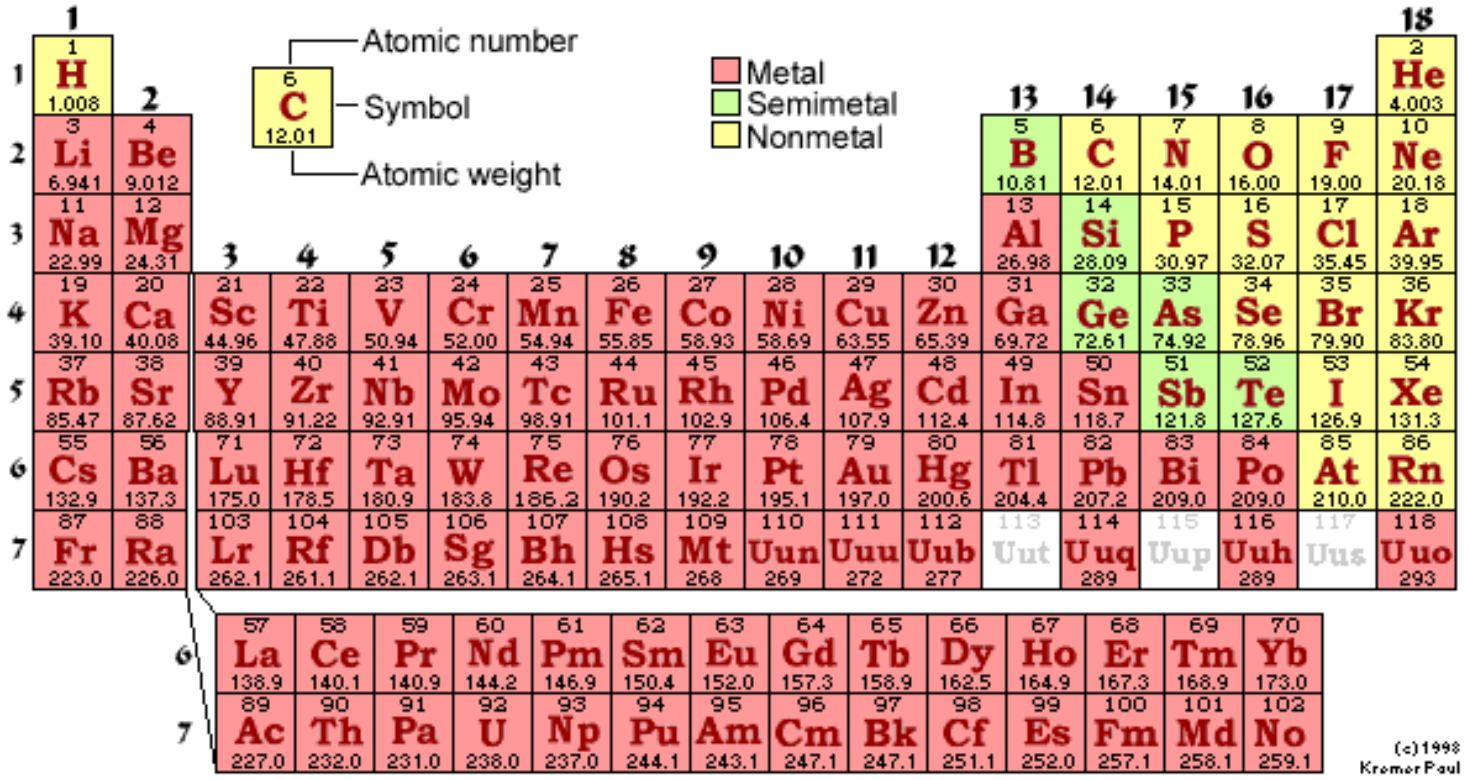
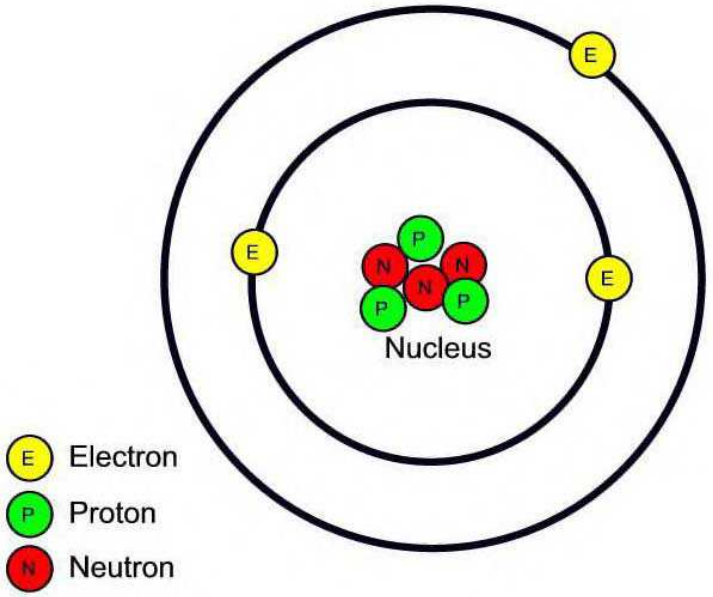
Chemistry Content Review

Periodic Table of the Elements



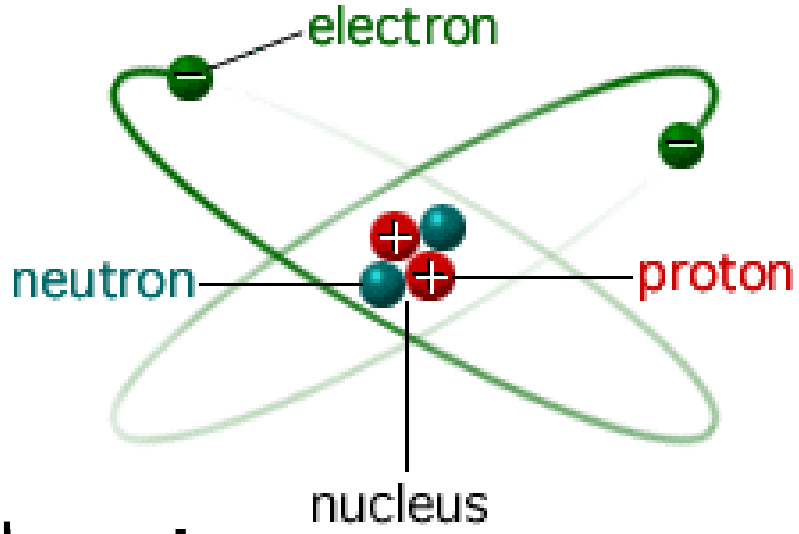
Matter

- Anything that has mass and **takes** up **space**.
- All matter is made from three basic particles:
  - **protons**
  - **neutrons**
  - **electrons**



- Protons, neutrons, and electrons make up atoms.
- Different *types* of atoms are called elements.
- Elements contain protons, neutrons, and electrons in differing numbers.

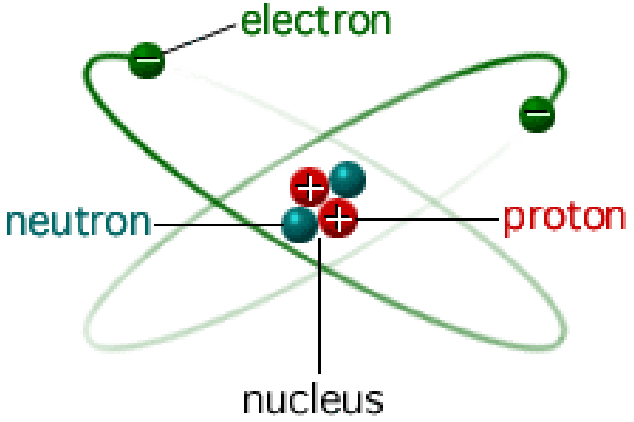
Subatomic Particles



Nucleus:

- Contains **protons** and **neutrons**
- Atomic mass is concentrated in the nucleus
  - Proton
    - **Positively** charged
    - Found in the nucleus
    - Determines **identity** of element
    - Mass = 1 amu
  - Neutron
    - **Neutral**
    - Found in Nucleus
    - Mass = 1 amu

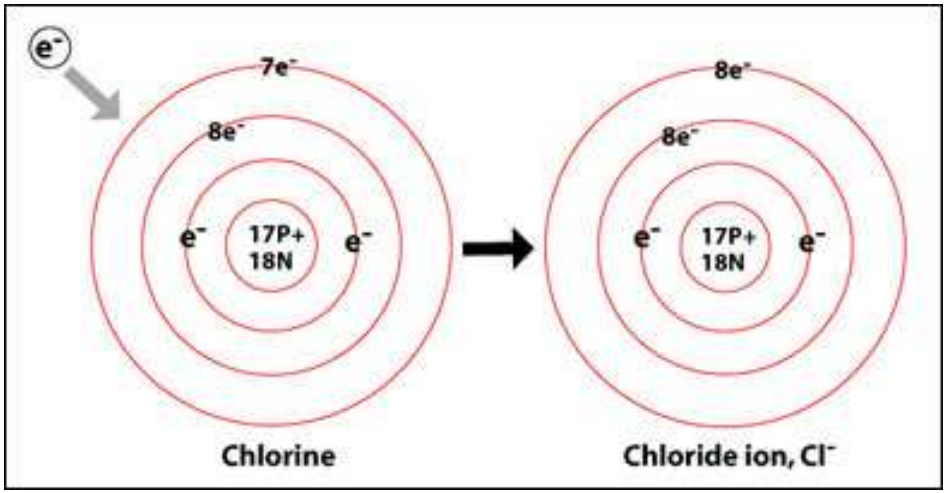
Subatomic Particles



Electron Cloud

- Electron Cloud surrounds the nucleus
- Contains **particles** which are negatively charged
- Electrons are located in specific energy levels.
- If the atom is neutral, the number of electrons equals the number of neutrons
- Very small mass (*negligible*)
- Electrons in the outermost shell are called **valance** electrons.

