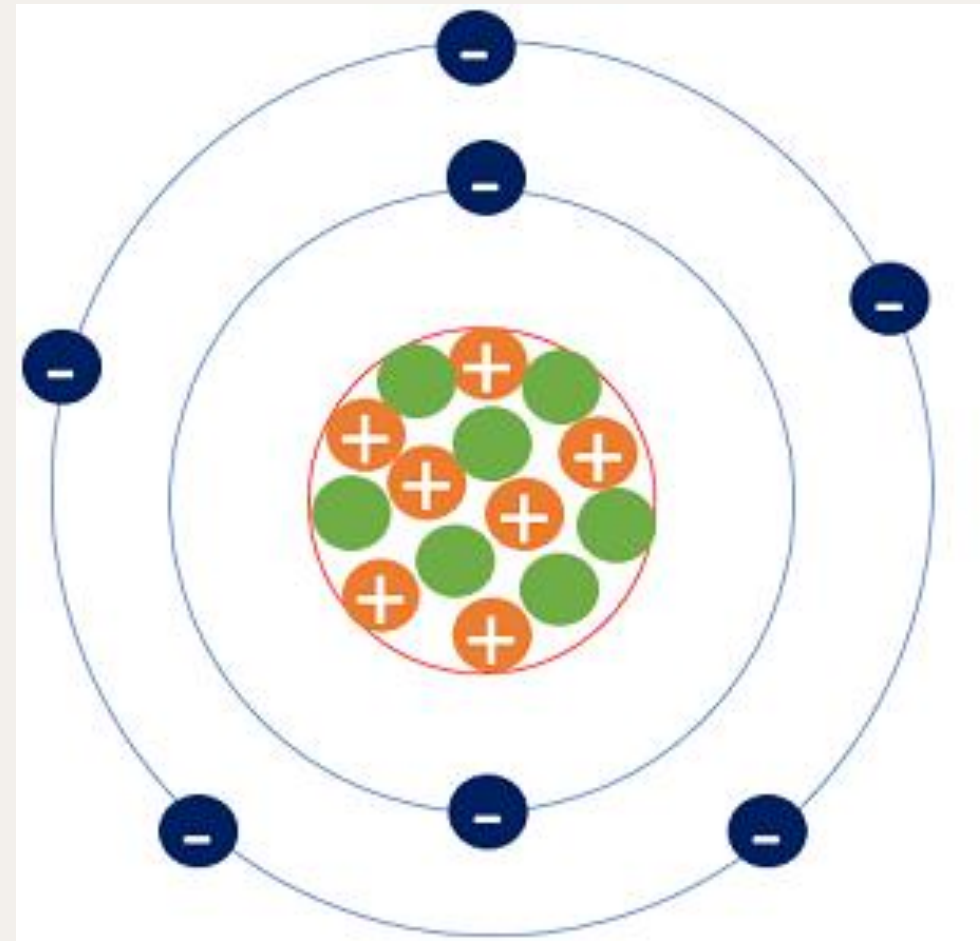
ATOMS

The number of protons gives an atom its identity!

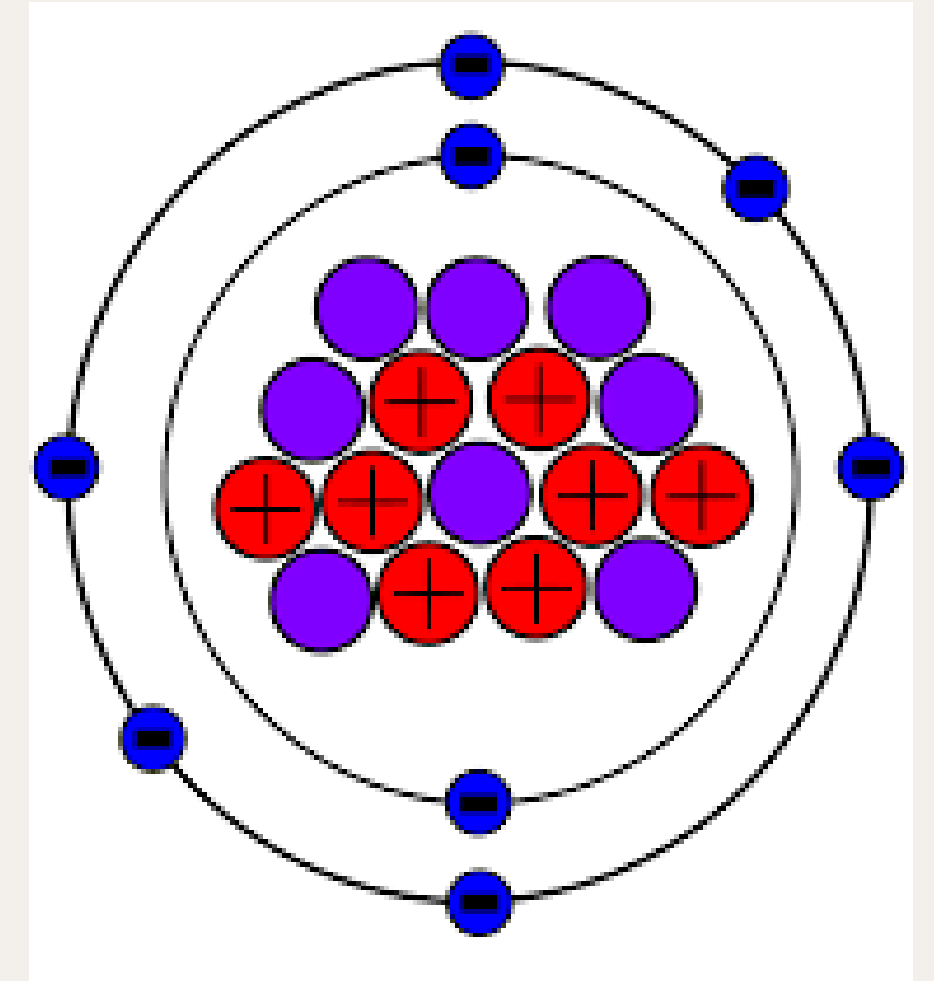
This is called the atomic number.



Carbon: 6 protons



Nitrogen: 7 protons



Oxygen: 8 protons



ATOMS

Atoms are naturally electrically neutral ($p^+ = e^-$)

How much matter is in a subatomic particle? This is measured by the **MASS**.

How much charge is in a subatomic particle? This is the source of the attraction or repulsion between objects. It is measured in **Coulombs**.

Subatomic Particle	Symbol	Mass		Charge	
		Grams	Atomic Mass units (amu/u)	Coulombs	Charge
Proton	p^+	1.67×10^{-24}	1.007276	$+1.602 \times 10^{-19}$	+1 (nuclear charge)
Neutron	n^0	1.67×10^{-24}	1.008665	0	0
Electron	e^-	9.11×10^{-28}	0.0005486	-1.602×10^{-19}	-1 (electronic charge)

Mass Number: The number of protons and neutrons in an atom (basically the mass of the nucleus)

If you need a refresher on scientific notation, please click [HERE](#).

ATOMS: Atomic mass unit

In chemistry, RELATIVE values are used to make many measurements. This is because we are dealing with EXTREMELY small values...so we just compare one value to another to make math much easier.

Here's an example:

Sulfur has 16 protons and 16 neutrons. What is the mass of the nucleus?

Hard way: Doing the actual math

$16(1.67 \times 10^{-24} \text{ g}) + 16(1.67 \times 10^{-24} \text{ g})$. Who wants to do the math?

Easy way: Using a “standard”

The International Union of Pure and Applied Chemistry (IUPAC) decided to make that standard exactly 1/12 the size of a carbon atom (has 6 protons and 6 neutrons), or $1.66054 \times 10^{-24} \text{ g}$. Dividing the mass of a proton or a neutron by this standard, gives a value of approximately 1 amu (atomic mass unit).

So... all protons and neutrons have a relative mass of 1 amu. Electrons don't really have a mass (it's negligible).

The answer: $16 + 16 = 32 \text{ amu}$

ATOMS: Charge

In chemistry, RELATIVE values are used to make many measurements. This is because we are dealing with EXTREMELY small values...so we just compare one value to another to make math much easier.

Here's another example:

Chlorine has 17 electrons and 17 protons. What is the charge from each of the subatomic particles?

Hard way: Doing the actual math
 $17(-1.602 \times 10^{-19} \text{ C})$: for electrons
Who wants to do the math?

$17(1.602 \times 10^{-19} \text{ C})$: for protons

Easy way: Using a “standard”

The International Union of Pure and Applied Chemistry ([IUPAC](#)) decided to make that standard the magnitude of the charge carried by exactly 1 electron or proton, or $1.602 \times 10^{-19} \text{ C}$. Dividing the charge of an electron or proton by this standard, gives a value of -1 (electron) or +1 (proton).

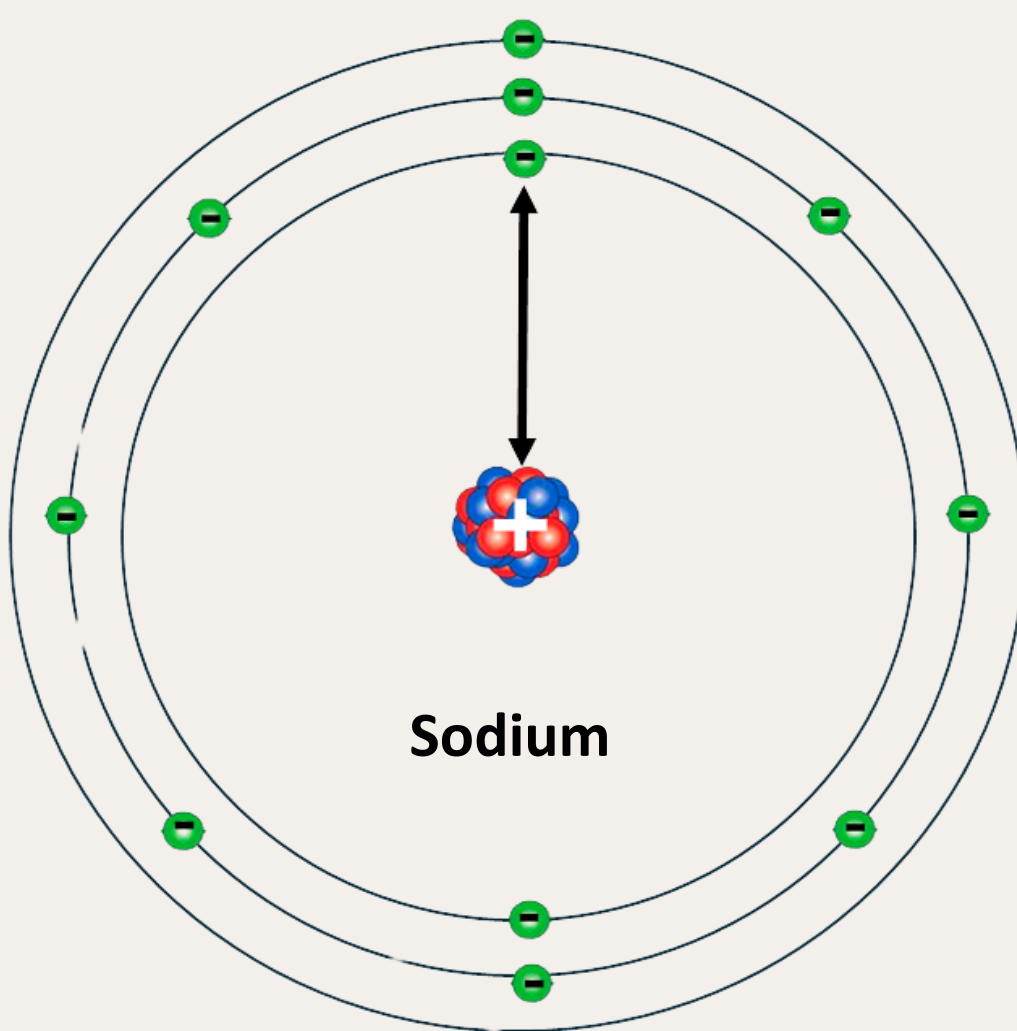
The answer: electrons: -17 (no units for relative charge)

protons: +17

Total electric charge: 0

PROPERTIES of matter are determined by the mass of the nucleus, the nuclear charge, and the arrangement of electrons!

Electrons are held in place by the nuclear charge (remember, positive and negative attract).



Electrons held more loosely

Less electrons in outer shell

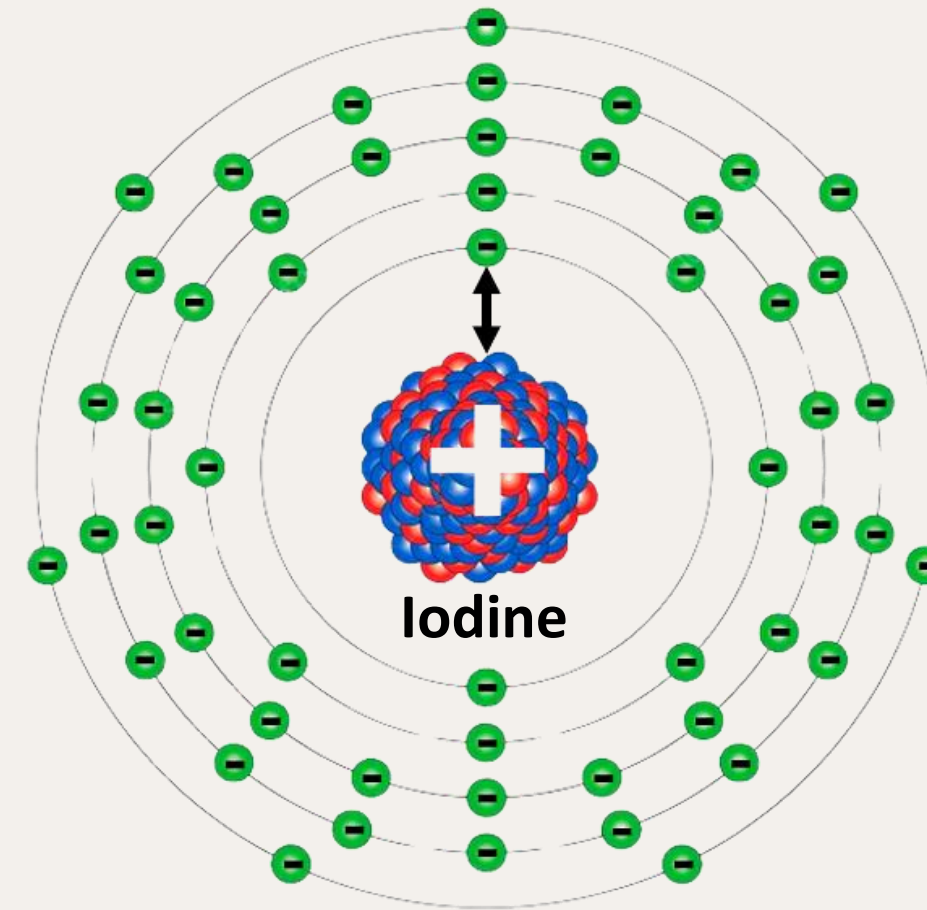
More likely to tarnish

Lower nuclear charge = smaller attraction to electrons

Conductive

Smaller nucleus, More volume

Lower Density



Electrons held more tightly

More electrons in outer shell

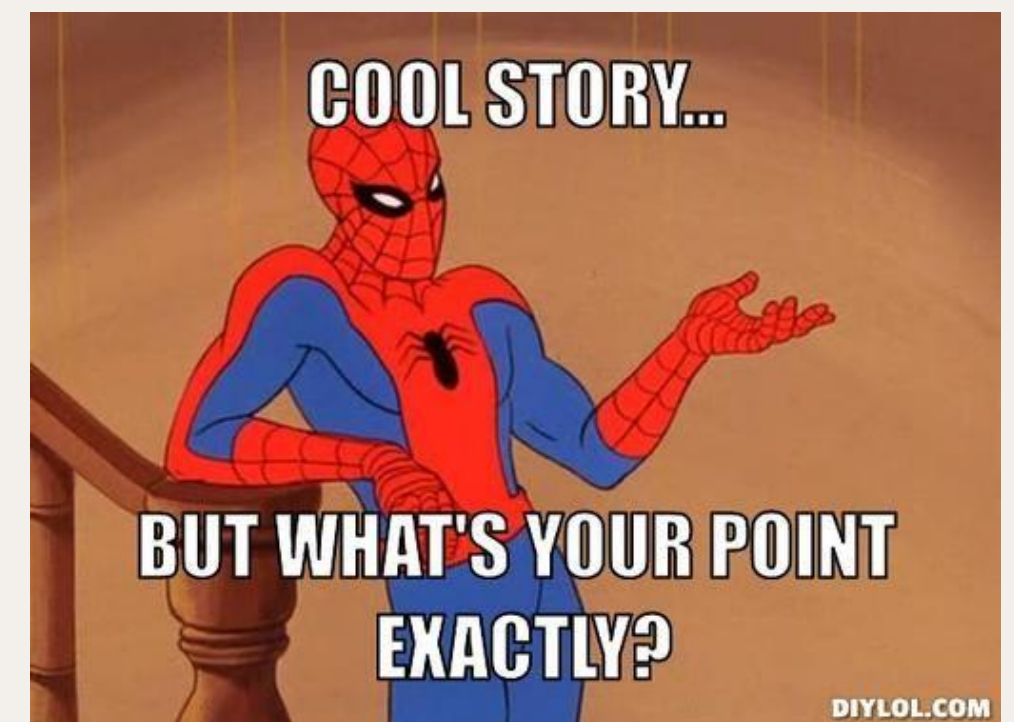
Less likely to tarnish

Higher nuclear charge = greater attraction to electrons

Non-conductive

Bigger nucleus, Less volume

Higher Density



Forces within and between atoms (electrostatic interactions) that hold electrons in place and allow them to move is what determines the properties of atoms!

**What are those?
I'm so glad you
asked...**

Specific forces called chemical bonds affect the structure and composition of substances

Atoms naturally form bonds to increase stability!

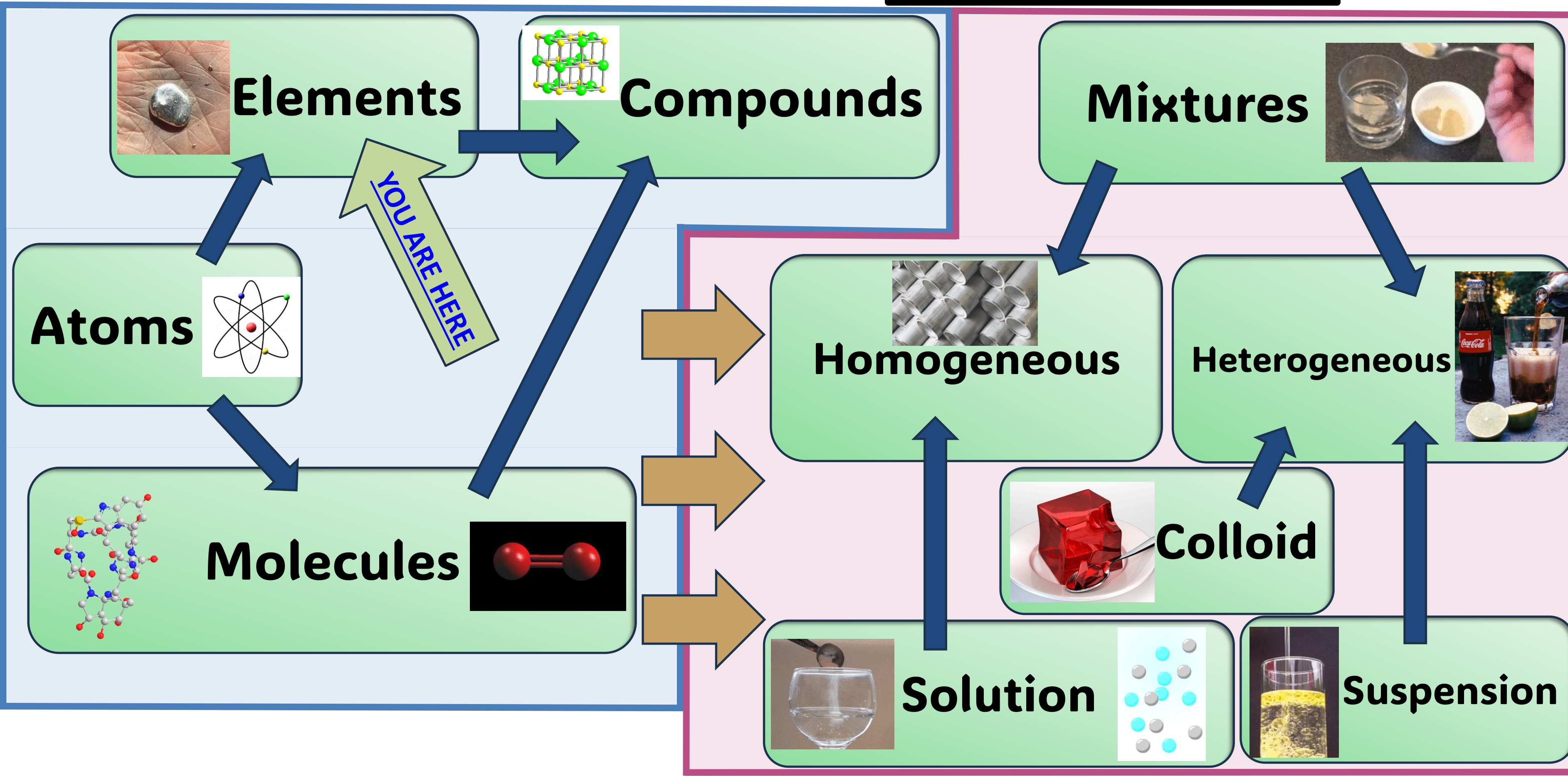
FORCES that occur between atoms

The presence and nature of chemical bonds are one factor that helps determine how matter is classified.

**BACK TO
MATTER MAP**



MATTER MAP



ELEMENTS Pure Substance

a substance made up of only one type of atom – 118 known elements

Confusing
Element Symbols
Explained

An element can actually refer to a singular atom or a group of the same atoms.

THE UPDATED
PERIODIC
TaBLE
SONG



PERIODIC TABLE OF ELEMENTS

GROUP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
PERIOD 1	1 H Hydrogen 1.008																	2 He Helium 4.003
PERIOD 2	3 Li Lithium 6.94	4 Be Beryllium 9.012											5 B Boron 10.81	6 C Carbon 12.01	7 N Nitrogen 14.01	8 O Oxygen 16.00	9 F Fluorine 18.99	10 Ne Neon 20.18
PERIOD 3	11 Na Sodium 22.99	12 Mg Magnesium 24.31											13 Al Aluminum 26.98	14 Si Silicon 28.09	15 P Phosphorus 30.97	16 S Sulfur 32.06	17 Cl Chlorine 35.45	18 Ar Argon 39.95
PERIOD 4	19 K Potassium 39.10	20 Ca Calcium 40.08	21 Sc Scandium 44.96	22 Ti Titanium 47.88	23 V Vanadium 50.94	24 Cr Chromium 52.00	25 Mn Manganese 54.94	26 Fe Iron 55.85	27 Co Cobalt 58.93	28 Ni Nickel 58.69	29 Cu Copper 63.55	30 Zn Zinc 65.39	31 Ga Gallium 69.72	32 Ge Germanium 72.64	33 As Arsenic 74.92	34 Se Selenium 78.96	35 Br Bromine 79.90	36 Kr Krypton 83.79
PERIOD 5	37 Rb Rubidium 85.47	38 Sr Strontium 87.62	39 Y Yttrium 88.91	40 Zr Zirconium 91.22	41 Nb Niobium 92.91	42 Mo Molybdenum 95.94	43 Tc Technetium (98)	44 Ru Ruthenium 101.1	45 Rh Rhodium 102.9	46 Pd Palladium 106.4	47 Ag Silver 107.9	48 Cd Cadmium 112.4	49 In Indium 114.8	50 Sn Tin 118.7	51 Sb Antimony 121.8	52 Te Tellurium 127.6	53 I Iodine 126.9	54 Xe Xenon 131.3
PERIOD 6	55 Cs Cesium 132.9	56 Ba Barium 137.3	57-71 Lanthanides	72 Hf Hafnium 178.5	73 Ta Tantalum 180.9	74 W Tungsten 183.8	75 Re Rhenium 186.2	76 Os Osmium 190.2	77 Ir Iridium 192.2	78 Pt Platinum 195.1	79 Au Gold 197.0	80 Hg Mercury 200.6	81 Tl Thallium 204.4	82 Pb Lead 207.2	83 Bi Bismuth 208.98	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon 222
PERIOD 7	87 Fr Francium (223)	88 Ra Radium (226)	89-103 Actinides	104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (266)	107 Bh Bohrium (264)	108 Hs Hassium (277)	109 Mt Meitnerium (268)	110 Ds Darmstadtium (271)	111 Rg Roentgenium (272)	112 Cn Copernicium (285)	113 Nh Nihonium (284)	114 Fl Flerovium (289)	115 Mc Moscovium (288)	116 Lv Livermorium (293)	117 Ts Tennessine (294)	118 Og Oganesson (294)

78 — Atomic Number
Pt — Symbol
Platinum — Name
195.1 — Average Atomic Mass

78 — Atomic Number
Pt — Symbol
Platinum — Name
195.1 — Average Atomic Mass

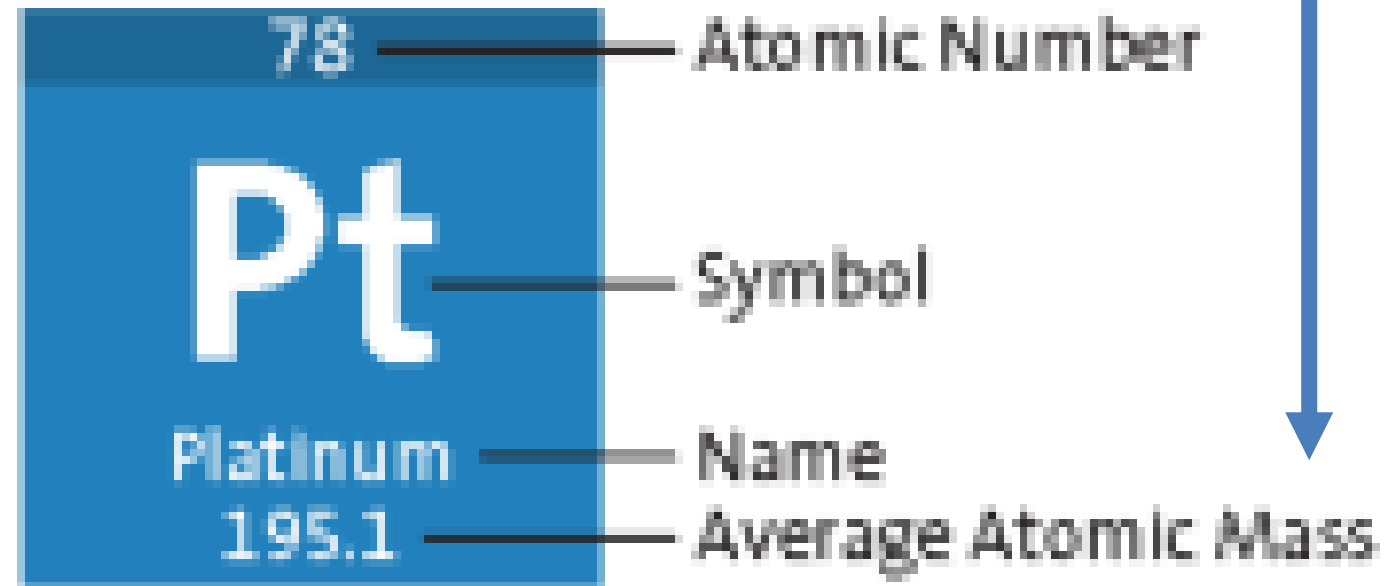
If you capitalize the second letter of an element, Dr. Green will be a SAD PANDA

Element symbols are abbreviations (usually based on Greek or Latin names).

AVERAGE ATOMIC MASS/WEIGHT

ISOTOPES

This is NOT the same as mass number

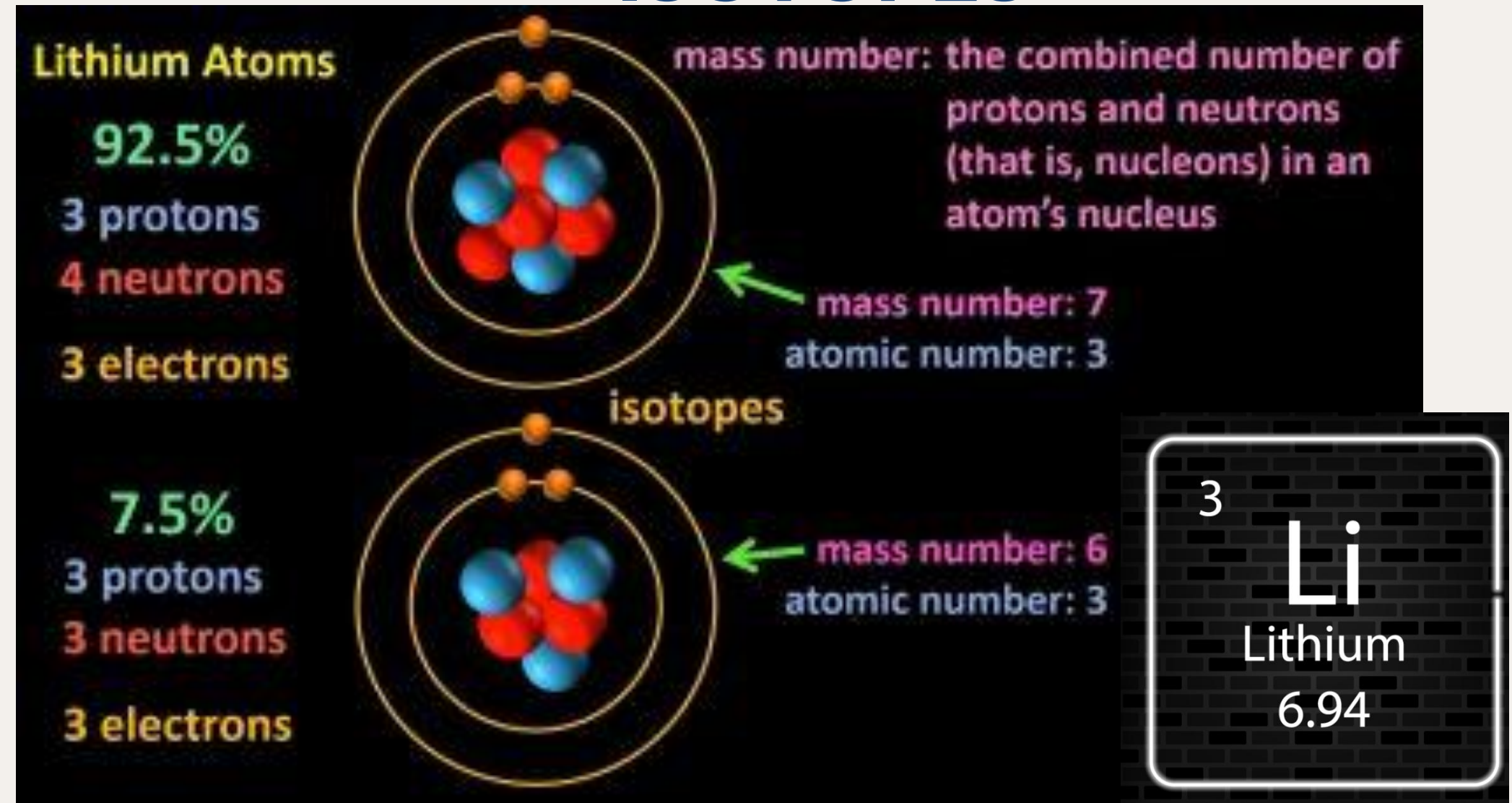


78	Atomic Number
Pt	Symbol
Platinum	Name
195.1	Average Atomic Mass

Mass numbers ($p^+ + n^0$) are whole numbers.

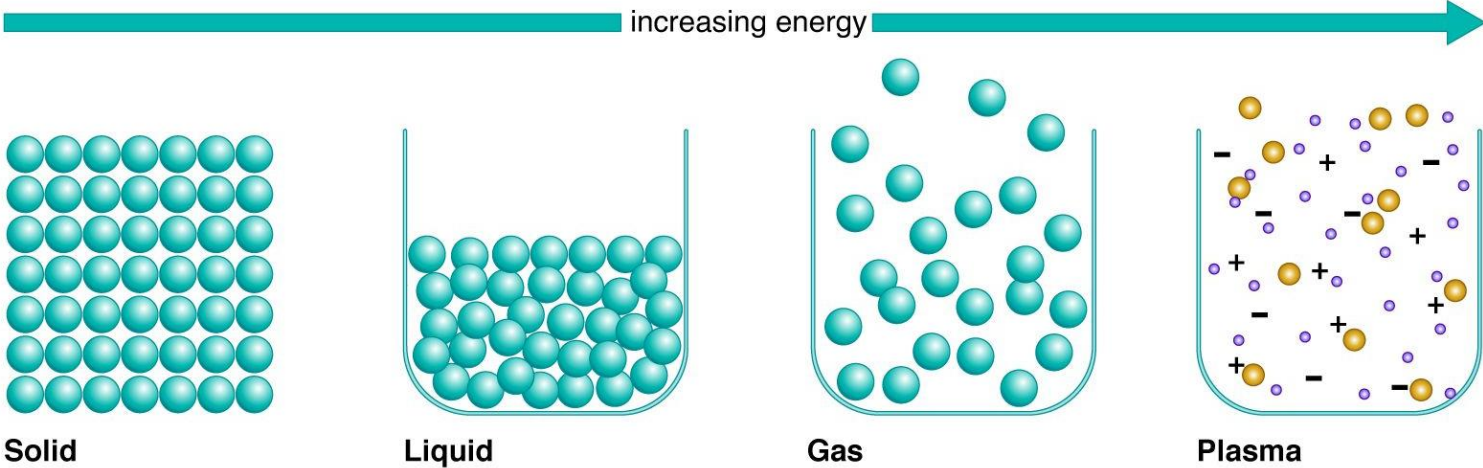
Average atomic mass (aka atomic weight) is the average WEIGHTED mass of all isotopes of an element.

Isotopes are why elements can have DIFFERENT physical properties (e.g. mass and density) but the SAME chemical properties (involve movement of electrons).



Have the same number of PROTONS, but different numbers of NEUTRONS. ELECTRONS are not affected.

STATES OF MATTER



Plasma (occurs when atoms lose their electrons at high temperatures) is mainly found in stars and in space.