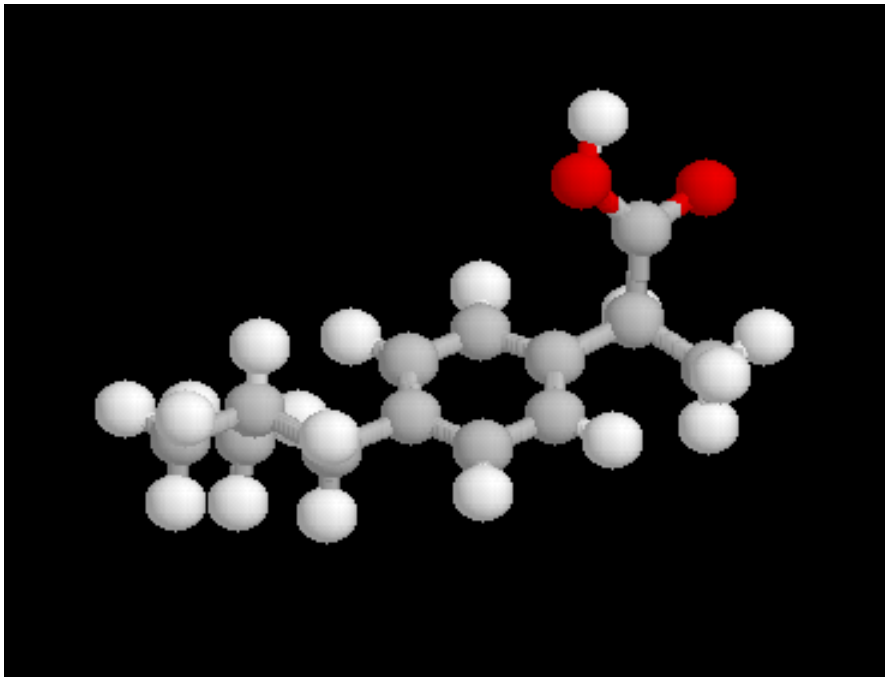
Ions



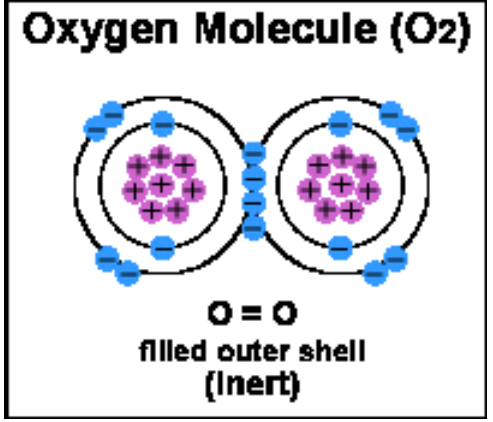
- An atom or group of atoms that has a **positive** or **negative** charge.
- If an atom loses an electron, it becomes **positive**
- If an atom gains an electron, it becomes **negative**.

Compounds

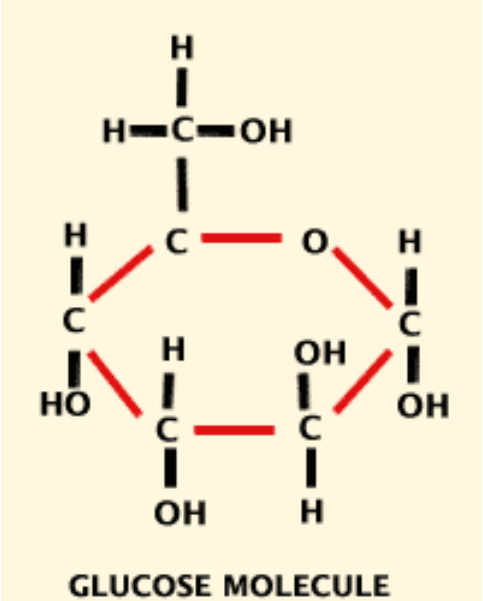
- A substance containing atoms of more than one element
  - NaCl
  - $C_6H_{12}O_6$
  - H_2SO_4
  - $C_{13}H_{18}O_2$ (ibuprofen)

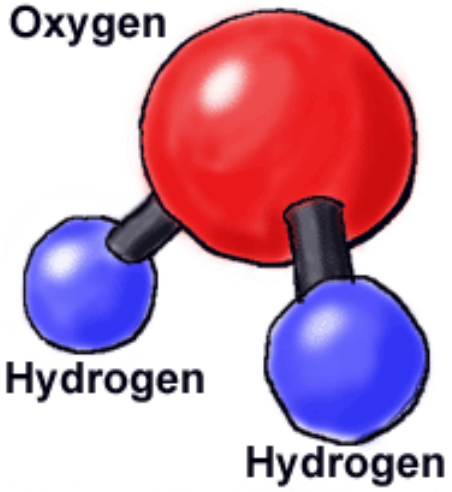


Molecules



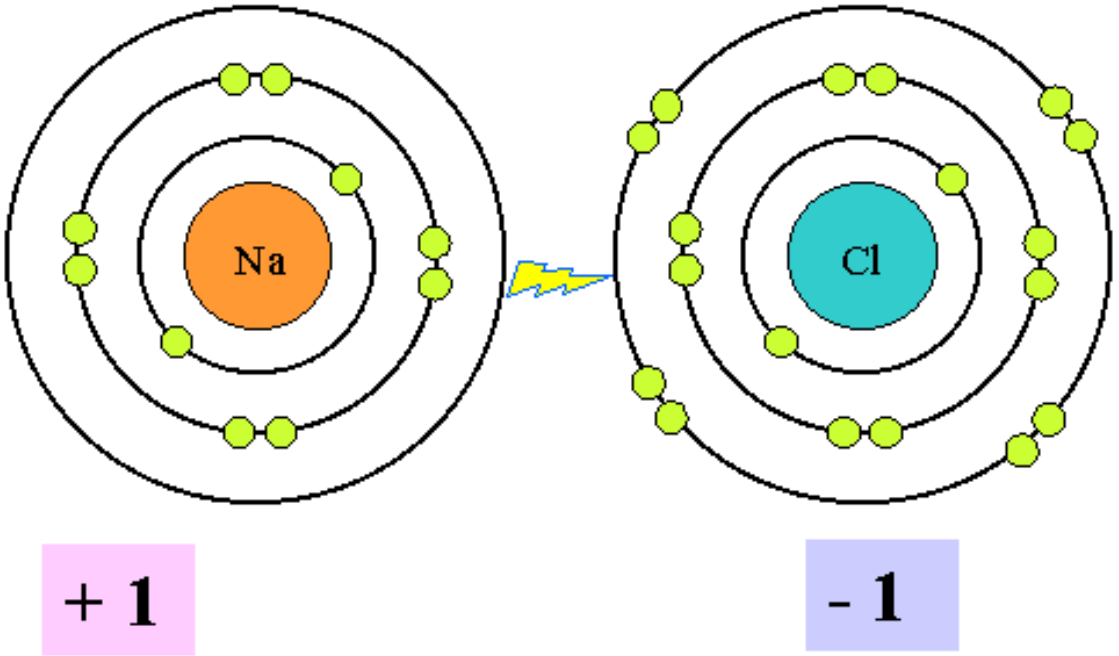
- Two or more atoms bound so tightly that they behave as a **single unit**.
- Linked by **covalent** bonds
- Consist of atoms of the same element or different elements





Ionic Compound

- Formed by the attraction of two ions that are **oppositely** charged.
- $Na^+ + Cl^- \rightarrow NaCl$



Practice

- Identify each of the following as an atom, ion, or molecule:
  - **Ne Atom**
  - **Cl^- Ion**
  - **Ca^{2+} Ion**
  - **CH_4 Molecule**
  - **NO Molecule**
  - **P^{3-} Ion**
  - **CO_2 Molecule**
  - **He Atom**
  - **SO_4^{2-} Ion**

Density

- Describes how closely packed atoms and molecules are in a given substance.
- The ratio of an object's mass to its volume.
- Volume of a cube = length x width x height
- Density = mass/volume
- Units: g/cm^3
- Common Densities
  - Air: .001 g/cm^3
  - Water (40C): 1.00 g/cm^3
  - Water/Ice (00C): 0.92 g/cm^3
  - Aluminum: 2.7 g/cm^3
  - Gold: 19.3 g/cm^3

Density Practice

- 1. Which object has a lower density, a brick or a block of Styrofoam?
  - **Styrofoam**
- 2. Which object will float in water, a rock or a piece of ice? Why?
  - **Ice will float because it is less dense than water; a rock is more dense than water.**
- 3. What is the density of a substance that has a mass of 55g and a volume of 11cm^3?
  - **5g/cm^3**

Pure Substance

- A type of matter in which all particles are of the **same** chemical composition
  - Au (pure gold)
  - H_2O
  - NaCl
  - Sugar ($C_6H_{12}O_6$)
  - Ar

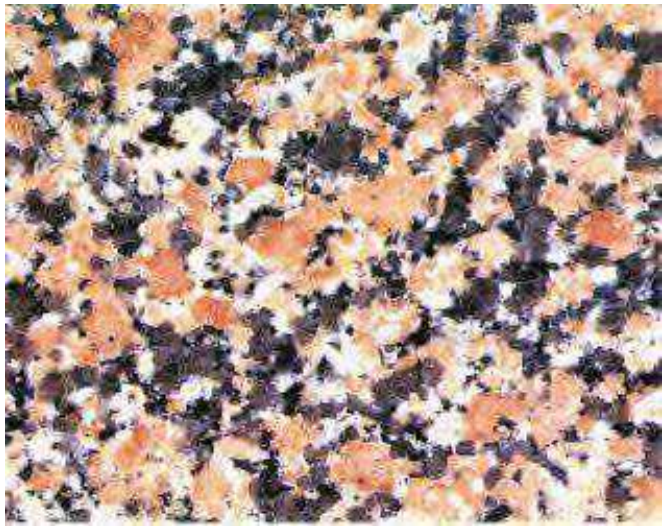
- Which of the previous examples is a compound? an element?
- Why is salt water not a pure substance?

Mixtures

- Two or more pure substances physically **mixed** together.
- Cannot be represented by a chemical formula.
  - Salt water
  - Sand and rocks
  - Air

Heterogeneous Mixture

- A mixture where substances are **not evenly** distributed (non uniform)
  - oil and vinegar salad dressing
  - vegetable soup
  - sand and sugar
  - soil
  - granite

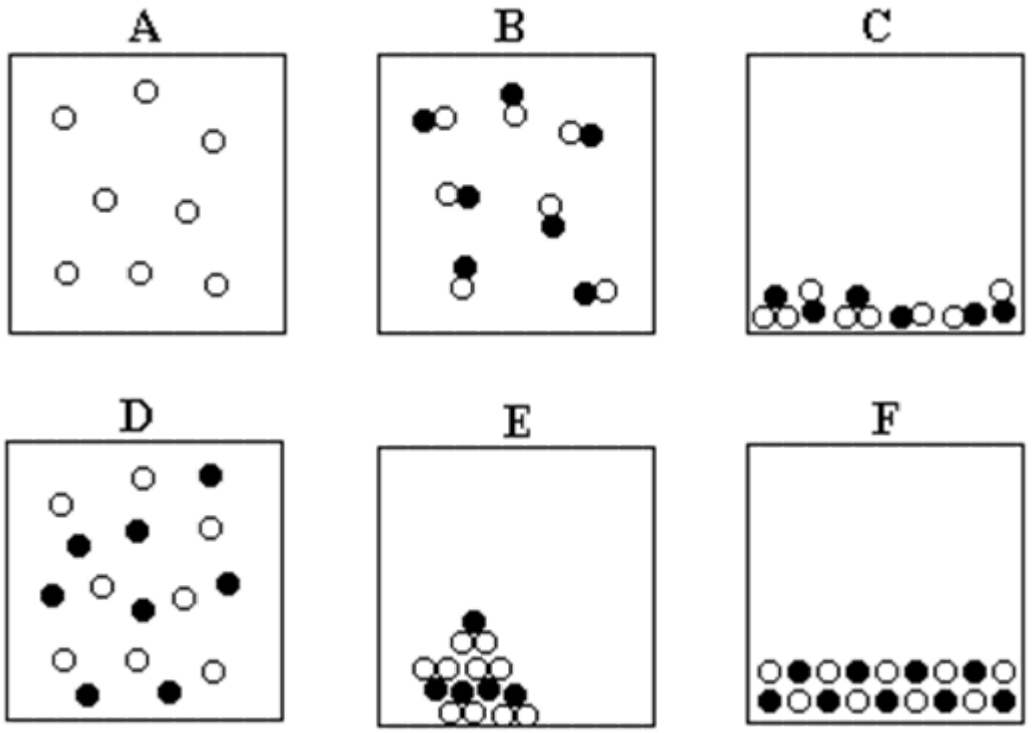


Homogeneous Mixture

- A mixture where all components are **evenly** distributed (uniform).
- "same throughout"
  - salt water
  - gasoline
  - syrup
  - air