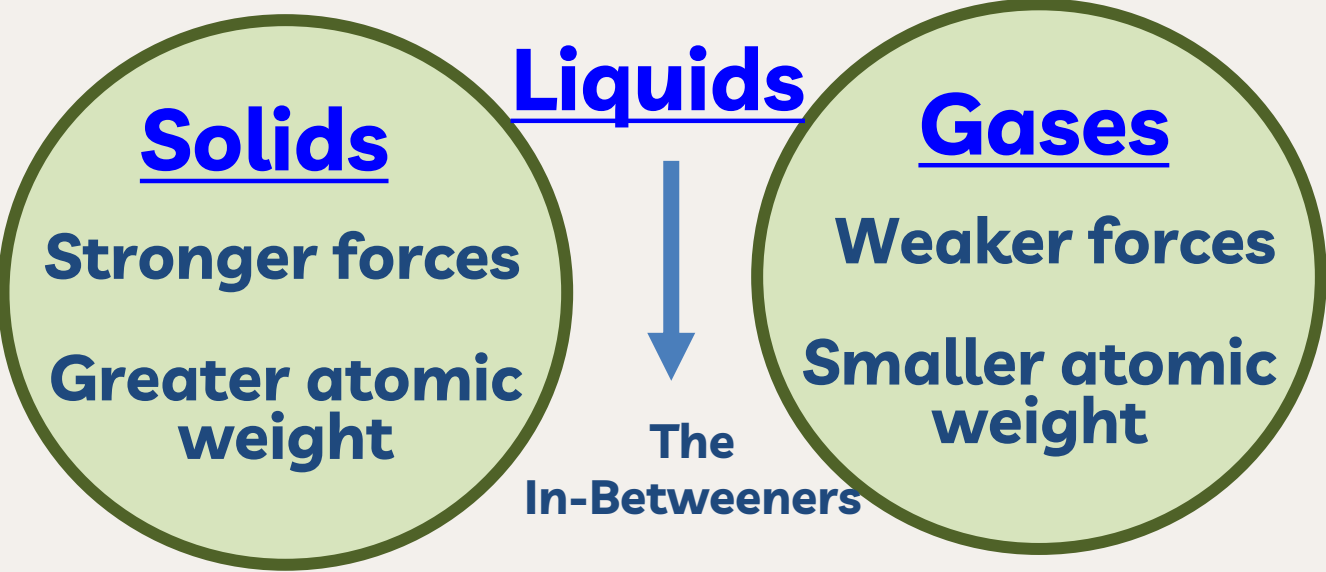


Most elements are solid
Gases are on the right side (except hydrogen)

Only 2 liquids (mercury and bromine)

WHY?

Again, **FORCES** between atoms in an element as well as the size of the atoms determines the state of matter.



Periodic Table of the Elements

Natural State

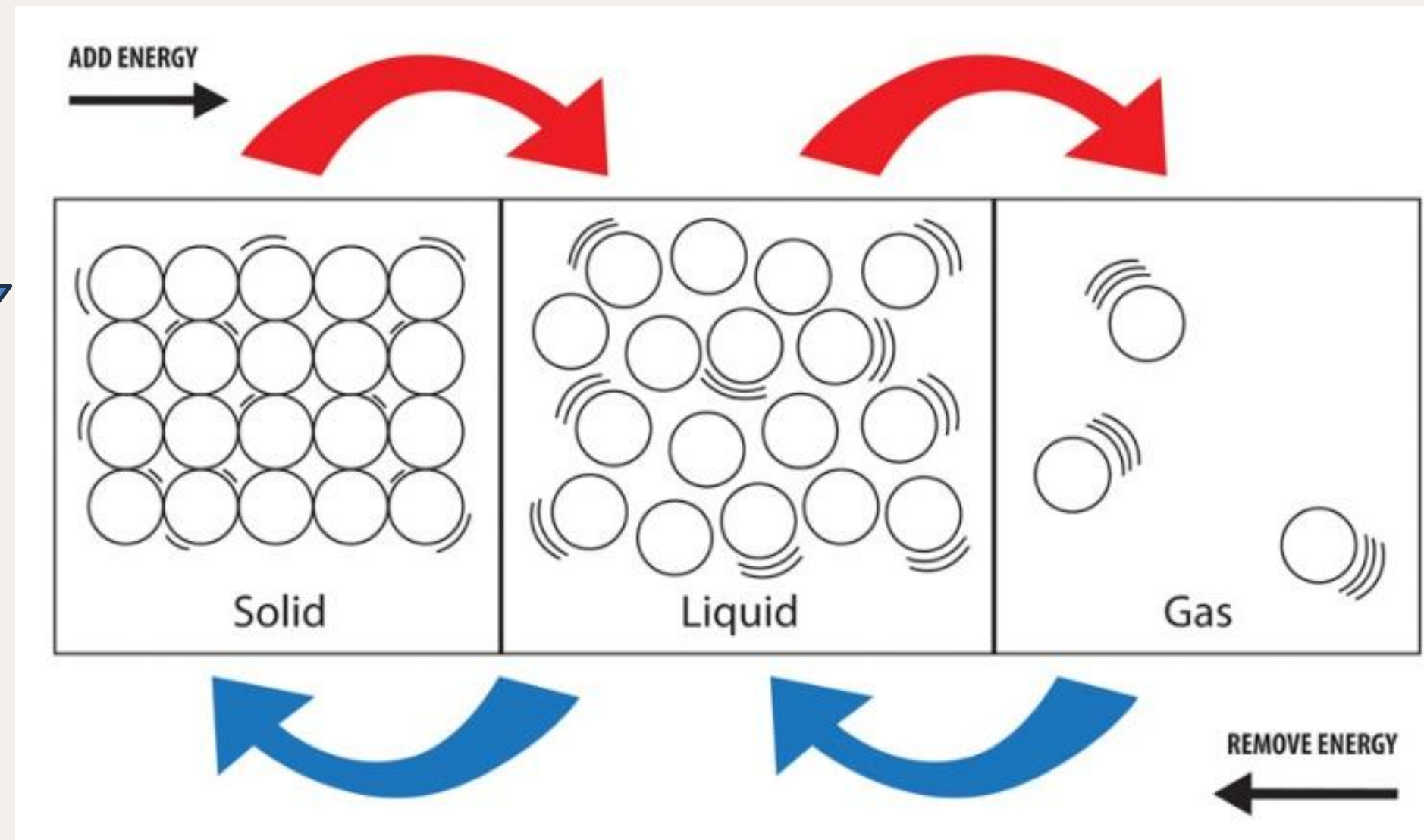
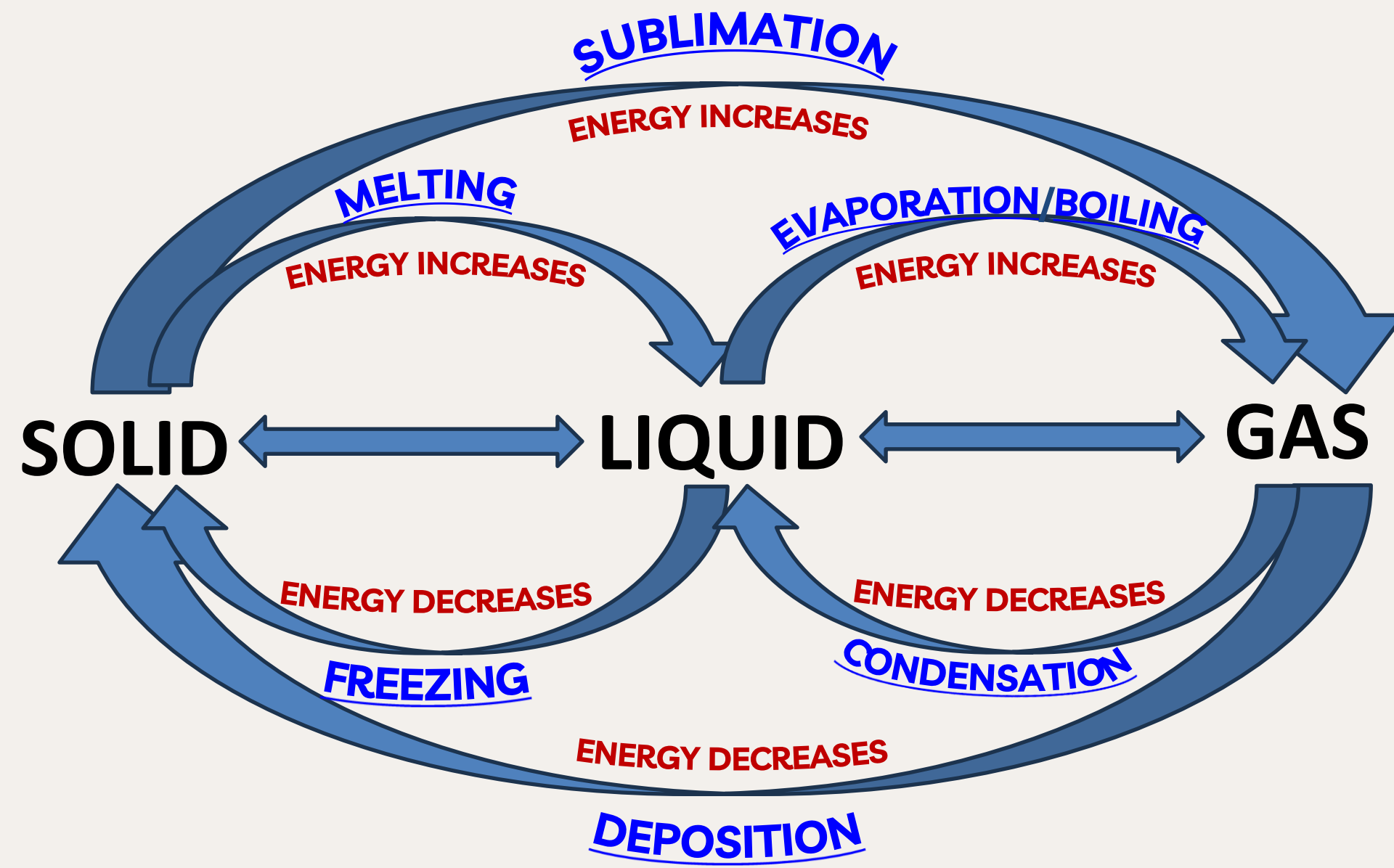
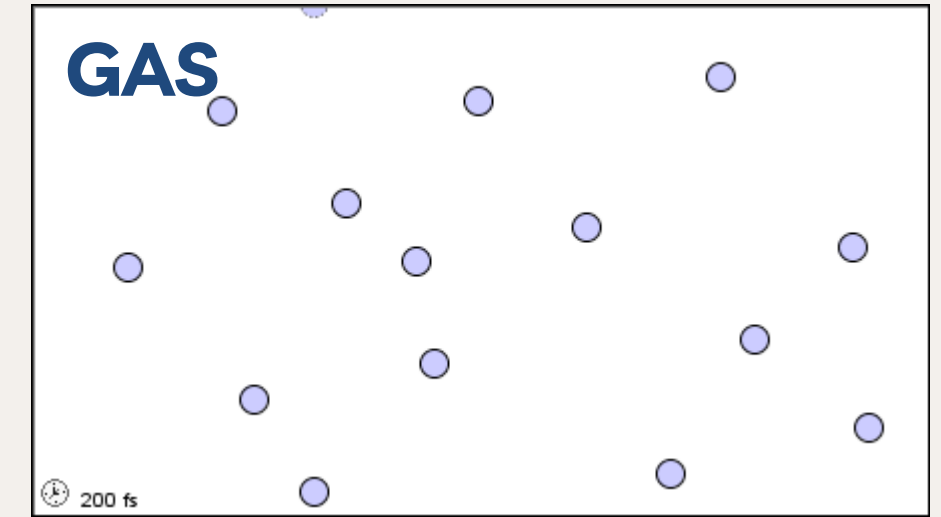
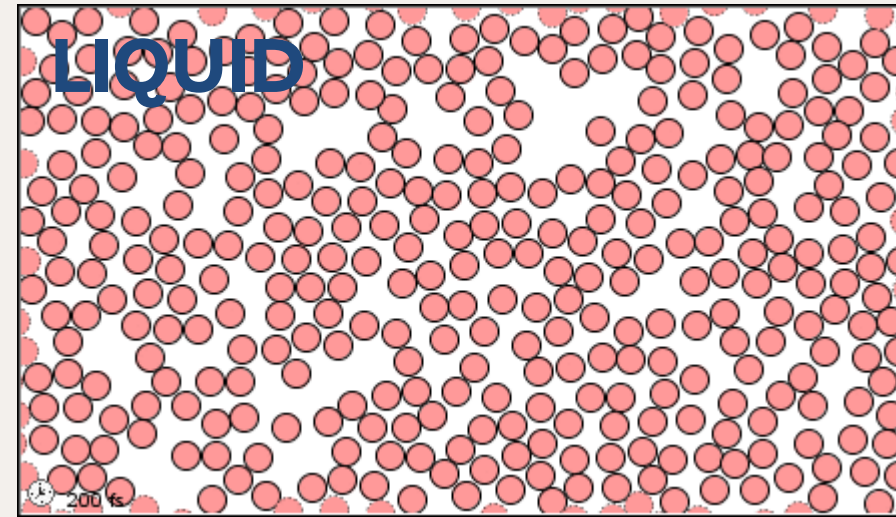
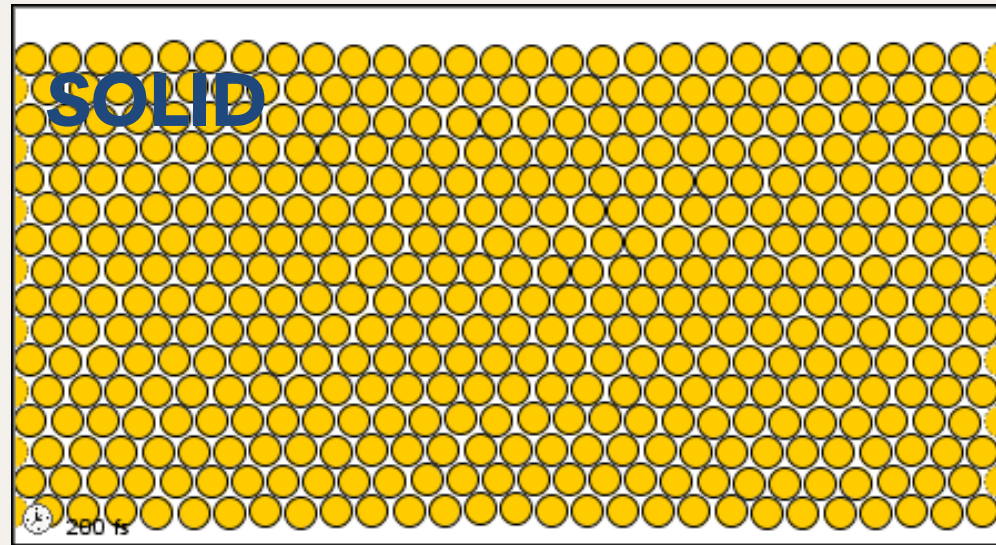
1 H Hydrogen GAS																	2 He Helium GAS
3 Li Lithium BCC	4 Be Beryllium HEX											5 B Boron RHOM	6 C Carbon HEX	7 N Nitrogen GAS	8 O Oxygen GAS	9 F Fluorine GAS	10 Ne Neon GAS
11 Na Sodium BCC	12 Mg Magnesium HEX											13 Al Aluminum FCC	14 Si Silicon FCC	15 P Phosphorus CUBIC	16 S Sulfur ORTHO	17 Cl Chlorine GAS	18 Ar Argon GAS
19 K Potassium BCC	20 Ca Calcium FCC	21 Sc Scandium HEX	22 Ti Titanium HEX	23 V Vanadium BCC	24 Cr Chromium BCC	25 Mn Manganese BCC	26 Fe Iron BCC	27 Co Cobalt HEX	28 Ni Nickel FCC	29 Cu Copper FCC	30 Zn Zinc HEX	31 Ga Gallium ORTHO	32 Ge Germanium FCC	33 As Arsenic RHOM	34 Se Selenium HEX	35 Br Bromine LIQUID	36 Kr Krypton GAS
37 Rb Rubidium BCC	38 Sr Strontium FCC	39 Y Yttrium HEX	40 Zr Zirconium HEX	41 Nb Niobium BCC	42 Mo Molybdenum BCC	43 Tc Technetium HEX	44 Ru Ruthenium HEX	45 Rh Rhodium FCC	46 Pd Palladium FCC	47 Ag Silver FCC	48 Cd Cadmium HEX	49 In Indium TETRA	50 Sn Tin TETRA	51 Sb Antimony RHOM	52 Te Tellurium HEX	53 I Iodine ORTHO	54 Xe Xenon GAS
55 Cs Cesium BCC	56 Ba Barium BCC	57-71 Lanthanides	72 Hf Hafnium HEX	73 Ta Tantalum BCC	74 W Tungsten BCC	75 Re Rhenium HEX	76 Os Osmium HEX	77 Ir Iridium FCC	78 Pt Platinum FCC	79 Au Gold FCC	80 Hg Mercury LIQUID	81 Tl Thallium HEX	82 Pb Lead FCC	83 Bi Bismuth RHOM	84 Po Polonium CUBIC	85 At Astatine UNK	86 Rn Radon GAS
87 Fr Francium UNK	88 Ra Radium BCC	89-103 Actinides	104 Rf Rutherfordium UNK	105 Db Dubnium UNK	106 Sg Seaborgium UNK	107 Bh Bohrium UNK	108 Hs Hassium UNK	109 Mt Meitnerium UNK	110 Ds Darmstadtium UNK	111 Rg Roentgenium UNK	112 Cn Copernicium UNK	113 Nh Nihonium UNK	114 Fl Flerovium UNK	115 Mc Moscovium UNK	116 Lv Livermorium UNK	117 Ts Tennessine UNK	118 Og Oganesson UNK

57 La Lanthanum HEX	58 Ce Cerium FCC	59 Pr Praseodymium HEX	60 Nd Neodymium HEX	61 Pm Promethium HEX	62 Sm Samarium RHOM	63 Eu Europium BCC	64 Gd Gadolinium HEX	65 Tb Terbium HEX	66 Dy Dysprosium HEX	67 Ho Holmium HEX	68 Er Erbium HEX	69 Tm Thulium HEX	70 Yb Ytterbium FCC	71 Lu Lutetium HEX
89 Ac Actinium FCC	90 Th Thorium FCC	91 Pa Protactinium TETRA	92 U Uranium ORTHO	93 Np Neptunium ORTHO	94 Pu Plutonium MONO	95 Am Americium HEX	96 Cm Curium HEX	97 Bk Berkelium HEX	98 Cf Californium HEX	99 Es Einsteinium HEX	100 Fm Fermium UNK	101 Md Mendelevium UNK	102 No Nobelium UNK	103 Lr Lawrencium UNK

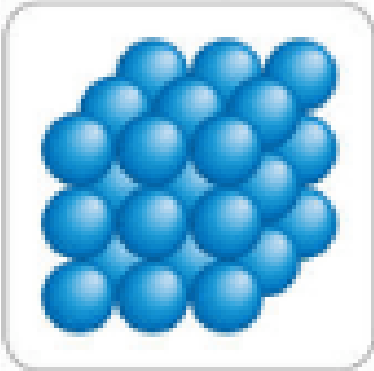
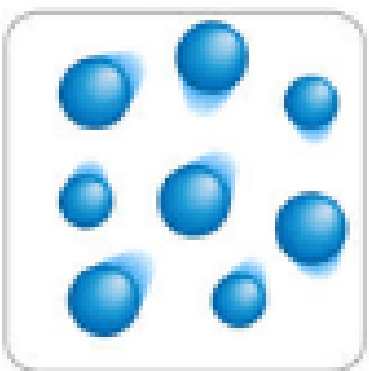
Most Stable Crystalline Structure Of Solids

CUBIC	Simple Cubic	FCC	Face Centered Cubic	ORTHO	Orthorhombic	TETRA	Tetragonal	UNK	Unknown
BCC	Body Centered Cubic	HEX	Hexagonal	RHOM	Rhombohedral	MONO	Monoclinic		

KINETIC MOLECULAR THEORY



KINETIC MOLECULAR THEORY

Property	Solids	Liquids	Gases
Shape	Definite shape	No definite shape, takes shape of the container	No definite shape, takes shape of the container
Volume	Definite volume	Definite volume	No fixed volume
Particle Arrangement	Tightly packed  Solid	Close together but can move  Liquid	Far apart, can move  Gas
Particle Motion	Vibrating in a fixed position	Flowing and sliding past each other	Moving rapidly and freely
Example	Carbon, Aluminum, Iodine, Sodium Chloride	Bromine, Mercury, Water	Oxygen, Nitrogen, Helium

Forces between particles in solids are stronger than those in liquids, which are stronger than those in gases.

Since forces between gas particles are so weak, the particles can move faster and have more kinetic energy.

METALS, NONMETALS, METALLOIDS

Metal	Metalloid	Nonmetal
-------	-----------	----------

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La-Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac-Lr															

Scientists haven't really
decided about Astatine (At)...

La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

METALS, NONMETALS, METALLOIDS



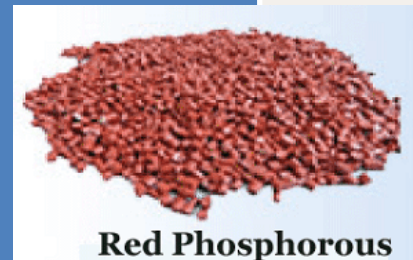
METALS

- High melting/boiling points
- High thermal/electrical conductivity
- Hard, durable (some can be soft)
- Shiny, reflective
- High density
- Solid at room temperature
- Malleable, ductile



NONMETALS

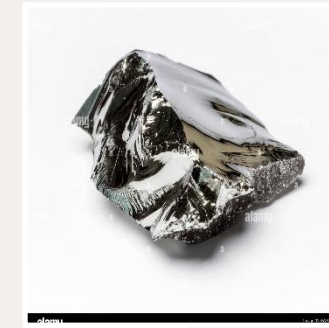
- Low melting/boiling points
- Low thermal/electrical conductivity
- Soft, brittle
- Dull, nonreflective
- Low density
- Solid, liquid, or gas at room temperature
- Nonmalleable, nonductile



Red Phosphorous



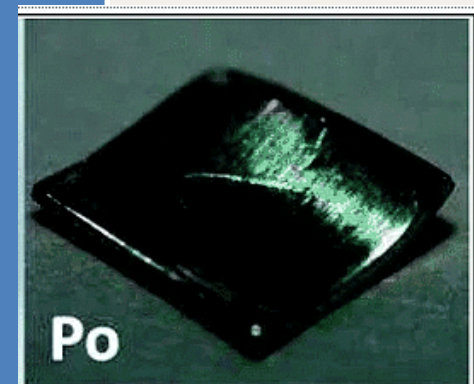
Carbon



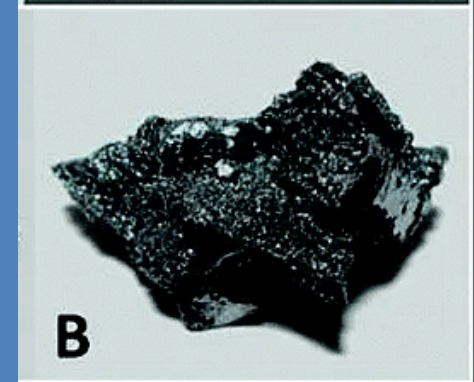
METALLOIDS

- Intermediate melting/boiling points
- Intermediate thermal/electrical conductivity
- Soft, brittle
- Dull, nonreflective OR shiny, reflective
- Intermediate densities
- Solid at room temperature but easily converted to liquid or gas upon heating
- Nonmalleable, nonductile

Click to read
a good
article about
their
properties!

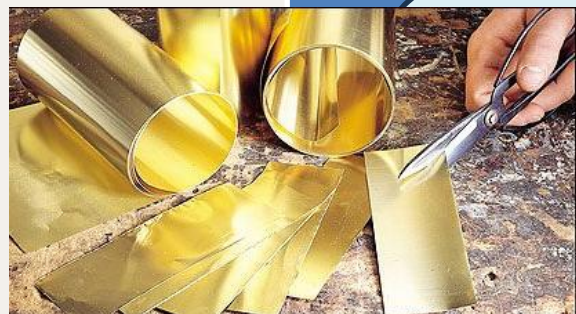


Po



B

Reminder! These physical and chemical properties are determined by strength of forces between atoms as well as the nuclear size and charge.



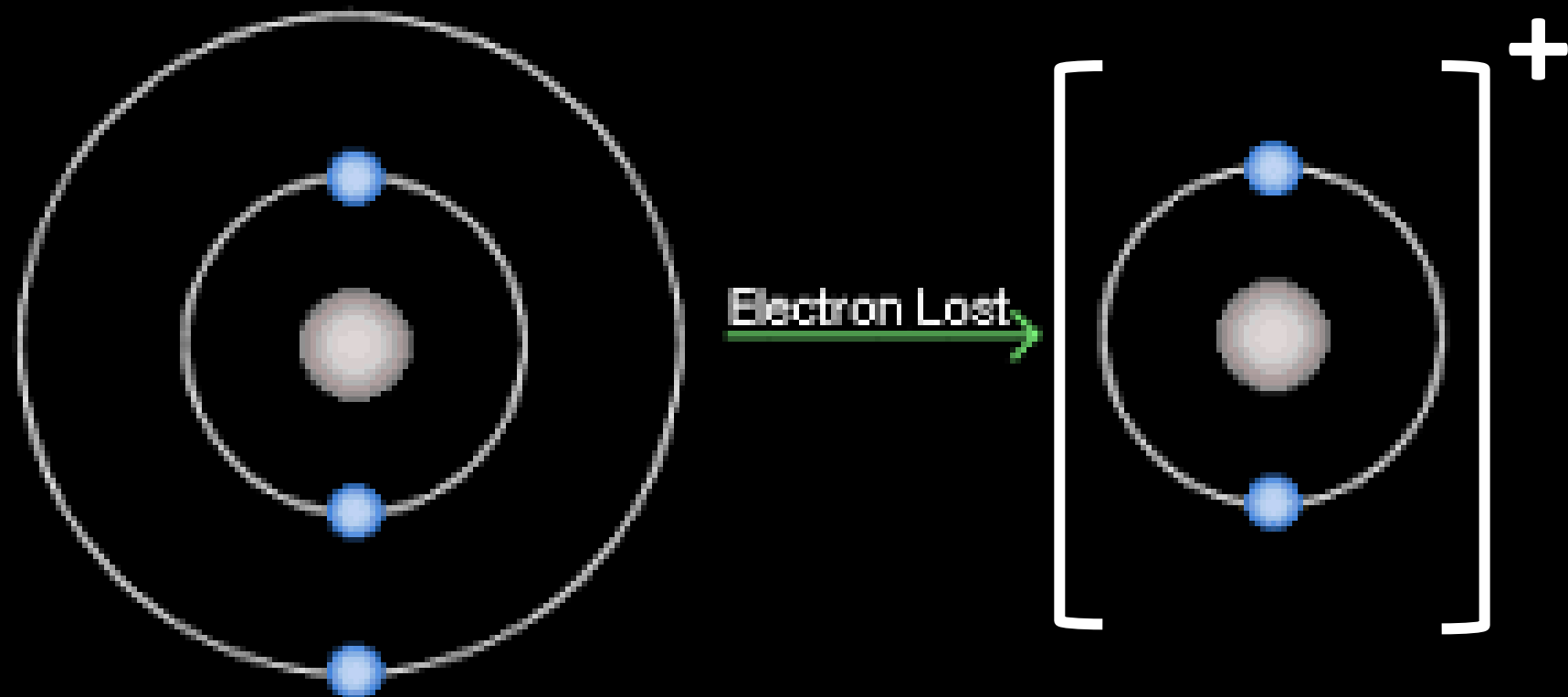
ELEMENTS LIKE TO FORM IONS

Atoms that are charged (no longer neutral) ions are more stable!

Metals form cations

Lose electrons and become more positive

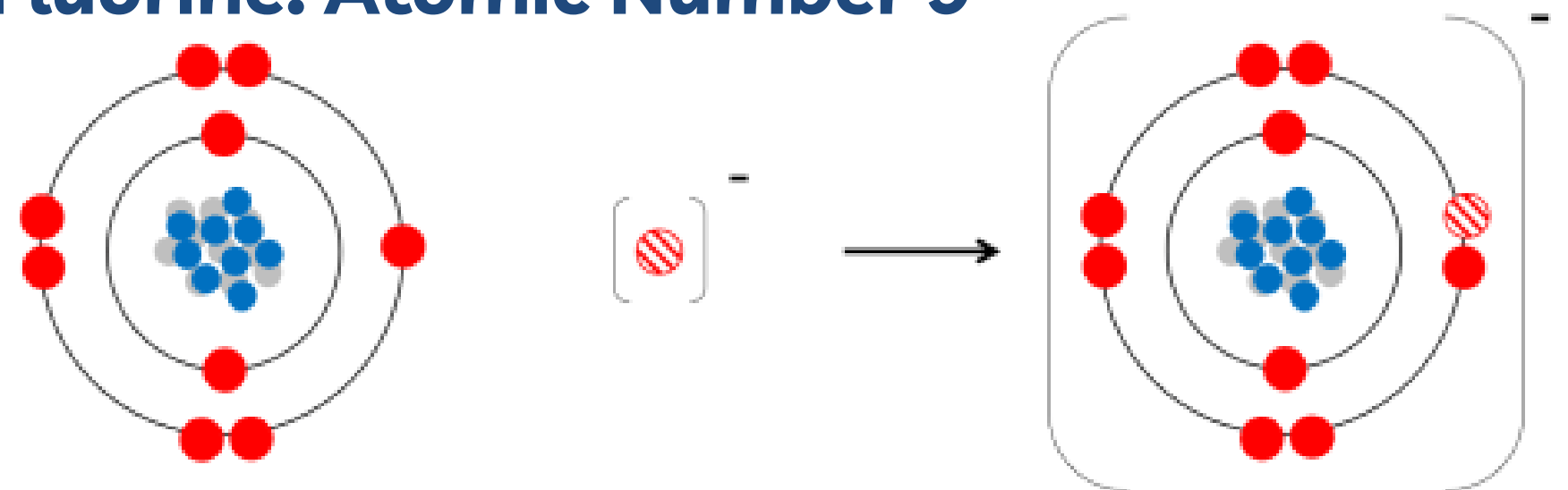
Lithium: Atomic Number 3



Nonmetals form anions

Gain electrons and become more negative

Fluorine: Atomic Number 9

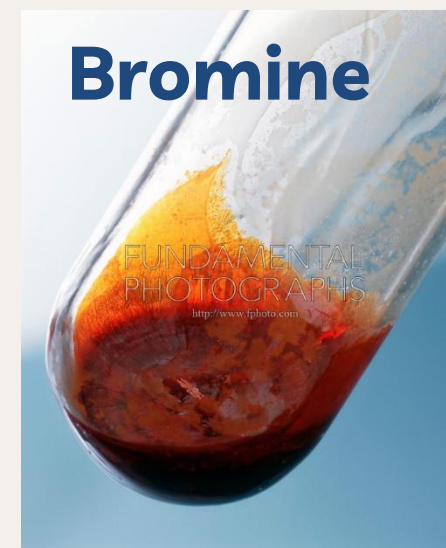
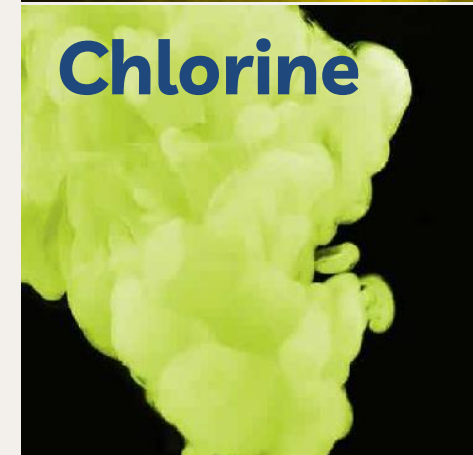




DIATOMIC ELEMENTS

“2 atoms”

Some nonmetals cannot exist individually
2 of the SAME atoms bond together to form diatomics



The Diatomic 7



CHEM 101

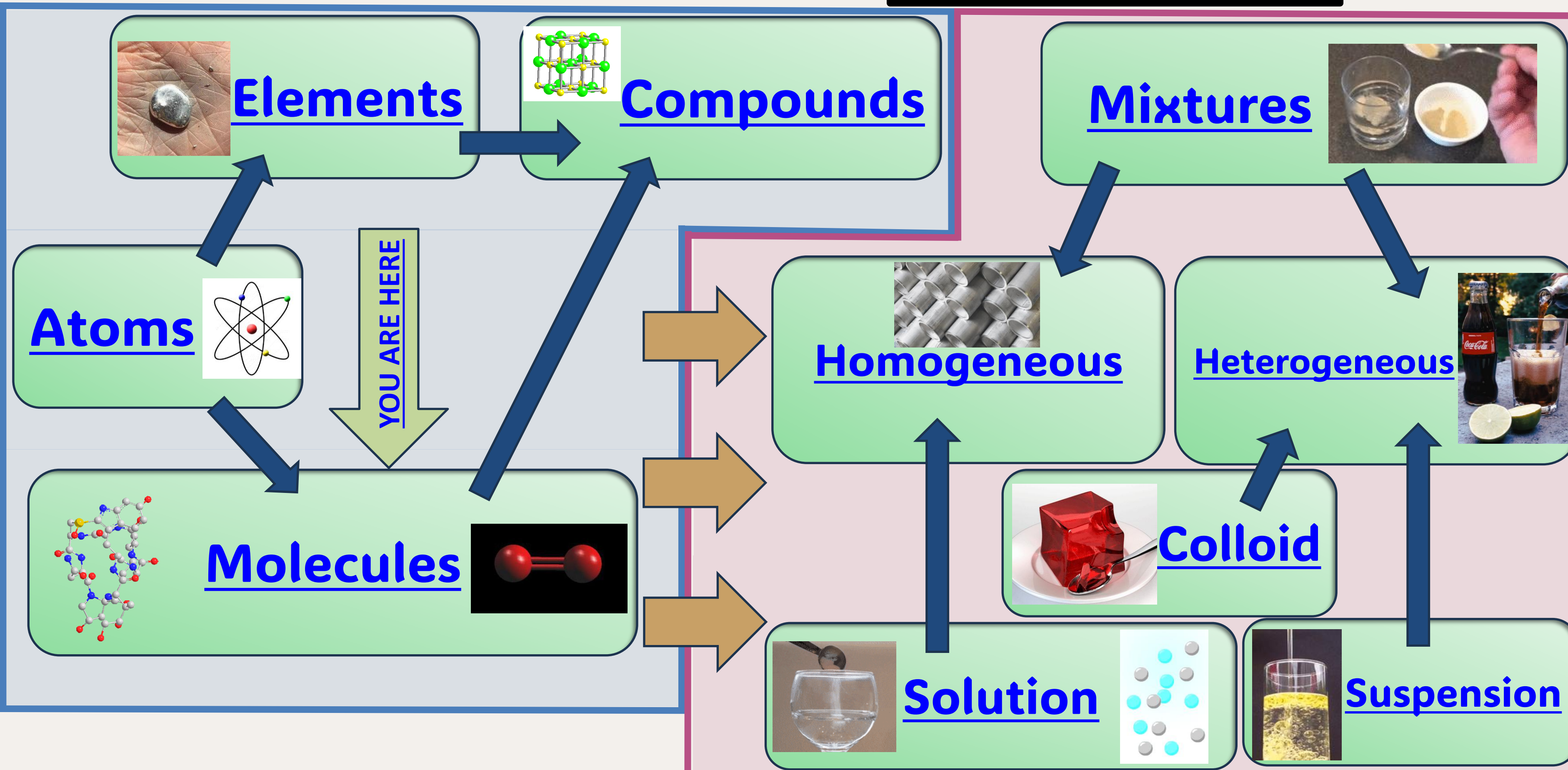
Periodic Table

B. HARKNESS

Periodic Table of Elements																			
1 IA												13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA		
1 H 1.008	2 He 4.00											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 Li 6.94	4 Be 9.01											11 Na 22.99	12 Mg 24.31	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	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 72.61	33 As 74.92	34 Se 76.96	35 Br 79.90	36 Kr 83.80		
BACK TO MATTER MAP																			
		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	49 In 114.8	50 Sn 118.71	51 Sb 121.75	52 Te 127.60	53 I 126.90	54 Xe 131.29				
		73 Ta 180.9	74 W 183.9	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 208.98	84 Po (209)	85 At (210)	86 Rn (222)				