Practice

- Identify each of the following as:
  - pure substance/mixture
  - element/compound



Solution

- Formed when one substance is dissolved by another.
- In order to be dissolved, a substance must be **soluble.**
- A **homogeneous** mixture.
- Particles are **evenly** distributed.
- Parts cannot be separated by **filtering**.
- Solvent—**does the dissolving**
- Solute—**dissolved by the solvent**

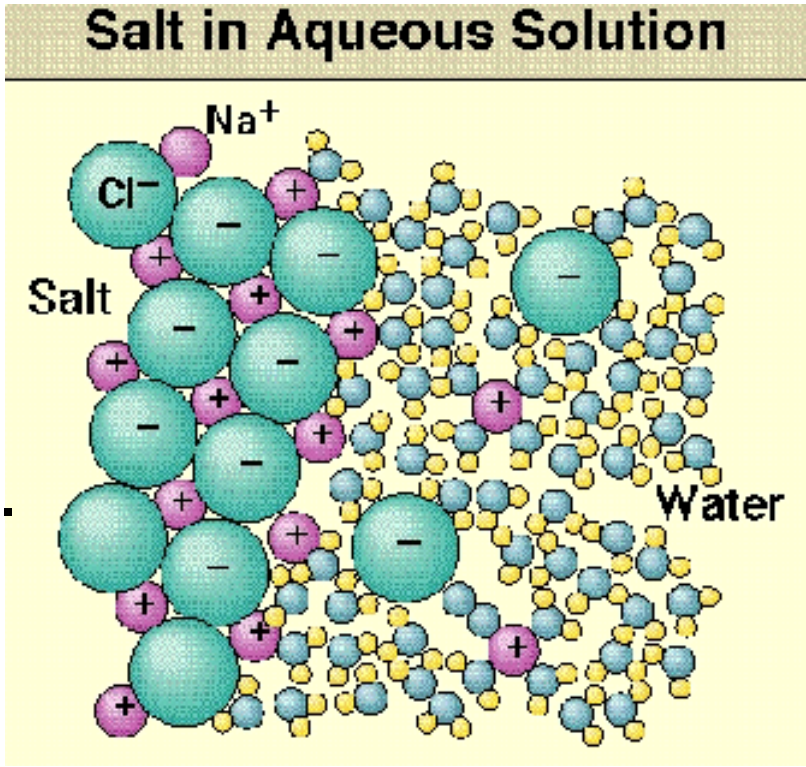
Solution Practice

- Identify the solute and solvent in each of the following:
  - Salt water
  - iced tea
  - kool aid
  - paint/paint thinner
  - nail polish/acetone

Types of Solutions

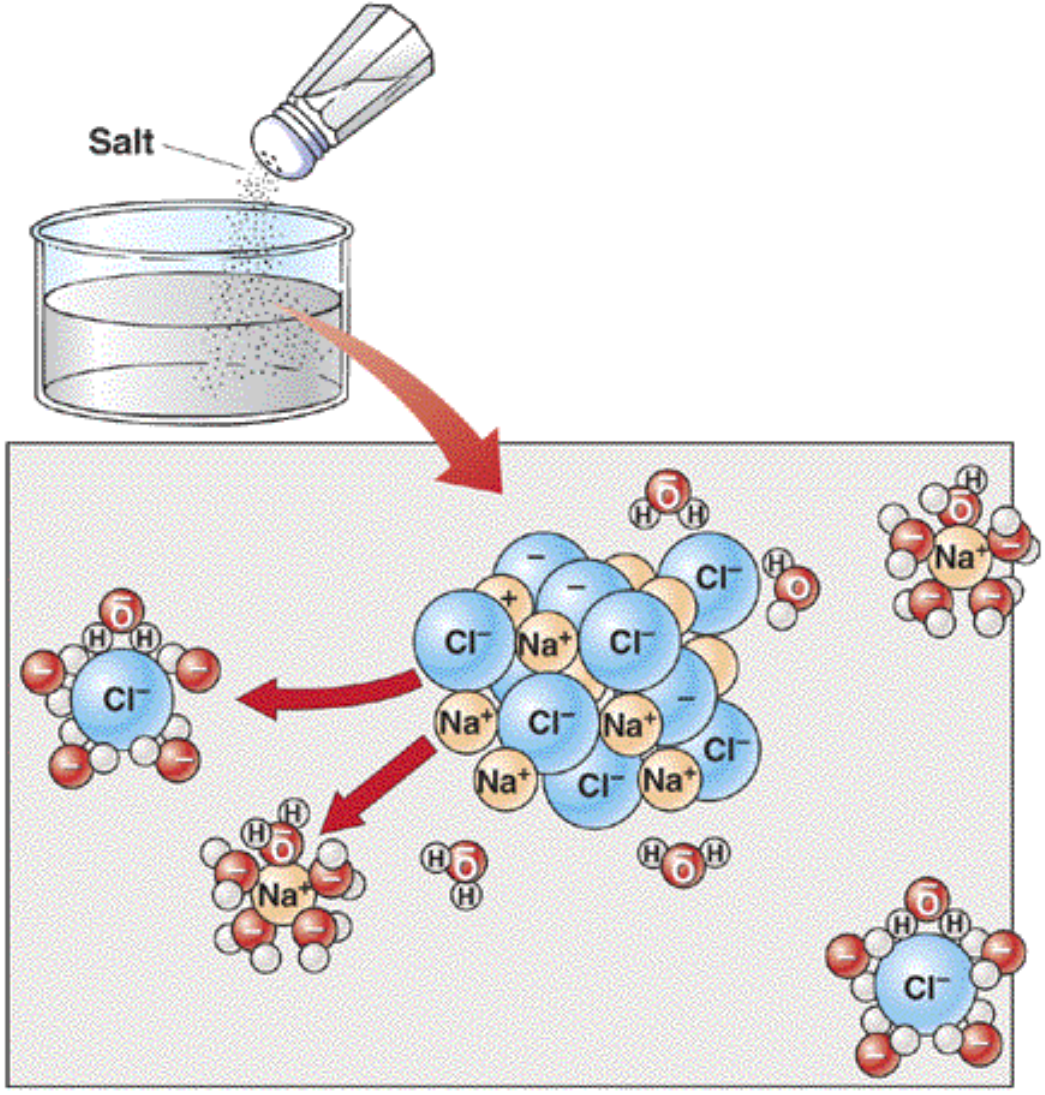
- Solid dissolved in a liquid.
  - Salt water
- Gas dissolved in a liquid
  - Coca-cola
- Two solids
  - Metal alloys: brass = copper + zinc
- Two gasses
  - Air: nitrogen (78% vol), oxygen (21% vol), argon (1% vol), carbon dioxide (0.03% vol).
- In solutions of two solids or two gases, the solvent is the component present in largest quantity.

Water



- The “universal solvent”
- A solution in which water is the solvent is called an **aqueous** (aq) solution.
- Does NOT dissolve *everything*.
  - Why is this a good thing? —think about the paint on your house..
    .
- Because water is polar, it dissolves other polar substances.
  - **“Like** dissolves **like”**
- Water dissolves many other compounds.