BACK TO
MATTER MAP

MATTER MAP



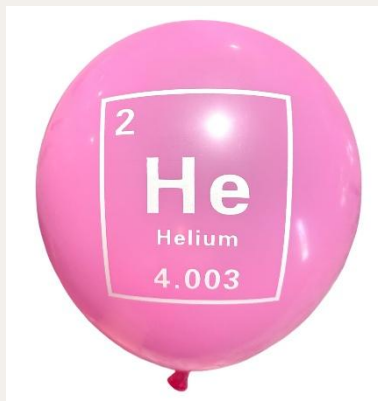
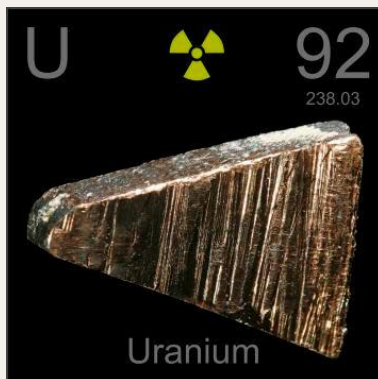
MOLECULES

A group of 2 or more **atoms** held together by chemical bonds

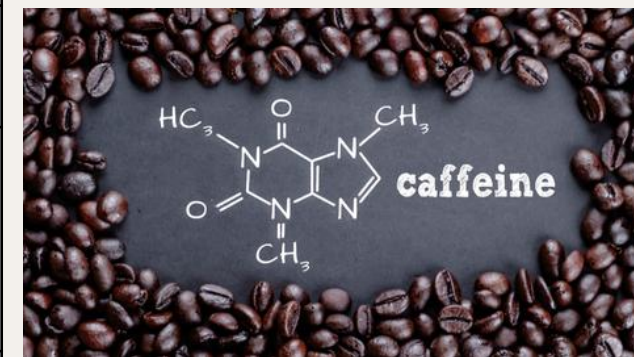
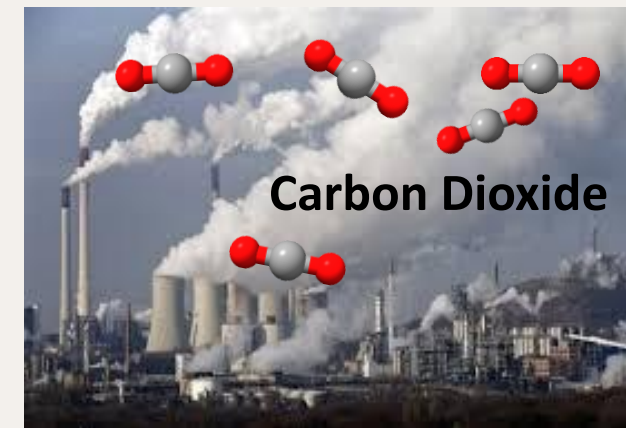
The diatomic 7 are classified as both elements and molecules!

What's The Difference?

Elements



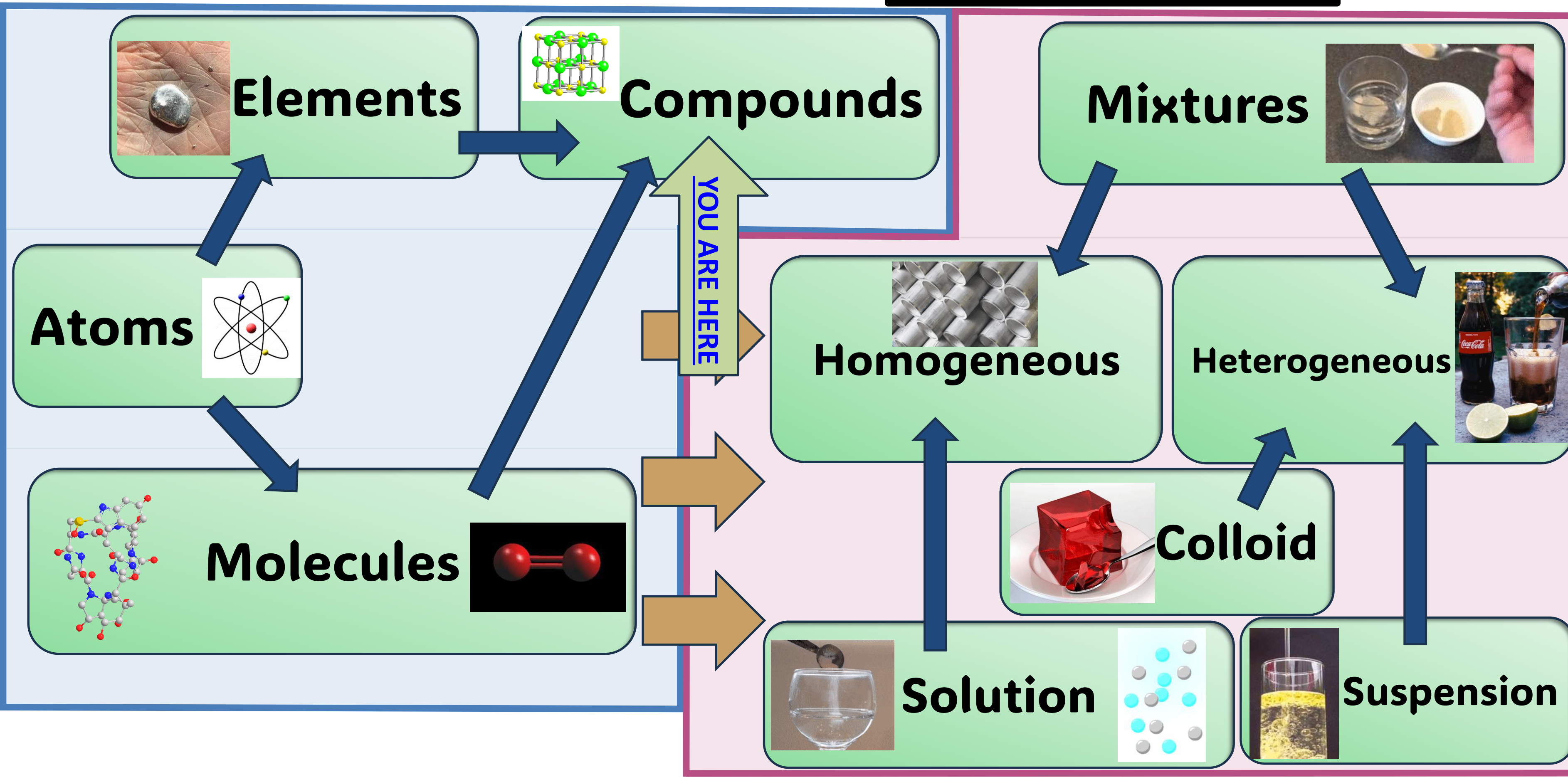
Molecules



Feature	Elements	Molecules
Type of Substance	Pure Substance	Pure Substance
Basic Unit	Atom	Group of atoms (can be the same or different)
Can be diatomic?	Yes	Yes
Chemical composition	One type of atom only	Can be one or more types of atoms
Chemical Representation	Symbol listed on the periodic table (except diatomics)	Not listed on the periodic table. Consist of multiple symbols with subscripts to represent the number of atoms (e.g. H ₂ O, CO ₂ , H ₂)

BACK TO
MATTER MAP

MATTER MAP



COMPOUNDS

Pure
Substance

Different atoms or ions that are held together by chemical bonds.

Two Types

Chemical bonds are
electrostatic
interactions between
atoms/ions in
compounds

Ionic

metal + nonmetal

Covalent

nonmetal + nonmetal
metalloid + nonmetal

Molecules can
have the same or
different atoms

Held together by
electrostatic interactions

This is a
particular type of
FORCE

Chemical bonds in ionic compounds:
electrostatic forces occur between
oppositely charged ions

Chemical bonds in covalent (aka
molecular) compounds: electrostatic
forces occur between electrons and
nuclei on adjacent atoms

All covalent compounds are also classified as molecules

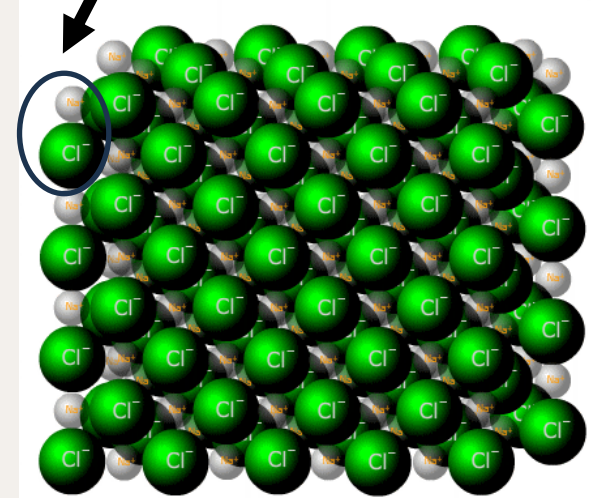
TYPES OF COMPOUNDS

Ionic

- Formed when **metals** and **nonmetals (as ions)** form a chemical bond
- High melting and boiling points (chemical bonds are broken)
- Easily dissolve in water
- Conduct electricity when dissolved in water (not in their solid state)
- Solid at room temperature



Its smallest unit is called a formula unit

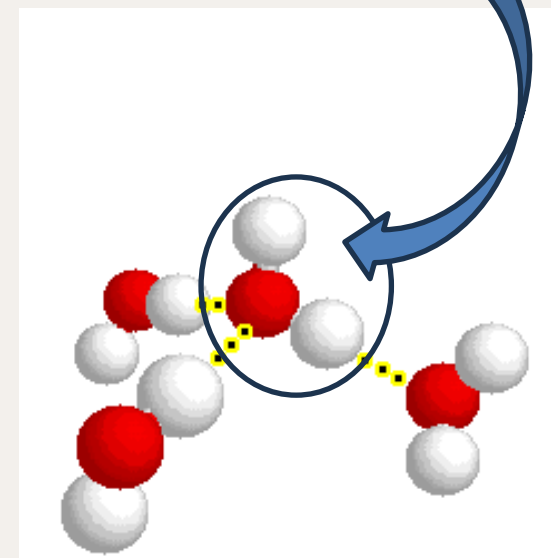


Covalent (Molecular)

- Formed when **nonmetals** (or metalloids and nonmetals) form a chemical bond
- Low melting and boiling points (forces between covalent compounds are broken)
- Do not easily dissolve in water
- Do not conduct electricity well
- Usually liquids or gases at room temperature

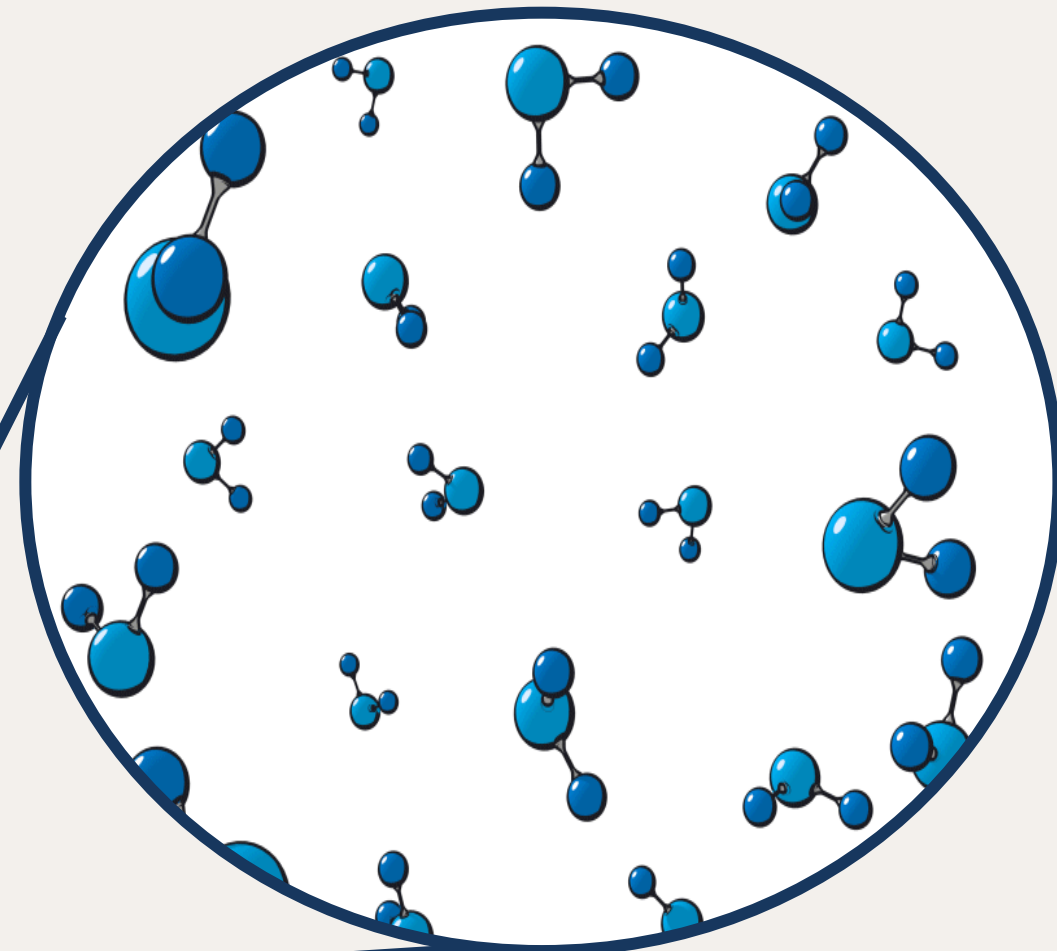
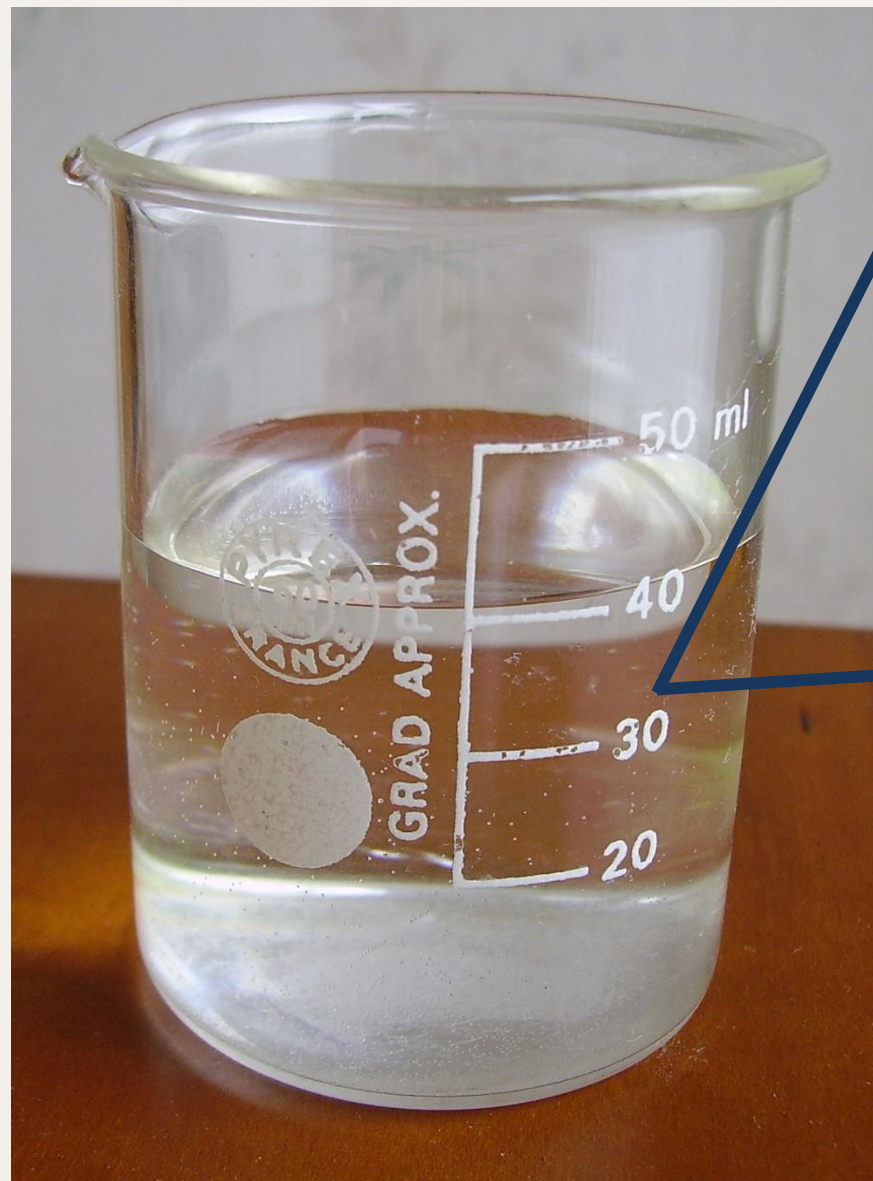