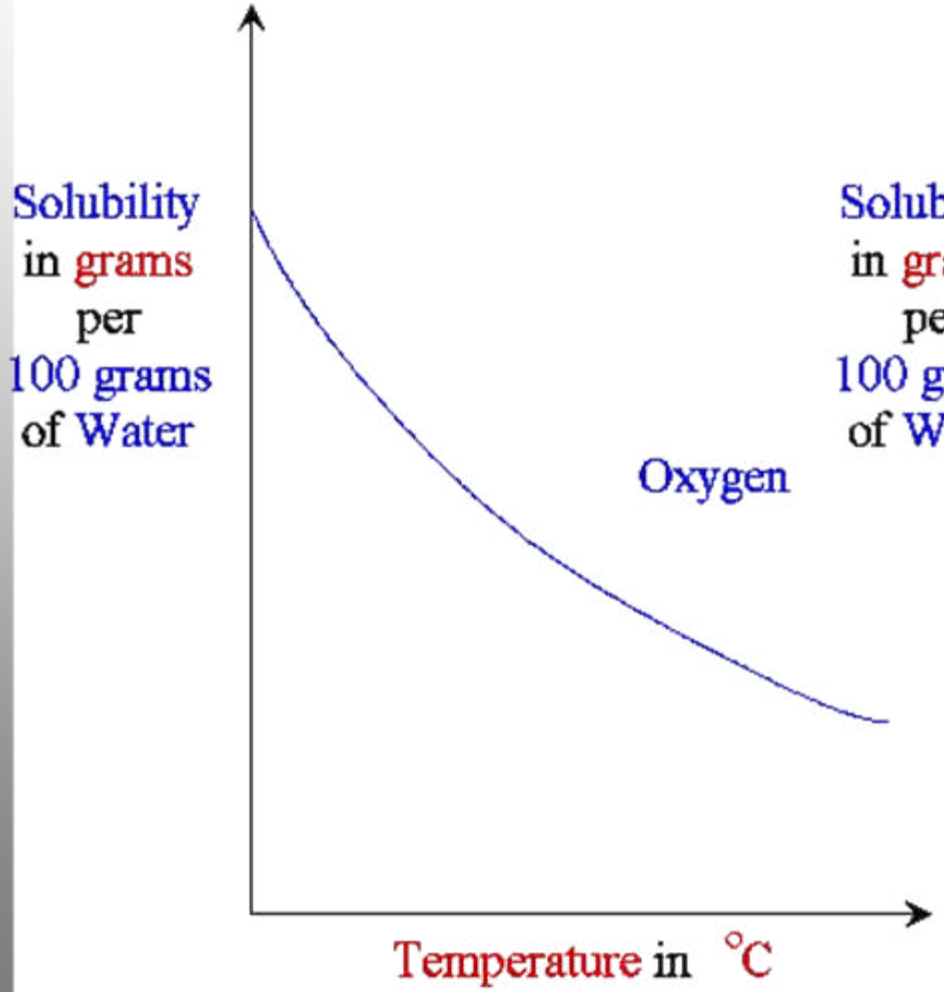
Water the Universal Solvent

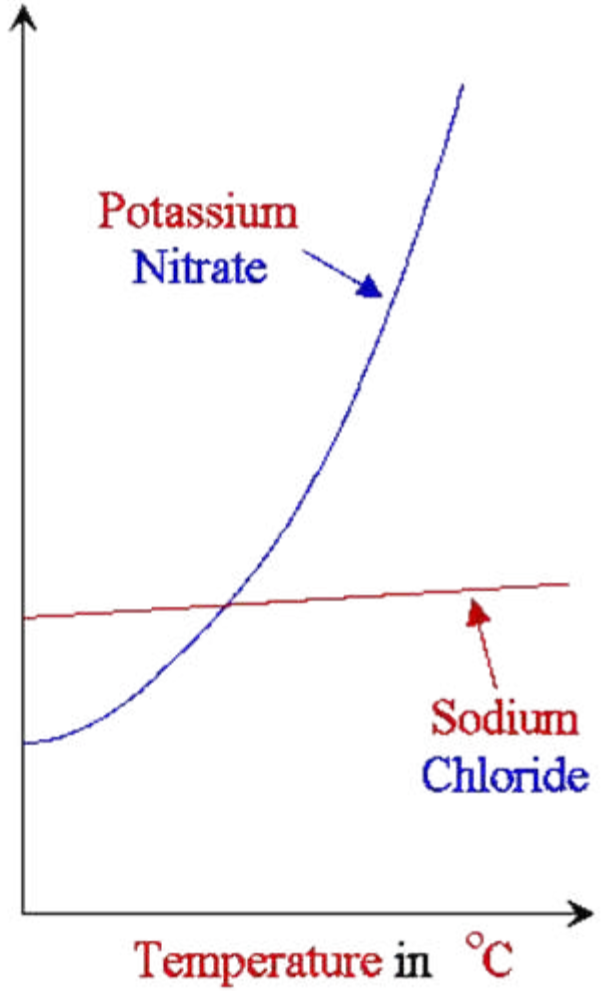


Solubility

- How much of a solute will dissolve in a given solvent.
- How do you increase the solubility of a solid in a liquid? (hint: iced tea)
- How do you increase the solubility of a gas in a liquid? (hint: can of soda)

Solubility Curve





Solubility of a Solid in a Liquid

- Increasing temperature will make a solid **more** soluble in a liquid.
- Decreasing temperature will make a solid **less** soluble in a liquid
- Heat water before adding tea/sugar for iced tea.

Solubility of a Gas in a Liquid

- Increasing temperature will make a gas **less** soluble in liquid.
- Decreasing temperature will make a gas **more** soluble in a liquid.
- Increasing pressure will make a gas **more** soluble in a liquid.
- Decreasing pressure will make a gas **less** soluble in a liquid.

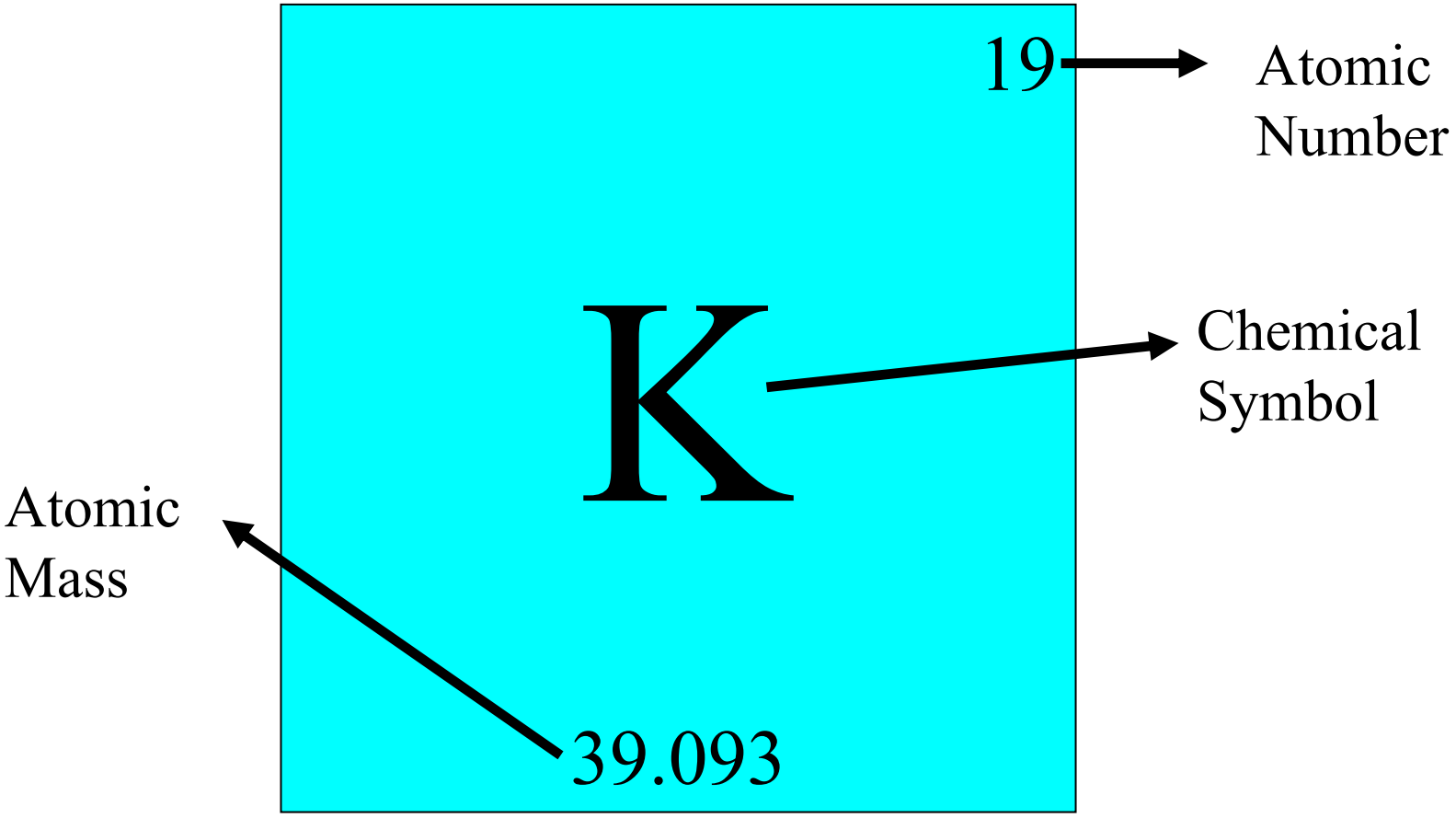
Types of Solutions

- Saturated
  - Holding the **maximum** solute at a given temperature.
- Unsaturated
  - Holding **less** than the maximum solute at a given temperature.
- Supersaturated
  - Holding **more** than the maximum solute at a given temperature.

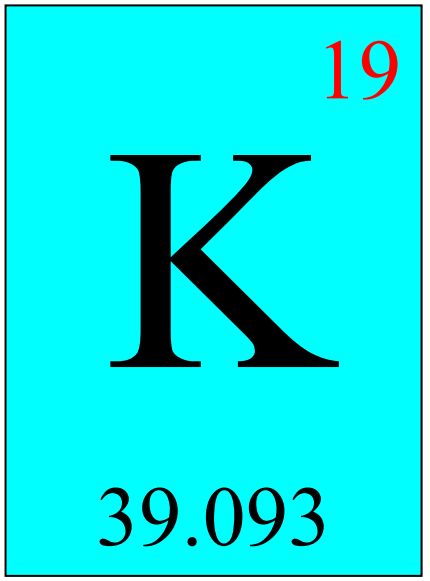
Solution Questions

- What term is used to describe a substance that is not soluble in another substance, such as oil in water?
  - **Insoluble**
- A solid substance is dissolved in a liquid. If the solid comes out of solution and settles to the bottom, it is called a _____.
  - **precipitate**.

Periodic Table

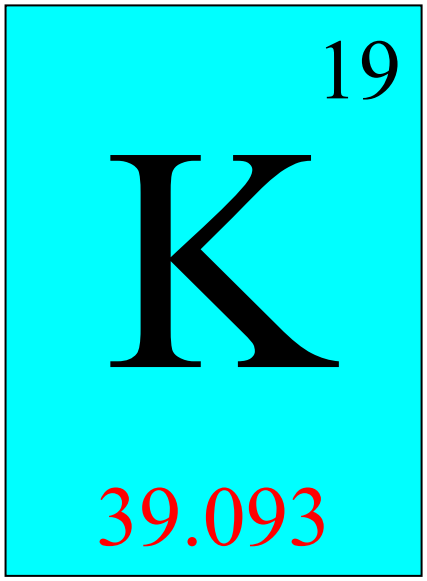


Periodic Table



- Atomic Number
  - **Identifies** the element
  - Tells you how many **protons** an atom has
  - Tells you how many **electrons** are contained by a neutral atom of a given element.

Atomic Mass



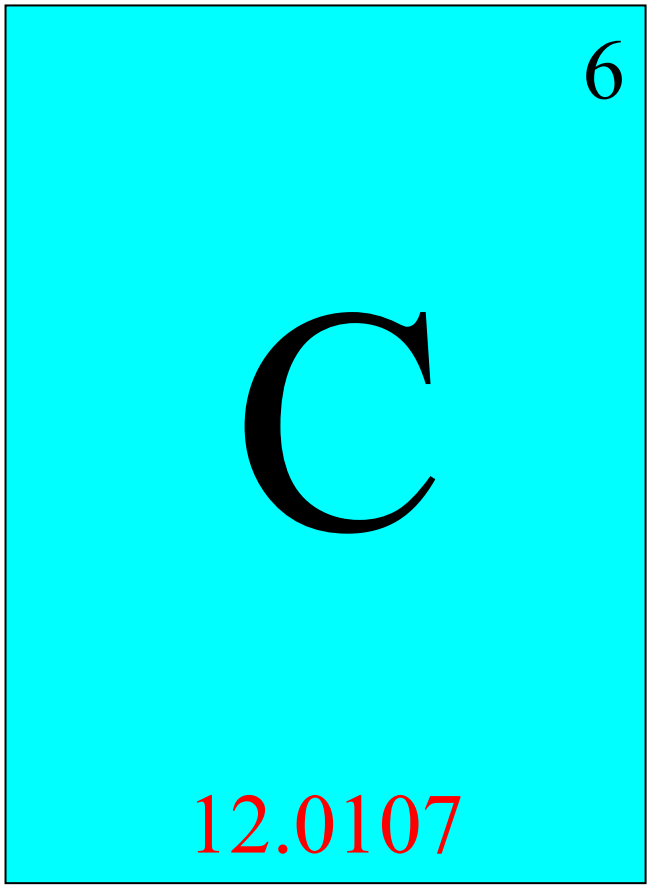
- **Average** mass of the atom
- Equal to number of **protons** plus number of **neutrons**.
- Electrons have mass BUT the mass is so small we do not factor it in to the overall mass.

Practice

- How many protons and neutrons do the following atoms contain?
  - Oxygen
  - Bromine
  - Carbon-14
  - Atomic Number 53
  - Atomic Number 10

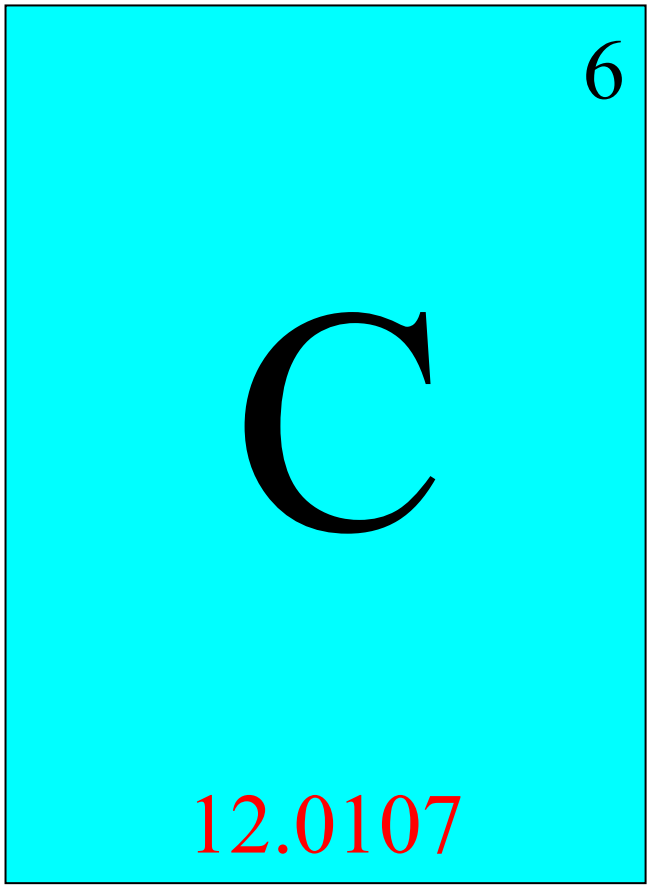
Isotopes

- The atomic mass of each atom represents an *average* of all of the individual isotopes of that element.
- Two atoms contain the same number of protons but different numbers of **neutrons**



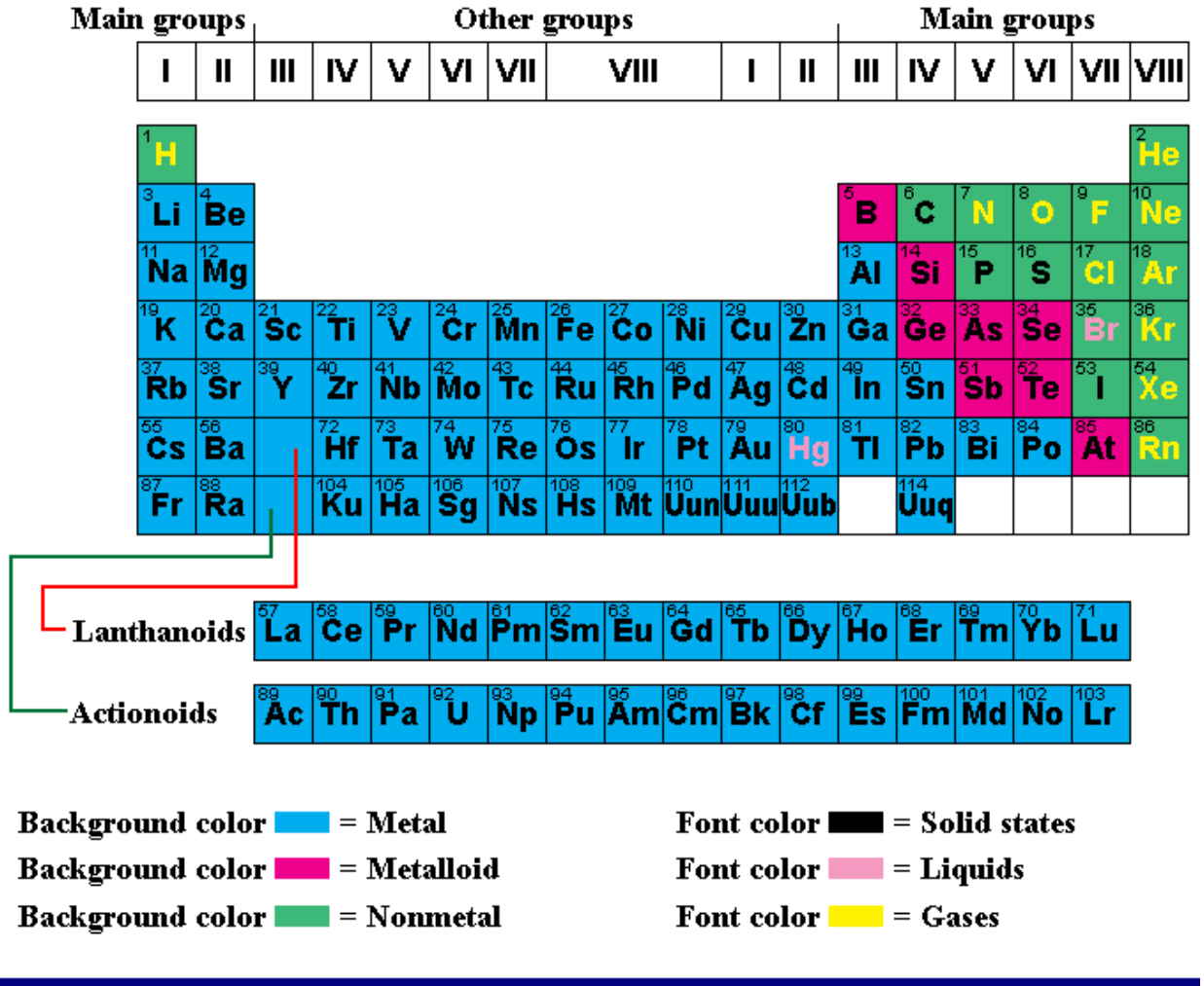
Isotopes

- Isotopes are atoms of the same **element**, but have different **masses**.
- Isotopes with an unstable nucleus will tend to breakdown or decay; these atoms are called **radioactive** and will release energy in the form of nuclear radiation as they decay.



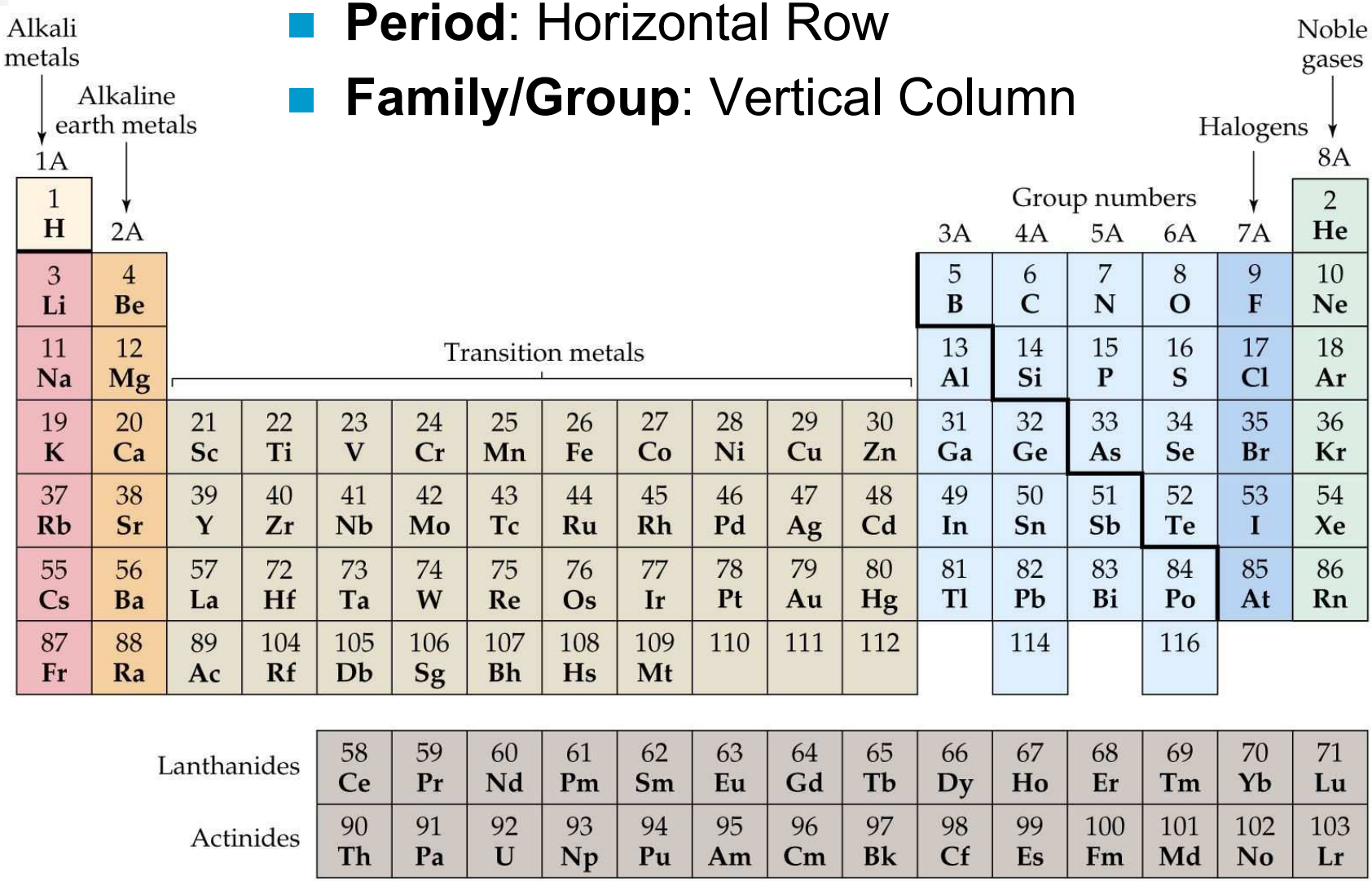
The Periodic Table of Elements

- Metals vs. Non-metals (and metalloids)



The Periodic Table of Elements

- **Period**: Horizontal Row
- **Family/Group**: Vertical Column



Oxidation States

- In order to become stable, atoms will gain or lose a certain number of **electrons**.
- The goal is to have a full outer shell (octet rule)
- A full outer shell contains **eight** electrons.
- When atoms gain or lose electrons, they become ions and take on a certain charge.
  - This charge is referred to as the oxidation number.