Its smallest unit is a molecule

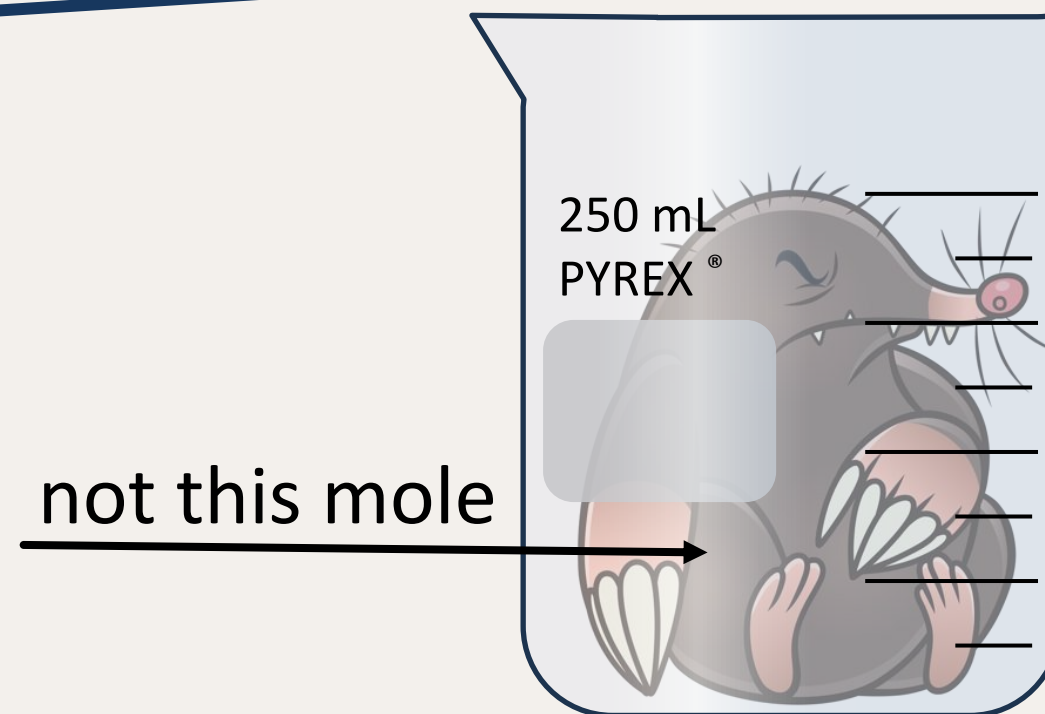


How Can We Measure Matter?

How many water molecules are in the beaker?



not this mole



What do we need to know to figure this out?

mass

- How much mass does the water have?
- Put the beaker on a balance to measure the mass.

?

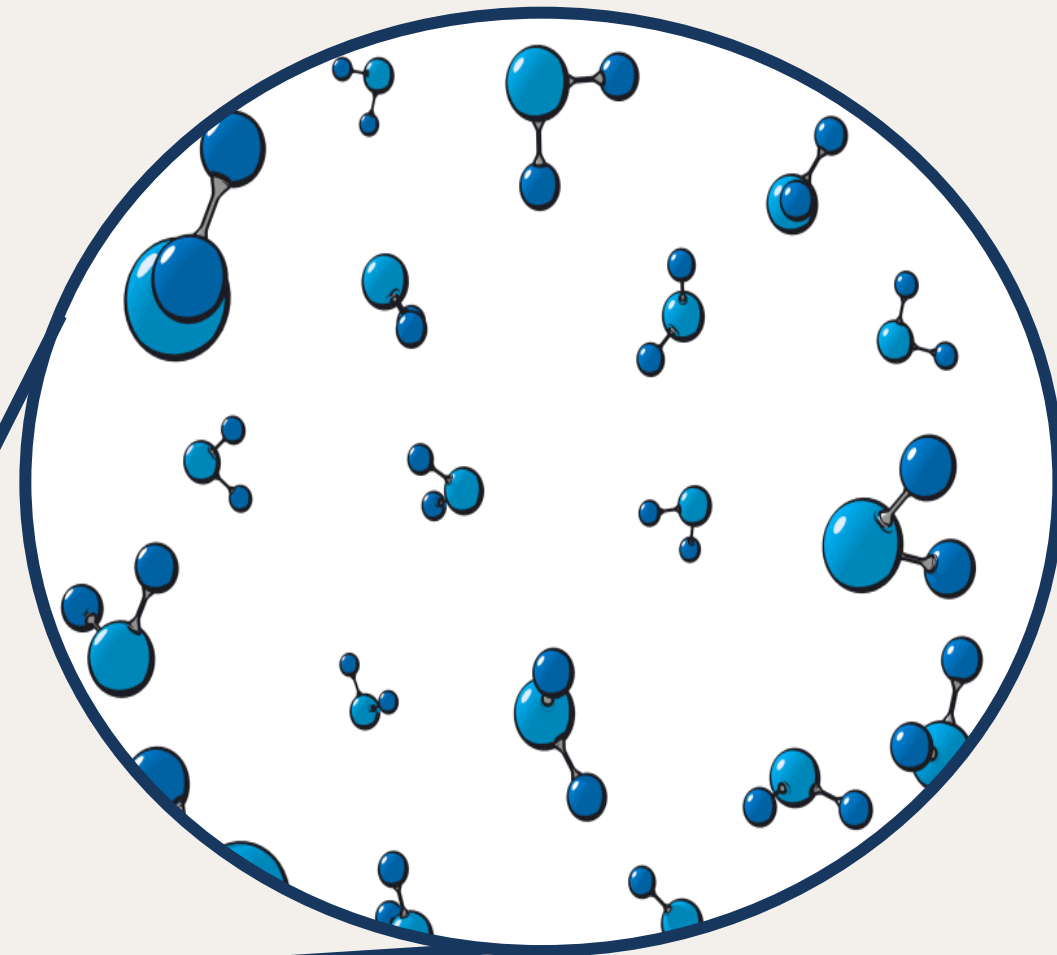
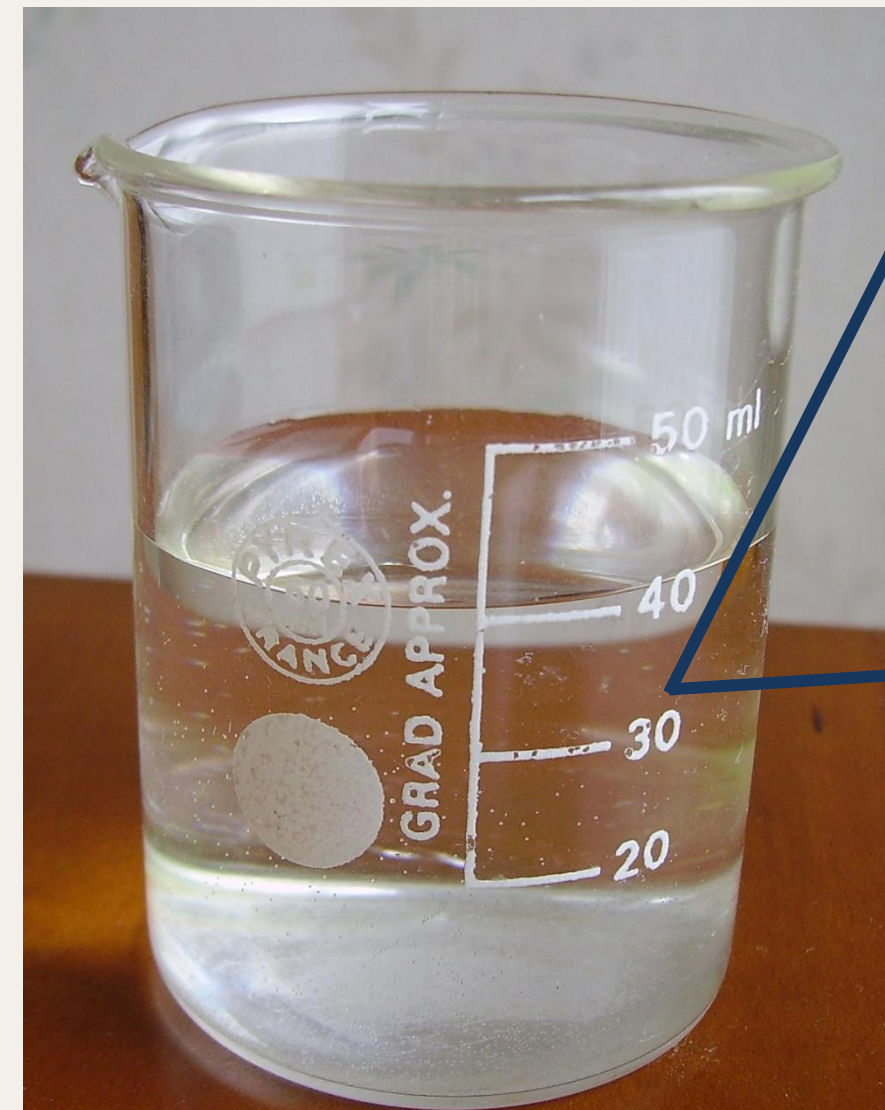
- We need a way to link the mass of the water to the number of water molecules!

molecules

- How many molecules of water are in the beaker?
- Use the [MOLE](#) as a conversion factor

How Can We Measure Matter?

How many moles of water are in the beaker?



**A balance
can't measure
in moles**

How can we connect grams to moles?

1

- Identify the unit we want (moles)

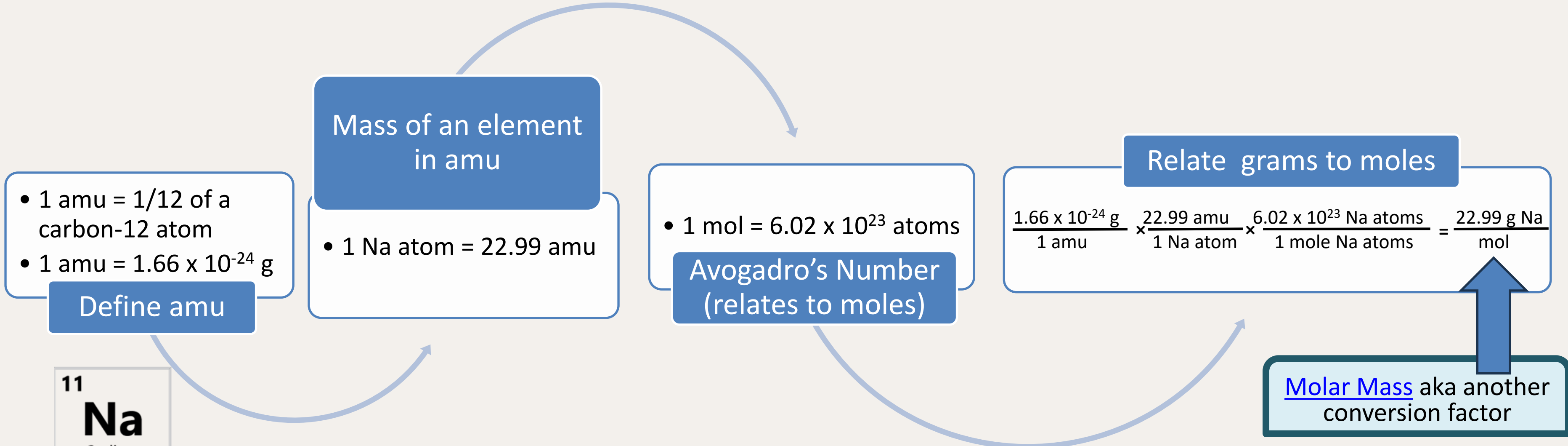
2

- Identify the unit we can measure/the unit the problem gives us (grams)

3

- Use conversion factors to get from Step 1 to Step 3

The Periodic Table to the Rescue!



11

Na

Sodium
22.990

Periodic Table of the Elements

1 1A H Hydrogen 1.008	2 He Helium 4.003	3 Li Lithium 6.941	4 Be Beryllium 9.012	5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180	11 Na Sodium 22.990	12 Mg Magnesium 24.305	13 Al Aluminum 26.982	14 Si Silicon 28.086	15 P Phosphorus 30.974	16 S Sulfur 32.065	17 Cl Chlorine 35.453	18 Ar Argon 39.948
19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.867	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.631	33 As Arsenic 74.922	34 Se Selenium 78.971	35 Br Bromine 79.904	36 Kr Krypton 83.798
37 Rb Rubidium 85.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.94	43 Tc Technetium [98]	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.906	46 Pd Palladium 106.42	47 Ag Silver 107.868	48 Cd Cadmium 112.414	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.760	52 Te Tellurium 127.6	53 I Iodine 126.905	54 Xe Xenon 131.29
55 Cs Cesium 132.905	56 Ba Barium 137.327	57-71 Lanthanide Series	72 Hf Hafnium 178.49	73 Ta Tantalum 180.948	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.222	78 Pt Platinum 195.084	79 Au Gold 196.967	80 Hg Mercury 200.59	81 Tl Thallium 204.383	82 Pb Lead 207.2	83 Bi Bismuth 208.980	84 Po Polonium [209]	85 At Astatine [210]	86 Rn Radon [222]
87 Fr Francium [223]	88 Ra Radium [226]	89-103 Actinide Series	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Hassium [265]	109 Mt Meitnerium [268]	110 Ds Darmstadtium [271]	111 Rg Roentgenium [272]	112 Cn Copernicium [285]	113 Nh Nihonium [286]	114 Fl Flerovium [289]	115 Mc Moscovium [288]	116 Lv Livermorium [293]	117 Ts Tennessine [294]	118 Og Oganesson [294]

Lanthanide Series

57 La Lanthanum 138.905	58 Ce Cerium 140.116	59 Pr Praseodymium 140.908	60 Nd Neodymium 144.242	61 Pm Promethium [145]	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.925	66 Dy Dysprosium 162.50	67 Ho Holmium 164.930	68 Er Erbium 167.257	69 Tm Thulium 168.934	70 Yb Ytterbium 173.055	71 Lu Lutetium 174.967
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Actinide Series

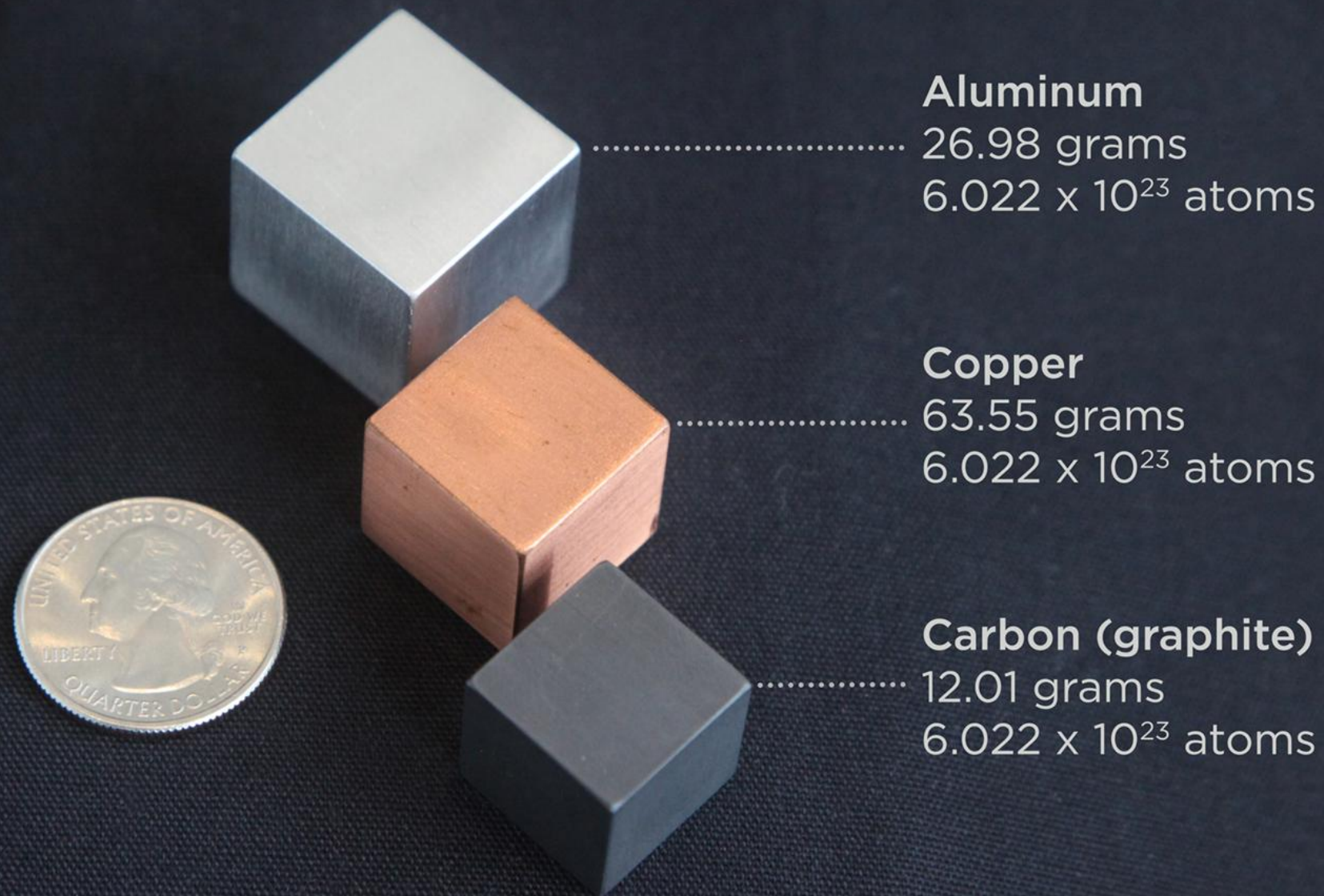
89 Ac Actinium 227.028	90 Th Thorium 232.038	91 Pa Protactinium 231.036	92 U Uranium 238.029	93 Np Neptunium 237.048	94 Pu Plutonium 244.064	95 Am Americium 243.061	96 Cm Curium 247.070	97 Bk Berkelium 247.070	98 Cf Californium 251.080	99 Es Einsteinium [254]	100 Fm Fermium 257.095	101 Md Mendelevium 258.1	102 No Nobelium 259.101	103 Lr Lawrencium [262]
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Comparison	Atomic Mass	Molar Mass
Definition	Mass of individual atom	Mass of one mole of particles
Particles	Protons, neutrons, electrons (negligible)	6.02×10^{23} particles
Units	amu	g/mol
Known as	Atomic weight	Molar weight
Used as	Atomic scale	Macroscopic scale
Isotopic Values	Included	Included
Example	Na = 22.99 amu	Na = 22.99 g/mol

HOW BIG IS A MOLE?