Oxidation Numbers

PERIODIC CHART OF THE ELEMENTS

+1	IIA	IIIB	IVB	VB	VIB	VIIB	VIII		IB	IIB	IIIA	IVA	VA	VIA	VIIA	INERT GASES
1 H 1.00797	+2										+3		-3	-2	-1	2 He 4.0026
3 Li 6.939	4 Be 9.0122										5 B 10.811	6 C 12.0112	7 N 14.0067	8 O 15.9994	9 F 18.9984	10 Ne 20.183
11 Na 22.9898	12 Mg 24.312										13 Al 26.9815	14 Si 28.086	15 P 30.9738	16 S 32.064	17 Cl 35.453	18 Ar 39.948
19 K 39.102	20 Ca 40.08	21 Sc 44.956	22 Ti 47.90	23 V 50.942	24 Cr 51.996	25 Mn 54.9380	26 Fe 55.847	27 Co 58.9332	28 Ni 58.71	29 Cu 63.54	30 Zn 65.37	31 Ga 69.72	32 Ge 72.59	33 As 74.9216	34 Se 78.96	35 Br 79.909	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.905	40 Zr 91.22	41 Nb 92.906	42 Mo 95.94	43 Tc (99)	44 Ru 101.07	45 Rh 102.905	46 Pd 106.4	47 Ag 107.870	48 Cd 112.40	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.904	54 Xe 131.30
55 Cs 132.905	56 Ba 137.34	*57 La 138.91	72 Hf 178.49	73 Ta 180.948	74 W 183.85	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.09	79 Au 196.967	80 Hg 200.59	81 Tl 204.37	82 Pb 207.19	83 Bi 208.980	84 Po (210)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	‡89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 ? (271)	111 ? (272)	112 ? (277)						

Numbers in parenthesis are mass numbers of most stable or most common isotope.

Atomic weights corrected to conform to the 1963 values of the Commission on Atomic Weights.

The group designations used here are the former Chemical Abstract Service numbers.

* Lanthanide Series

58 Ce 140.12	59 Pr 140.907	60 Nd 144.24	61 Pm (147)	62 Sm 150.35	63 Eu 151.96	64 Gd 157.25	65 Tb 158.924	66 Dy 162.50	67 Ho 164.930	68 Er 167.26	69 Tm 168.934	70 Yb 173.04	71 Lu 174.97

‡ Actinide Series

90 Th 232.038	91 Pa (231)	92 U 238.03	93 Np (237)	94 Pu (242)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (249)	99 Es (254)	100 Fm (253)	101 Md (256)	102 No (256)	103 Lr (257)

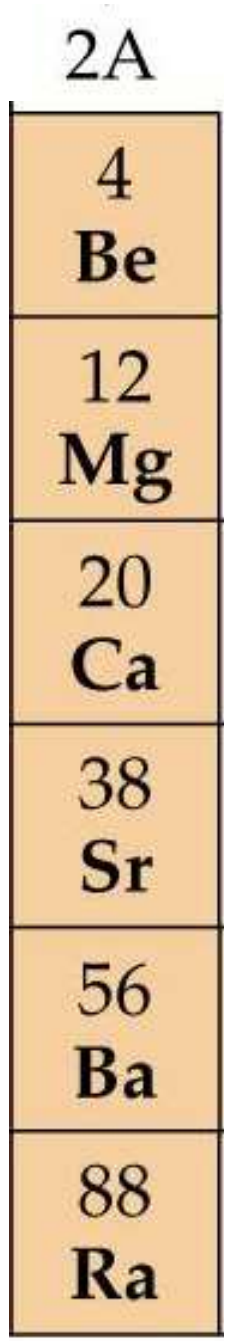
Alkali Metals

- Group 1
- 1 valance electron
- Oxidation Number = +1
- Highly reactive

1A
1 H
3 Li
11 Na
19 K
37 Rb
55 Cs
87 Fr

Alkaline Earth Metals

- Group 2
- 2 valance electrons
- Oxidation Number = +2
- Harder, Denser, Stronger than Alkali Metals
- Very reactive, but less reactive than Alkali Metals



Transition Metals

- Groups 3-12
- Varied oxidation numbers
- Not as reactive as groups 1 and 2.

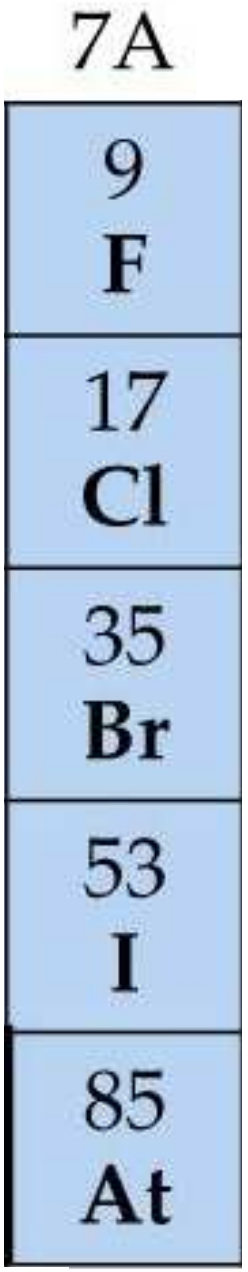
Transition metals

21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn
39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd
57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg
89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110	111	112

Lanthanides	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
Actinides	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

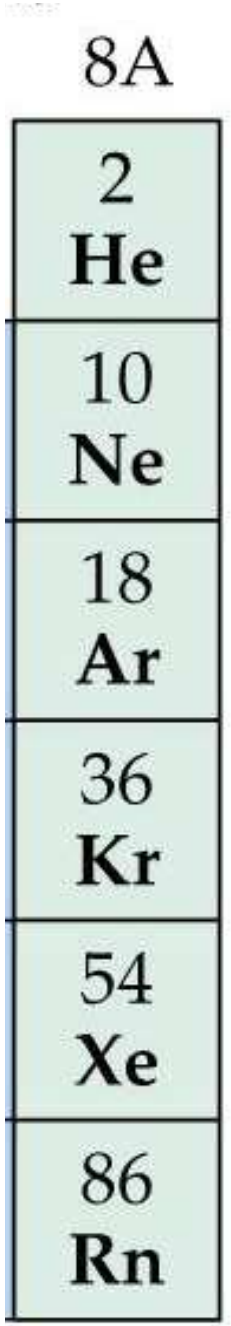
Halogens

- Group 17
- 7 valance electrons
- Oxidation Number = -1
- Most reactive non-metals
- Combine with metals
  - NaCl, KBr, MgBr



Noble Gases

- Group 18
- 8 outer electrons
  - will not gain or lose electrons
  - no oxidation number
- Very **stable**

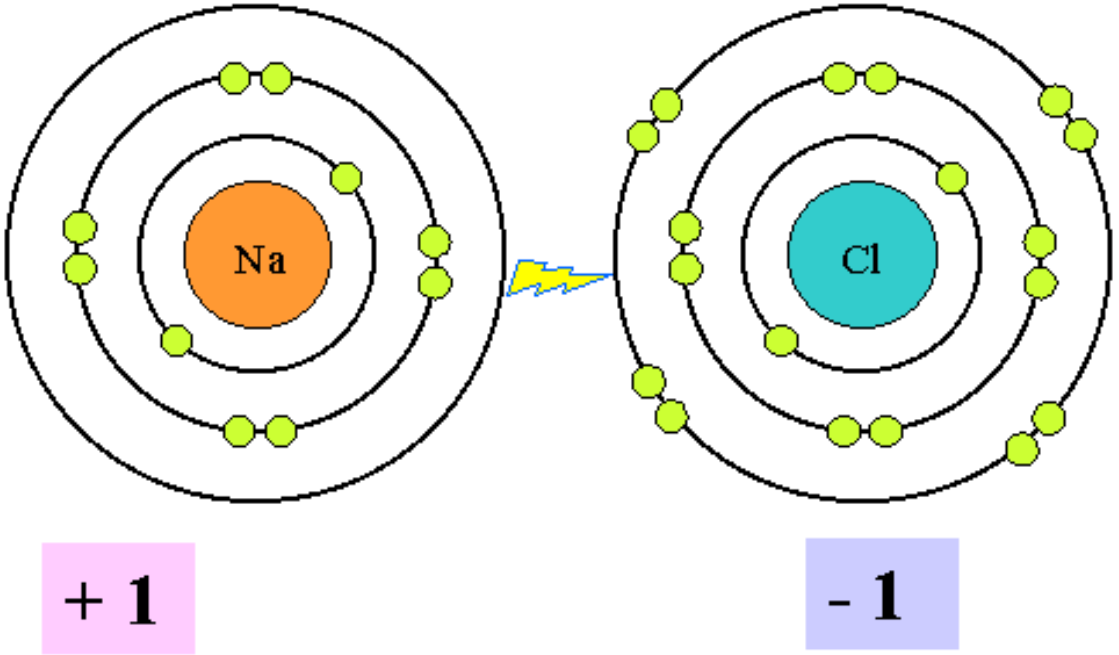


Bonding

- When forming compounds, atoms will bond in a way that leads to an overall charge of zero.
- Bonding is due to interactions of the **electron** clouds that surround an atom.
- Types of bonds
  - **Ionic**
  - **Covalent**

Ionic Bonds

- Formed between a **metal** and a **non-metal**.
- Forms a compound—not a molecule.
- Involves gain/loss of electrons.
- Produces compound with net charge of zero.



Ionic Bonds

- How to predict bonding pattern:
  - Na + Cl
  - Ca + Br
  - Ba + I
  - Mg + O
  - Al + O

Covalent Bonds

- Involves the **sharing** of electrons.
- Produces a molecule.
- Formed between two non-metals
- Examples
  - Water (H_2O)
  - Sugar ($C_6H_{12}O_6$)
  - Hydrogen gas (H_2)
- Diatomic Molecules:
  - H_2, F_2, Cl_2, Br_2, I_2, N_2, O_2

Bonding Practice

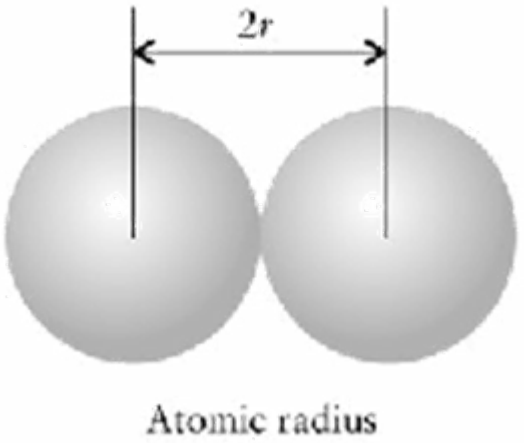
- What type of bond is produced when electrons are shared between atoms?
- What type of bond is produced when atoms with opposite charges are attracted to each other?
- What type of bond will be produced when the following atoms combine?
  - C + O
  - Mg + Cl
  - O + O
  - Ba + Br

Periodic Properties

- Electron Affinity
  - The ability of an atom to attract and hold extra electrons.
- Electronegativity
  - The tendency of an atom to attract electrons to itself when combined with another atom.
  - How might this predict bonding patterns?

Periodic Properties

- Ionization energy
  - Amount of energy required to remove an electron from an atom or ion.
- Atomic Radius
  - one half the distance between two nuclei of like atoms.
  - A measure of the **size** of an atom
  - What effect does atomic radius have on electron affinity and ionization energy?

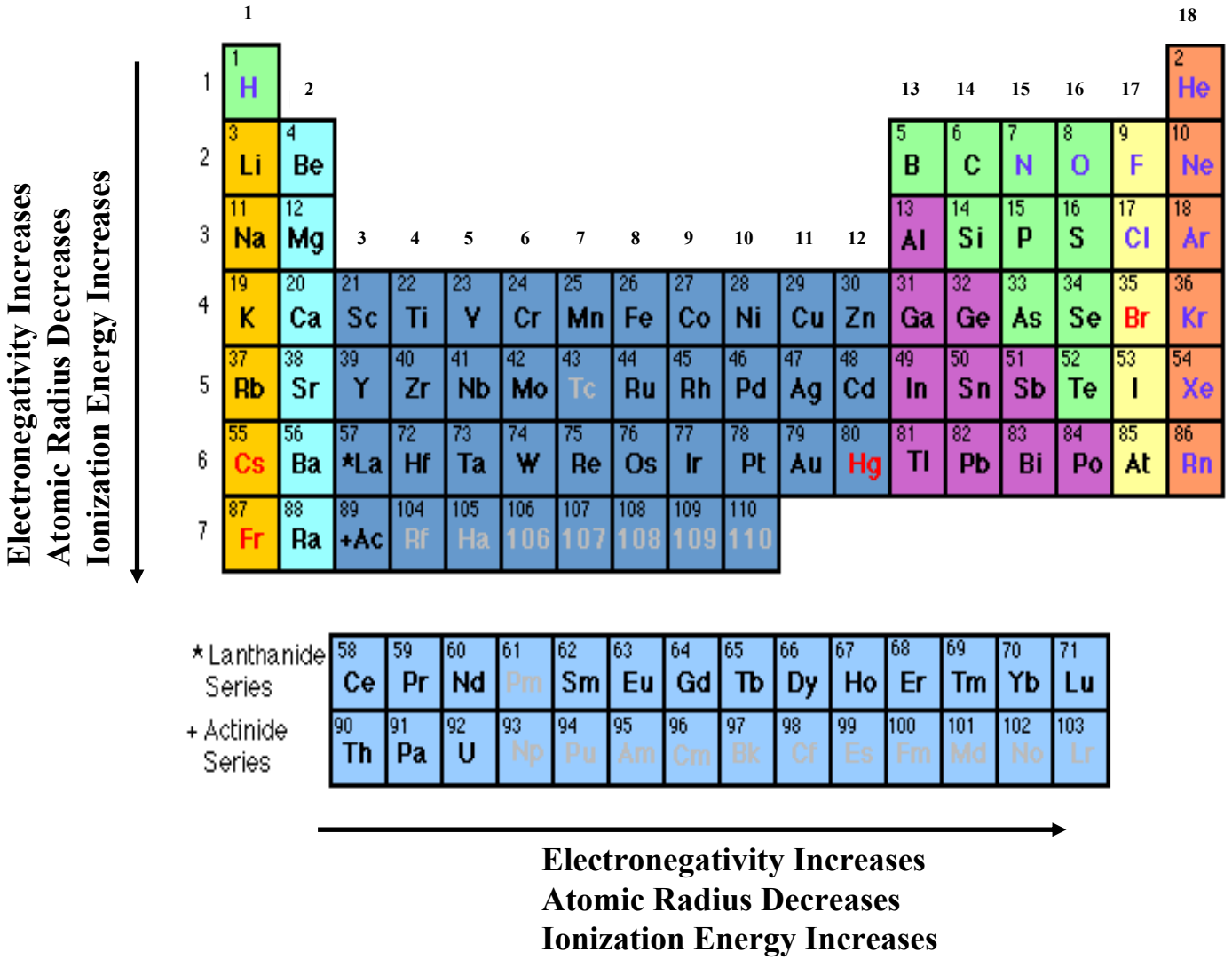


Atomic radius

Periodic Properties

- Reactivity
  - Metals
    - Increases as you move down a family.
    - Decreases as you move across a period.
    - Francium is most reactive metal.
  - Nonmetals
    - Decreases as you move down a family.
    - Increases as you move across a period.
    - Fluorine is the most reactive nonmetal.

Periodic Trends



Periodic Properties Practice

- List the following elements from highest to lowest electronegativity:
  - Al, Ca, Cl
  - I, Xe, Rb
  - N, Bi, As
  - Cs, Li, K

Periodic Properties Practice

- List the following elements from largest to smallest atomic radius:
  - Al, Ca, Cl
  - I, Xe, Rb
  - N, Bi, As
  - Cs, Li, K

Periodic Properties Practice

- List the following elements from highest to lowest ionization energy:
  - Al, Ca, Cl
  - I, Xe, Rb
  - N, Bi, As
  - Cs, Li, K

Chemical Reactions

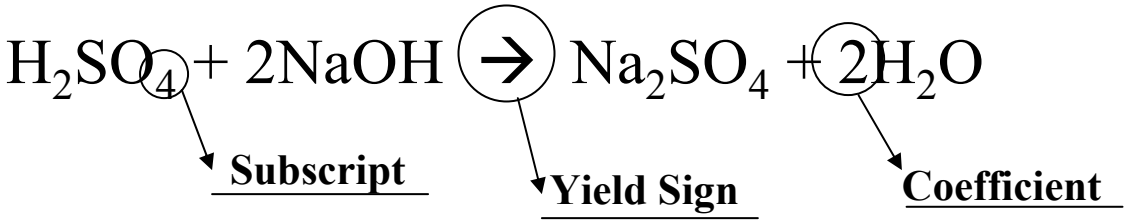
The process by which the atoms of one or more substances are rearranged to form different substances

- Reactant
  - The **starting** substance in a chemical reaction.
- Product
  - The substance **formed** during a chemical reaction.
- Catalyst
  - A substance that **increases** the rate of a chemical reaction by lowering activation energies but is not itself consumed in the reaction.

Chemical Reactions

- Chemical Equation
  - a statement using chemical formulas to describe the identities and relative amounts of the reactants and products involved in the chemical reaction.
- Law of Conservation of Matter
  - Matter is neither created nor destroyed
  - All chemical reactions should be **balanced**; the mass of the products should equal the mass of the reactants.

Chemical Reactions



Types of Reactions

- Synthesis
  - Two or more substances react to yield a **single** product.
  - $2H_2 + O_2 \rightarrow 2H_2O$
- Decomposition
  - A single compound breaks down into **two** or more elements or compounds.
  - $2H_2O \rightarrow 2H_2 + O_2$

Types of Reactions

- Single Displacement/Replacement
  - The atoms of one element **replace** the atoms of another element in a compound.
  - $2AgNO_3 + Cu \rightarrow Cu(NO_3)_2 + 2Ag$
- Double Displacement/Replacement
  - Involves the **exchange** of positive ions between two compounds.
  - $AgNO_3 + KCl \rightarrow AgCl(s) + KNO_3$

Types of Reactions

- Combustion
  - Occurs when a substance reacts with oxygen, releasing _____ in the form of heat and light.
  - $CH_4 + 2O_2 \rightarrow 2H_2O + CO_2$
- Dehydration
  - Occurs when monomers combine with the loss of a **water** molecule.
  - $C_6H_{12}O_6 + C_6H_{12}O_6 \rightarrow C_{12}H_{22}O_{11} + H_2O$
- Exothermic Reaction: Energy is **released**
- Endothermic Reaction: Energy is **absorbed**

Practice

Identify each reaction below

1. $2C_3H_7OH + 9O_2 \rightarrow 6CO_2 + 8H_2O$
   - **Combustion**

2. $Ca_3(PO_4)_2 + 3H_2SO_4 \rightarrow 3CaSO_4 + 2H_3PO_4$
   - **Double replacement**

3. $H_2O + SO_3 \rightarrow H_2SO_4$
   - **Synthesis**

4. $C_3H_8 + 5O_2 \rightarrow 4H_2O + 3CO_2$
   - **Combustion**

5. $2KClO_3 \rightarrow 2KCl + 3O_2$
   - **Decomposition**

6. $2KI + Cl_2 \rightarrow 2KCl + I_2$
   - **Single replacement**

Chemical and Physical Changes

- Chemical change
  - A change in the **arrangement** of **atoms**.
  - A change where you end up with a **new** and **different** substance from which you started.
  - Combustion, Fermentation, Electrolysis, Rusting/Oxidation, Tarnishing, Souring of Milk, "chemical reactions"
  - Examples
    - $2H_2O \rightarrow 2H_2 + O_2$
    - $C_6H_{12}O_6 + O_2 \rightarrow CO_2 + H_2O$
    - $HCl + NaOH \rightarrow NaCl + H_2O$

Chemical and Physical Changes

- Physical Change
  - A change in a physical property of a substance.
  - End up with same substance as original.
  - Phase changes
    - $H_2O(s) \rightarrow H_2O(l) \rightarrow H_2O(g)$
  - Dissolving, Melting, Freezing
  - Breaking into smaller particles

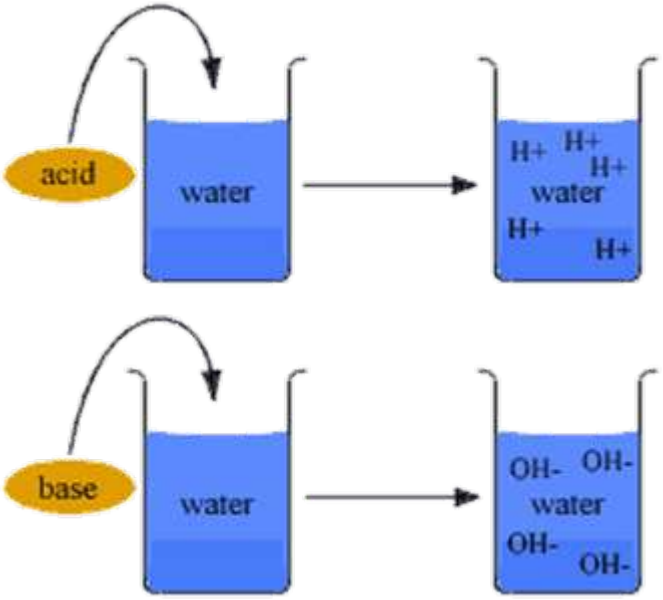
Practice

- Classify each of the following as a chemical or a physical change:
  1. boiling water
  2. bleaching clothes
  3. drying clothes
  4. slicing potatoes
  5. making coffee
  6. silver tarnishing
  7. cooking a hamburger
  8. Making Kool-Aid

Acids and Bases

- Acid
  - Forms **H^+** when dissolved in water.
  - Acidic solutions have more H^+ than OH^-.
  - pH less than **7**
  - Examples
    - HCl
    - Lemon juice
    - Vinegar
    - H_2SO_4
    - Stomach Acid

Acids and Bases



- Base
  - Donates **OH^-** when dissolved in water.
  - Basic solutions have more OH^- than H^+.
  - pH greater than **7**
  - Examples
    - NaOH
    - NH_3 (ammonia)
      - How is this a base if it does not have OH^-?