ONE MOLE



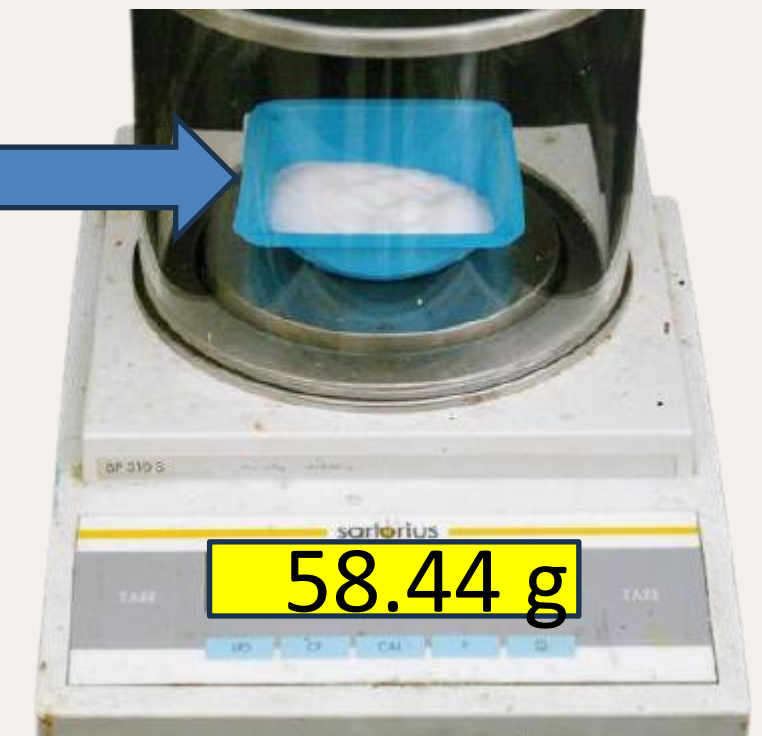
**Coin shown for scale*

Molecular mass/weight is the mass of ONE molecule, similar to how atomic mass is the mass of ONE atom.

You can find the molar mass of compounds as well by adding up the molar masses of all the atoms in the compound!



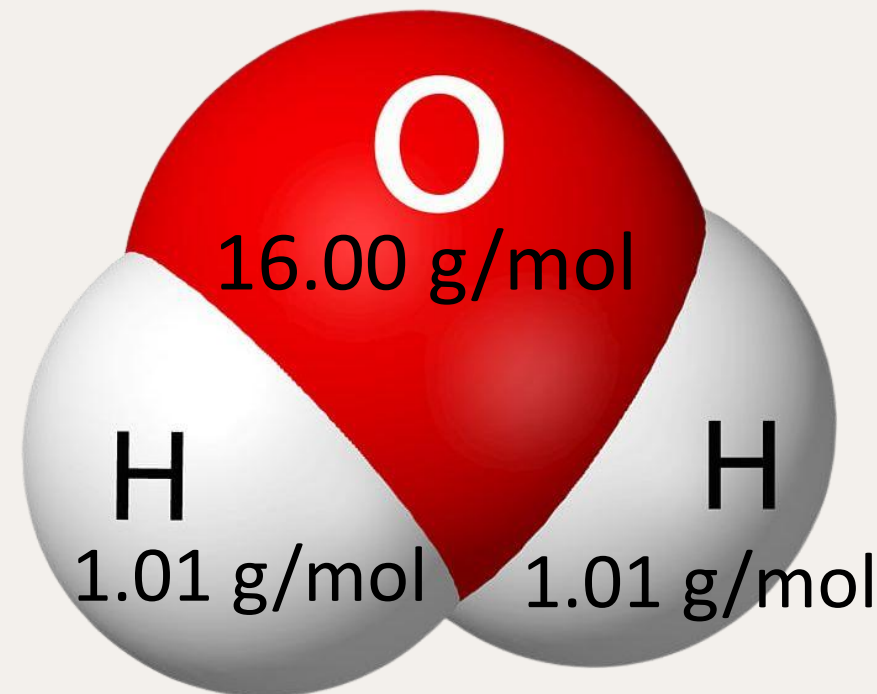
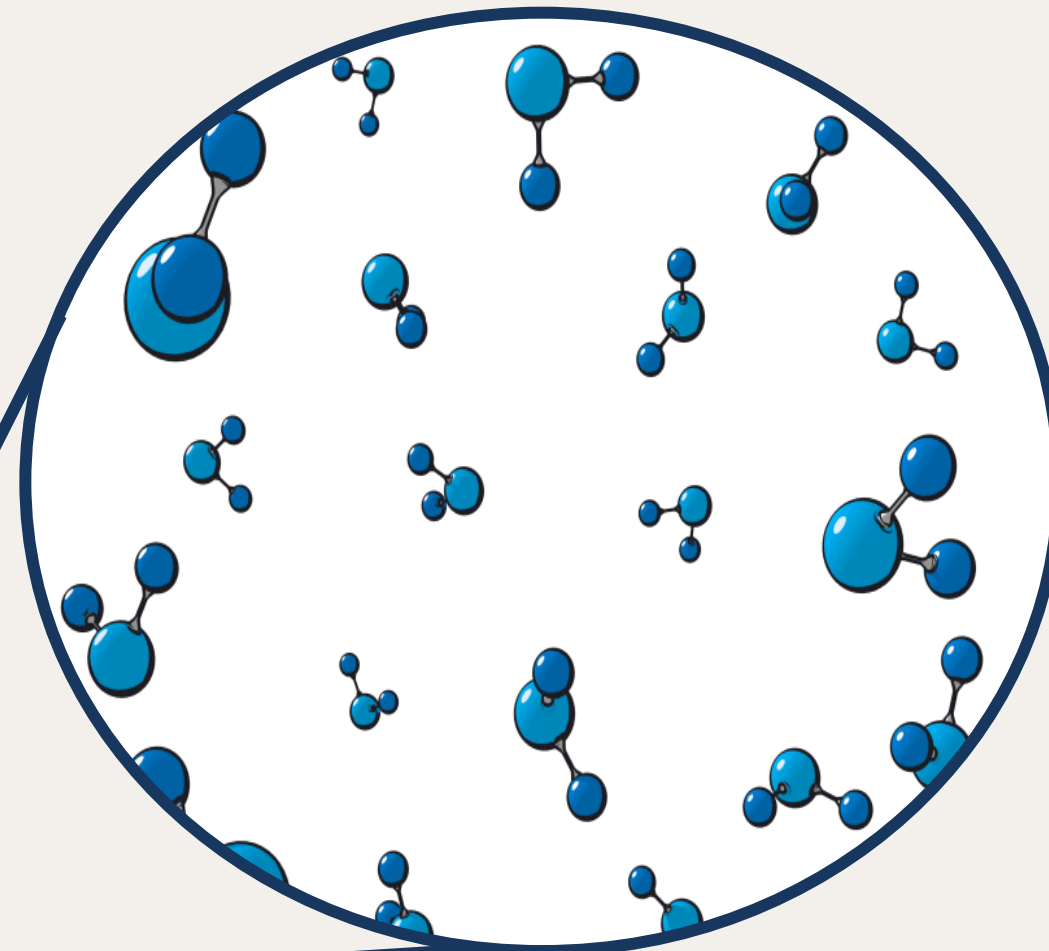
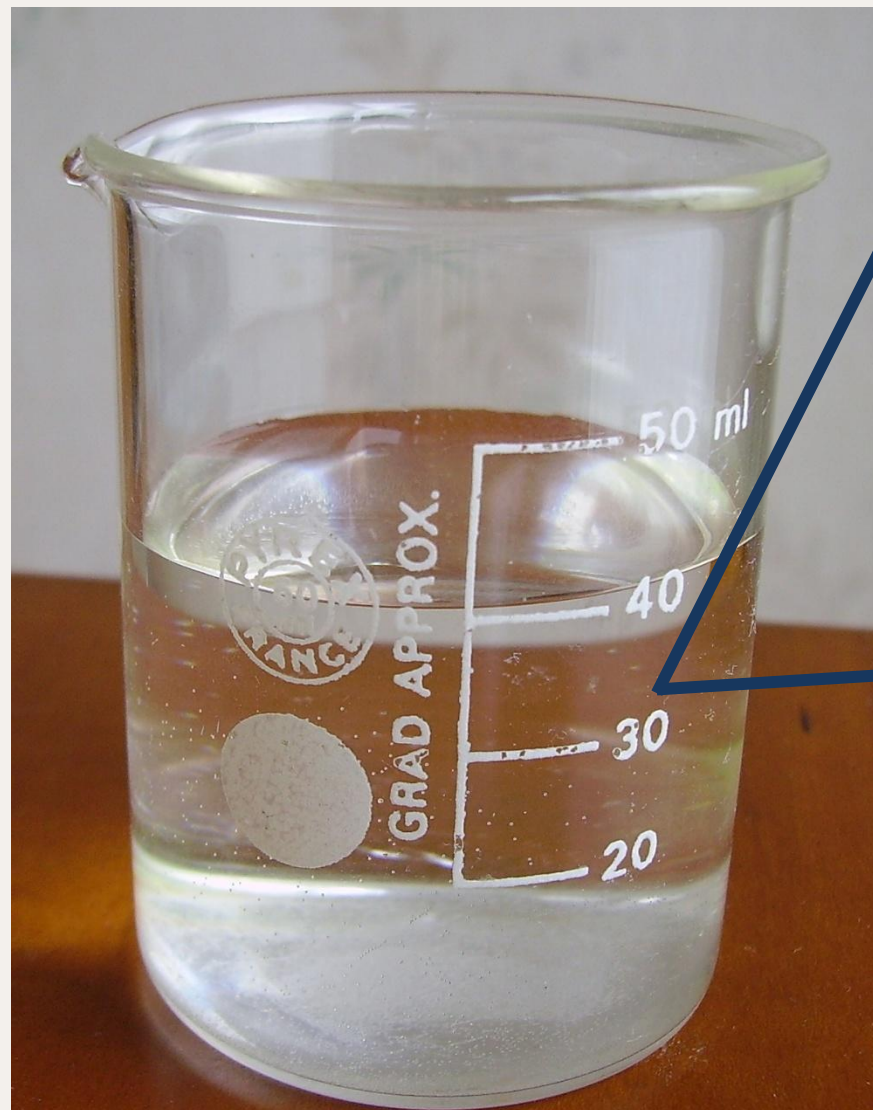
1 mol NaCl



How Can We Measure Matter?

How many moles of water are in the beaker?

What is the molar mass of water?



1

- Identify the unit we want (moles)

2

- Identify the unit we can measure/the unit the problem gives us (grams)

3

- Use conversion factors to get from 1 to 3

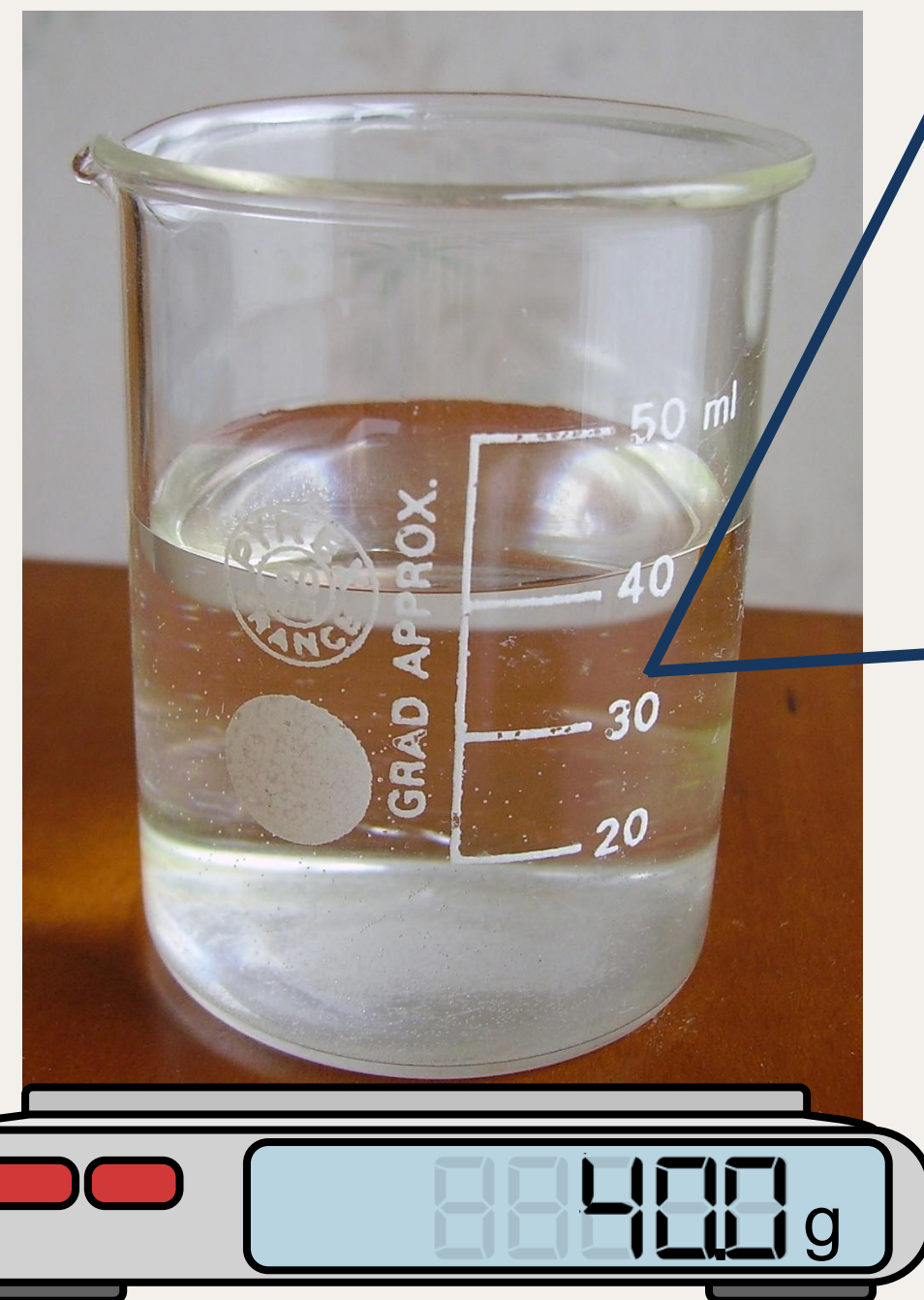
2 DECIMALS

$$16.00 \text{ g/mol} + 1.01 \text{ g/mol} + 1.01 \text{ g/mol} = 18.02 \text{ g/mol}$$

How Can We Measure Matter?

How many moles of water are in the beaker?

How many moles of water are in 40.0 g?



NOTE: CONVERSION FACTORS DON'T COUNT
TOWARDS SIG. FIG. RULES

$$40.0 \text{ g } \cancel{\text{H}_2\text{O}} \times \frac{1 \text{ mol H}_2\text{O}}{18.02 \text{ g } \cancel{\text{H}_2\text{O}}} =$$

2.22 mol H₂O

3 SIG FIGS

1

- Identify the unit we want (moles)

2

- Identify the unit we can measure/the unit the problem gives us (grams)

3

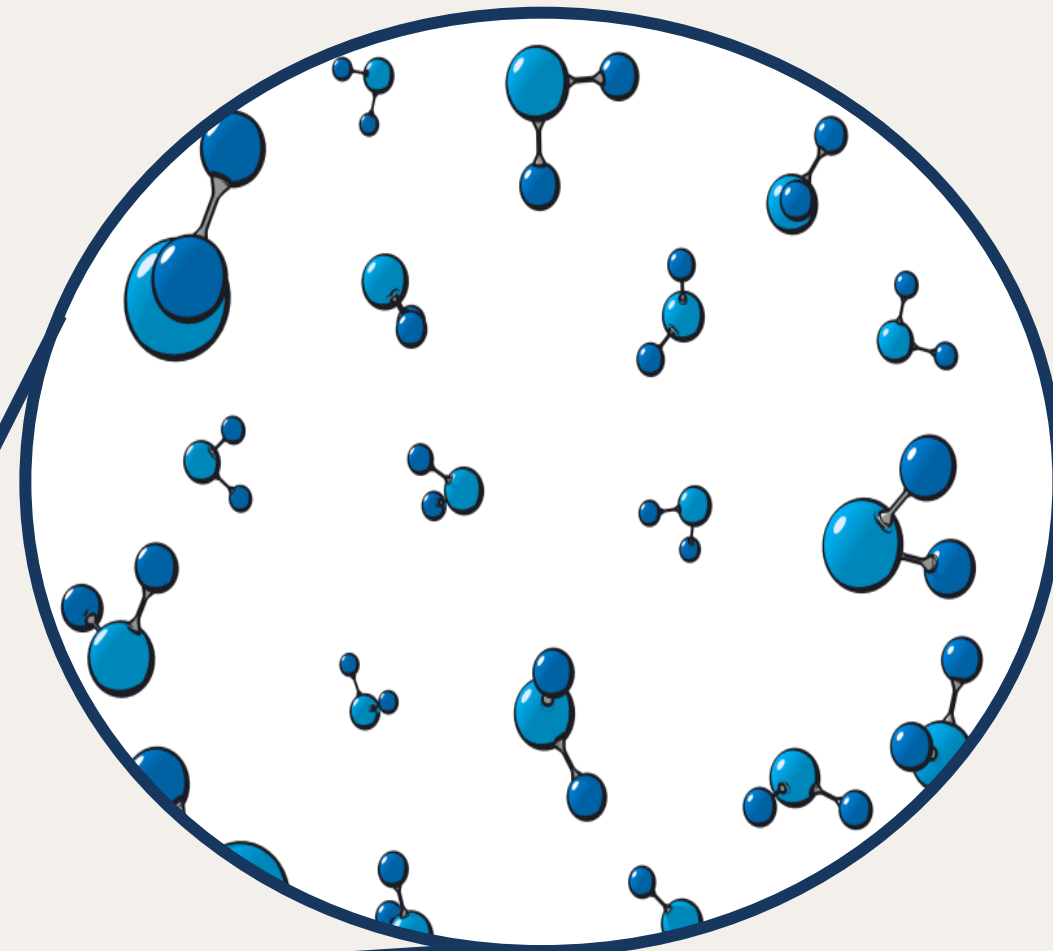
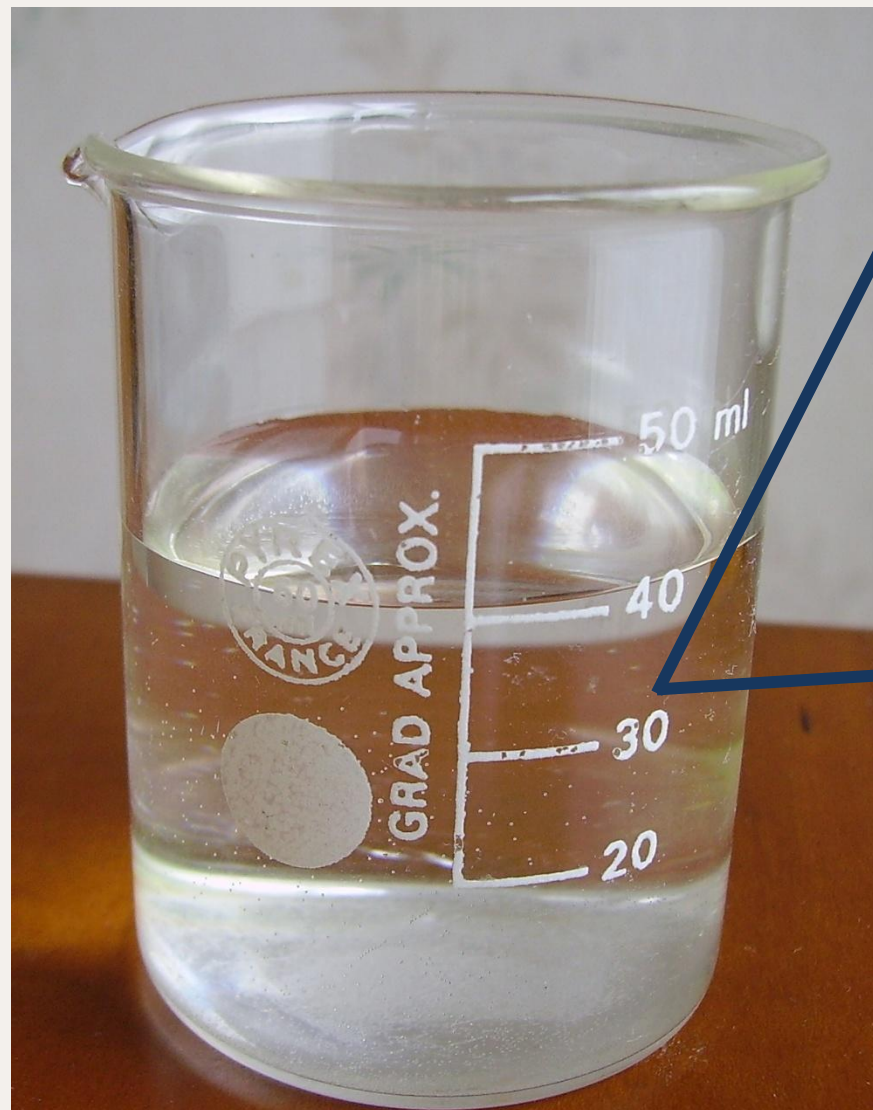
- Use conversion factors to get from 1 to 3

BACK TO TABLE
OF CONTENTS

How Can We Measure Matter?

How many water molecules are in the beaker?

How many molecules are in 2.22 moles?



NOTE: CONVERSION FACTORS DON'T COUNT TOWARDS SIG. FIG. RULES

$$2.22 \text{ mol } \cancel{\text{H}_2\text{O}} \times \frac{6.02 \times 10^{23} \text{ molecules } \text{H}_2\text{O}}{1 \text{ mol } \cancel{\text{H}_2\text{O}}} =$$

1.34 x 10²⁴ molecules H₂O

3 SIG FIGS

1

- Identify the unit we want (molecules)

2

- Identify the unit we can measure/the unit the problem gives us (grams)

3

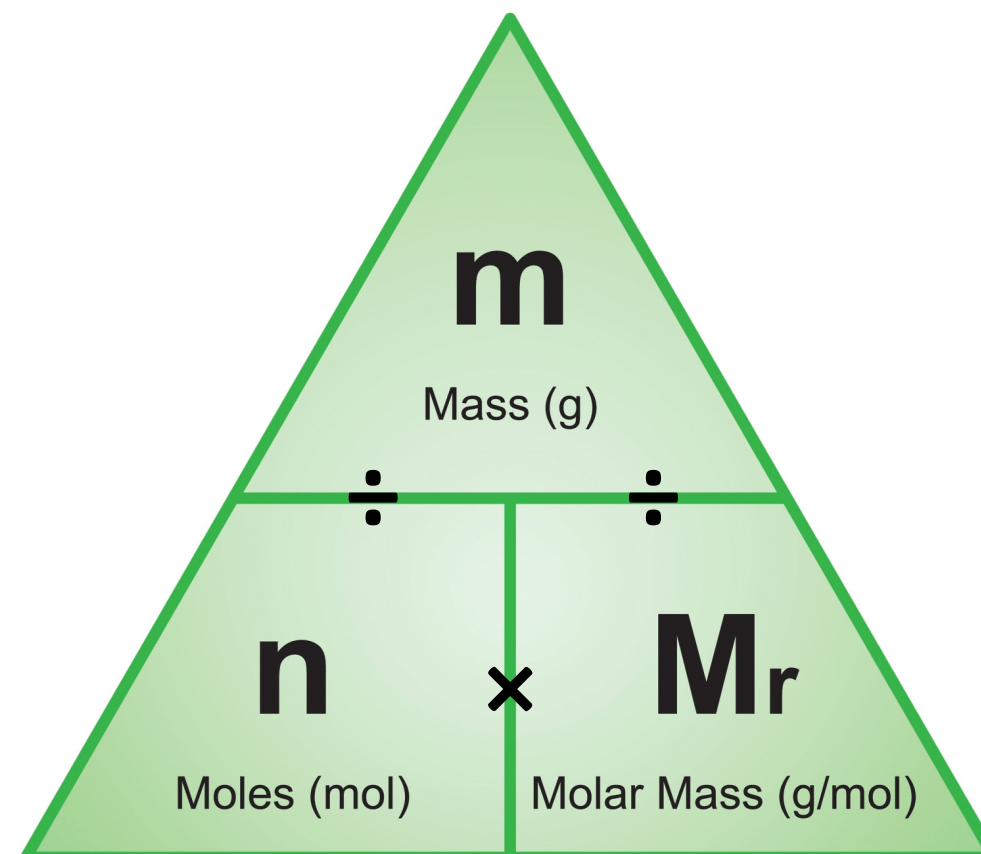
- Use conversion factors to get from 1 to 3

The Importance of Molar Mass

Used to measure the number of moles of a substance

Can be applied to many different types of matter (elements, molecules, compounds, ions, etc.)

Practical way to determine the mass of a substance needed for reactions or to make solutions

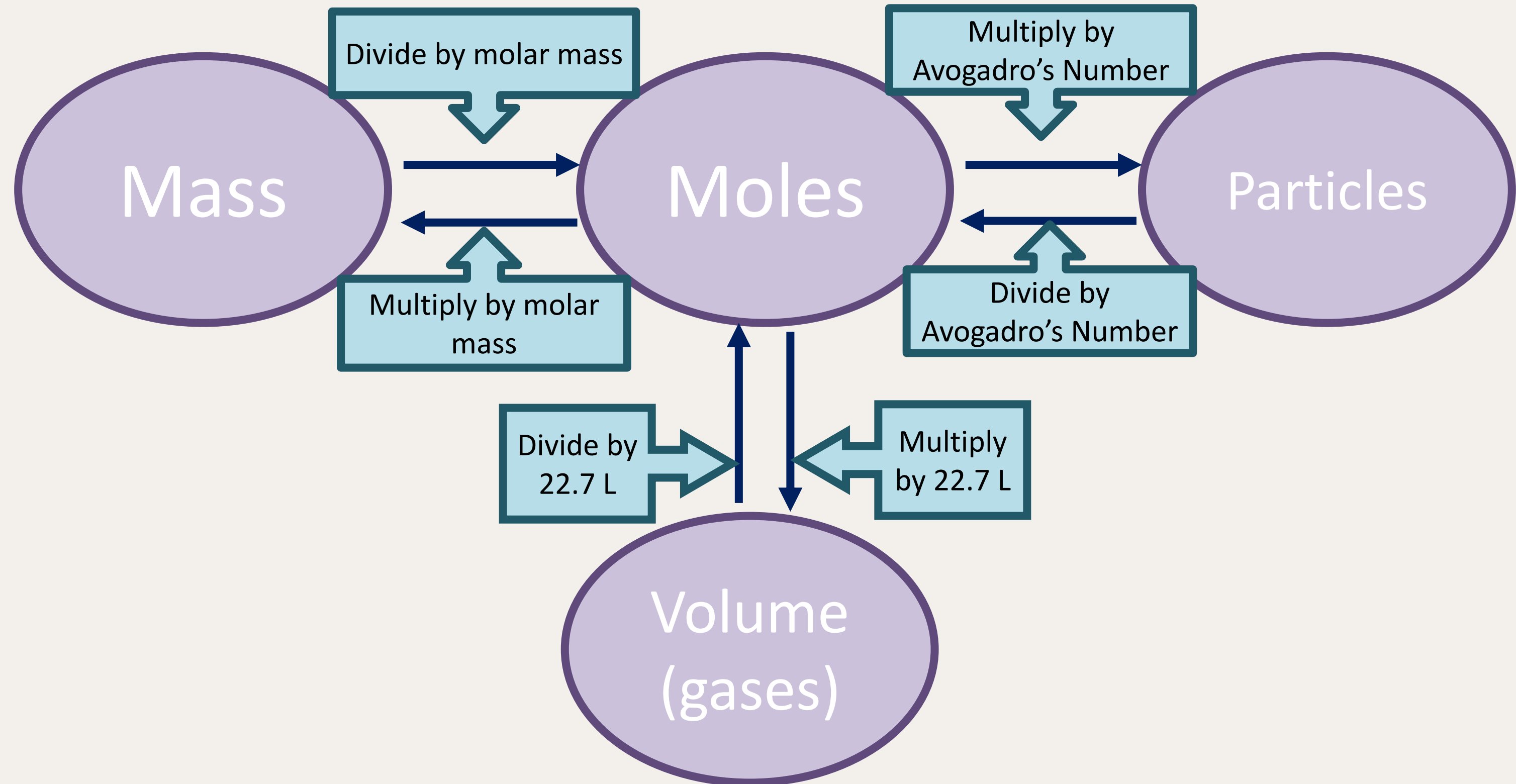


$$m = n \times M_r$$

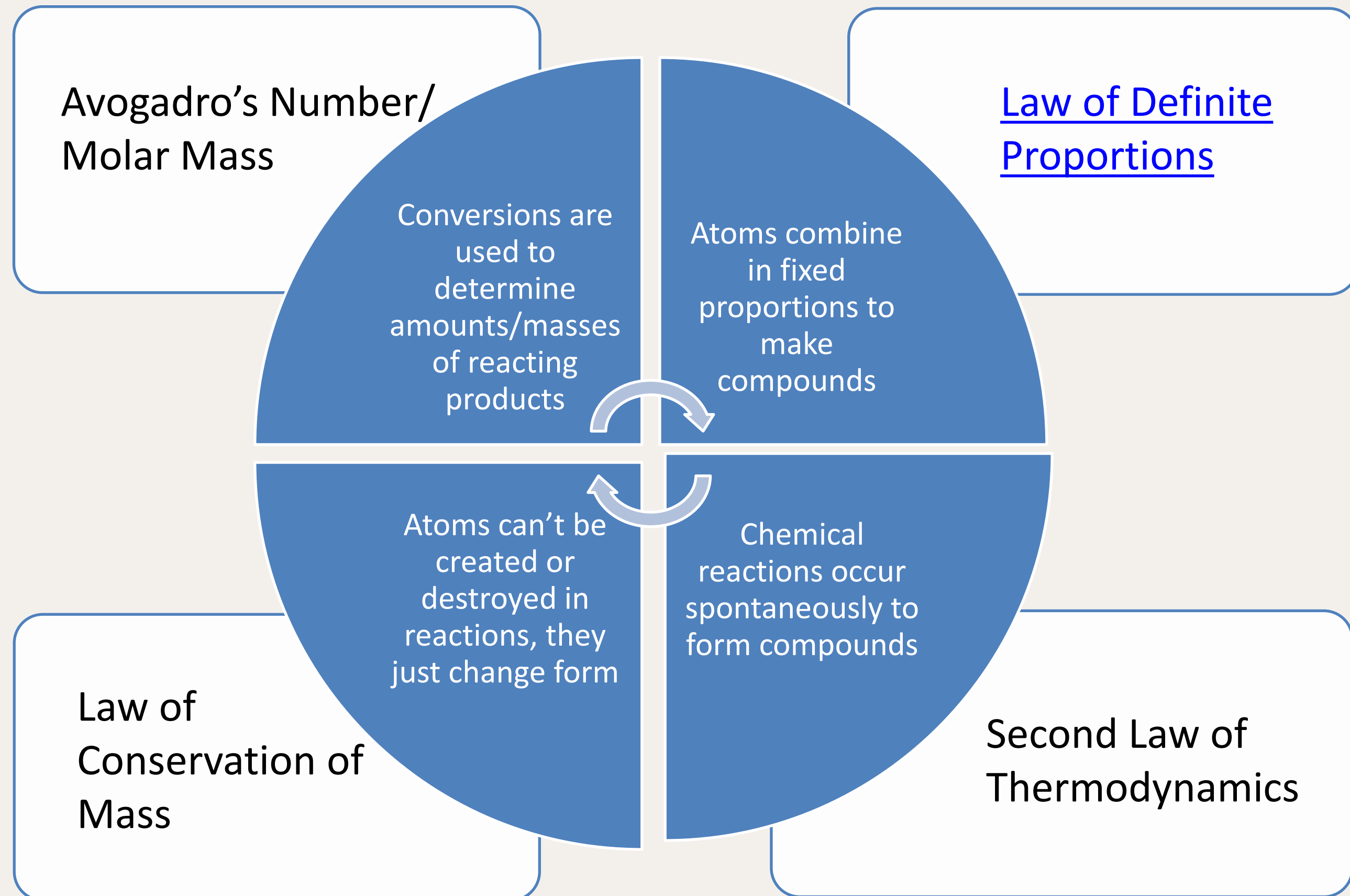
$$n = m \div M_r$$

$$M_r = m \div n$$

Summary mole map



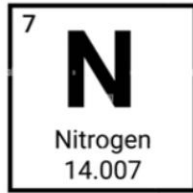
HOW DO CONVERSIONS RELATE TO THE BIG THREE?



HOW TO NAME COMPOUNDS

Nomenclature: Rules of naming substances

Greek prefix +
Name of Nonmetal



Greek prefix +
Base Name of Nonmetal



+ "ide"

Nitrogen monoxide
NO

SF₆
Sulfur
hexafluoride

I₂O₄
Diiodine
tetroxide

NH₃
Nitrogen
trihydride

Greek prefixes

mono.....1

di.....2

tri.....3

tetra.....4

penta.....5

hexa.....6

hepta.....7

octa.....8

nona.....9

deca.....10

Name of Metal



Base name of
nonmetal



+ "ide"

CaCl₂
Calcium
chloride

Magnesium Oxide
MgO

Ionic

No Greek Prefixes

Name of metal + base of
nonmetal + "ide"

K₂O
Potassium
oxide

NaBr
Sodium
bromide

Covalent

Greek prefixes +
name of nonmetals + "ide"

- Usually, nonmetal (or metalloid) more to the left in the periodic table is listed first (but oxygen and hydrogen are always listed last)
- "mono" is not ever required for first nonmetal and only in the second nonmetal when there is more than one compound with those two atoms (e.g. CO, CO₂).
- If two vowels in a row (oo or ao as in "monoxide" or "hexaoxide"), drop the first vowel