Examples of Acids and Bases

	$[H^+]$	pH	Example
Acids	1×10^{0}	0	HCl
	1×10^{-1}	1	Stomach acid
	1×10^{-2}	2	Lemon juice
	1×10^{-3}	3	Vinegar
	1×10^{-4}	4	Soda
	1×10^{-5}	5	Rainwater
	1×10^{-6}	6	Milk
Neutral	1×10^{-7}	7	Pure water
Bases	1×10^{-8}	8	Egg whites
	1×10^{-9}	9	Baking Soda
	1×10^{-10}	10	Tums® antacid
	1×10^{-11}	11	Ammonia
	1×10^{-12}	12	Mineral Lime - $Ca(OH)_2$
	1×10^{-13}	13	Drano®
	1×10^{-14}	14	NaOH

Acid and Base Terms

- Neutralization: an acid reacts with a base to produce a **neutral** solution.
  - Produces a **salt** and **water**
  - $HCl + NaOH \rightarrow NaCl + H_2O$

Acid and Base Terms

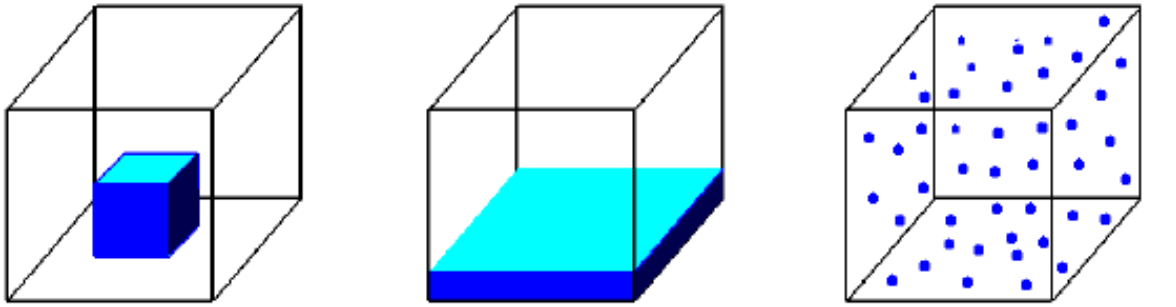
- Hydrogen ion: H^+
- Hydroxide ion: OH^-
- Indicator: a compound that changes color in the presence of an acid or base.
  - Phenolpthalein
  - Litmus paper: red (acid), blue (base)
- pH: a measure of the hydronium (hydrogen) ion concentration in a solution.

Acid Rain

- Normal Rain is slightly acidic due to reaction of water with dissolved CO_2
- Pollutants such as sulfur oxides and nitrogen oxides decrease the pH further.
- Rain with a pH less than **5.5** is considered acid rain.
- How would acid rain affect plants?
- How would acid rain affect buildings and monuments?

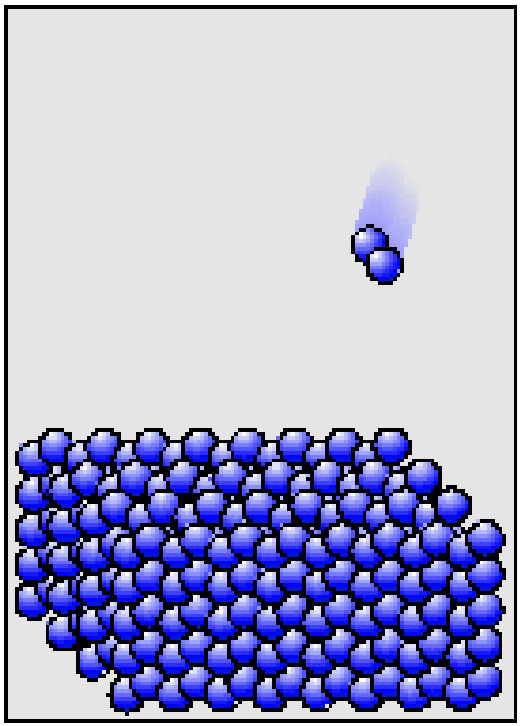
States of Matter

- Matter exists in three primary states
  - **Solid**
  - **Liquid**
  - **Gas**



Solid

- Particles **closest** together
- Most **dense***
- Definite shape and volume
- **Strongest** intermolecular forces
- Least amount of particle **motion** (kinetic energy)



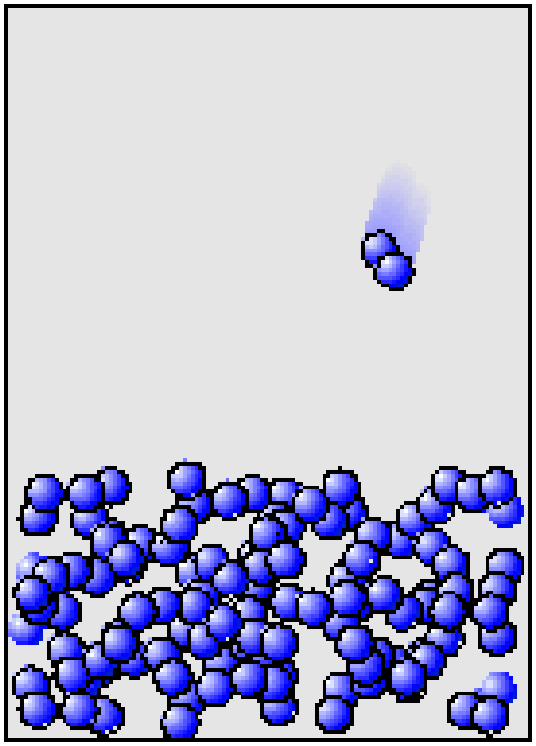
solid

*Density—amount of mass per unit volume.

Units = g/cm^3

Liquid

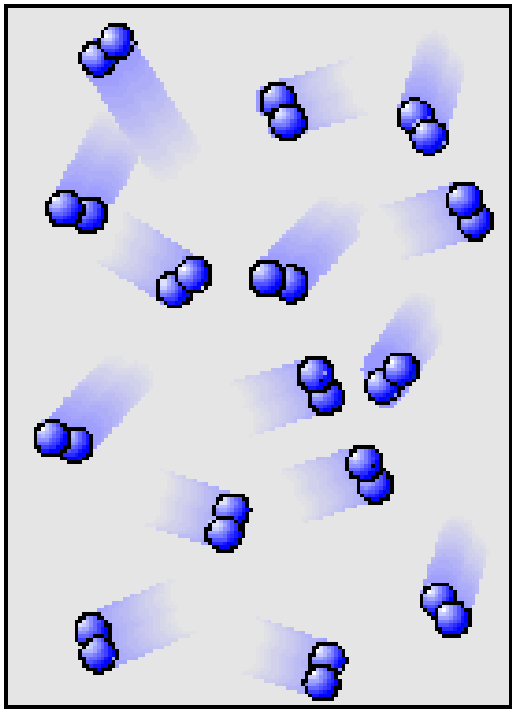
- Particles **further apart**
- Particles have greater range of motion compared to solid
- **Less** dense
- Definite volume, but not definite shape
- Takes the shape of its container
- Weaker intermolecular forces



liquid

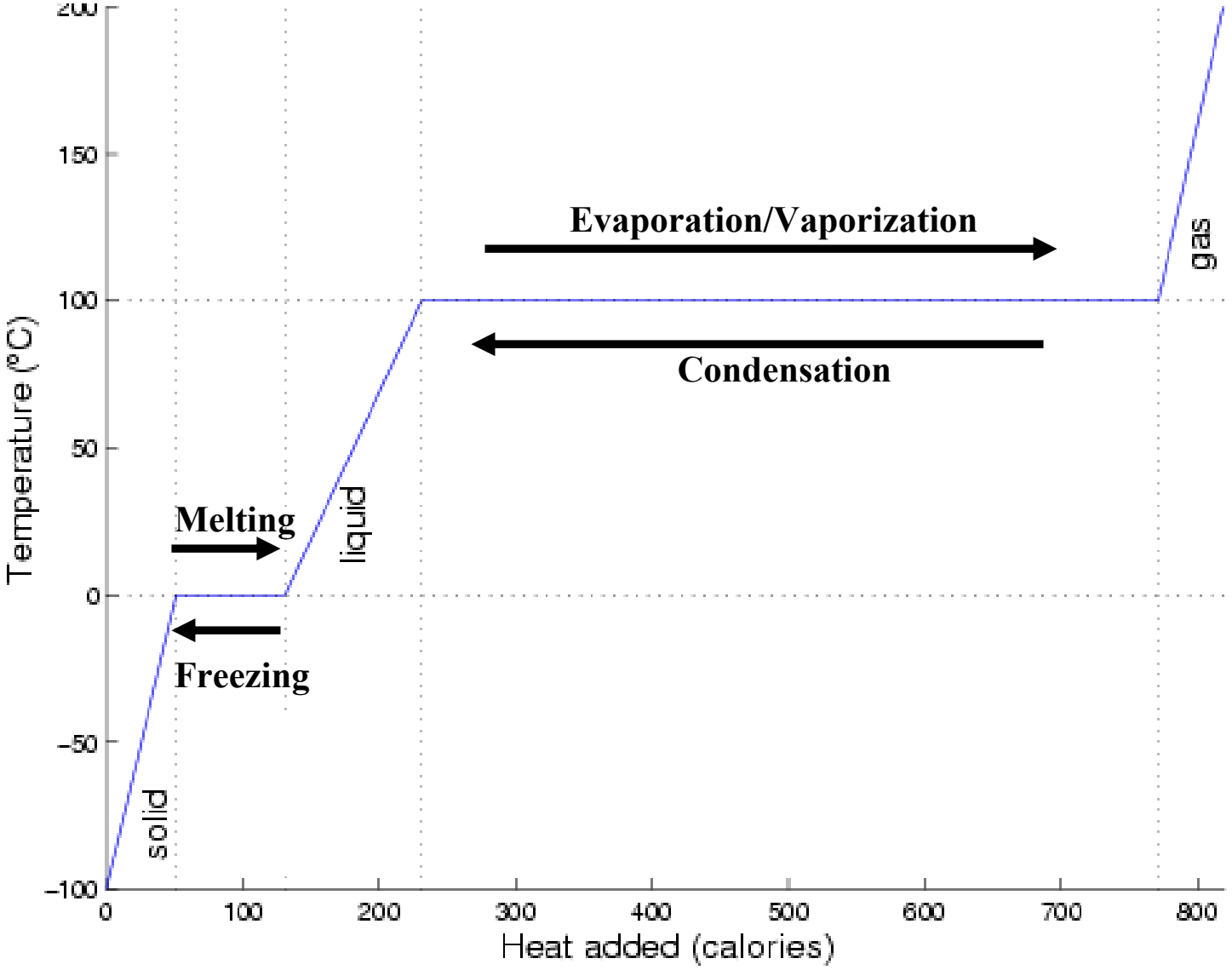
Gas

- Particles **farthest apart**
- Greater particle motion and energy content than solids and liquids
- **Least** dense
- No definite shape or volume
- Takes the shape of its container
- Weakest intermolecular forces
- Random collisions between particles.



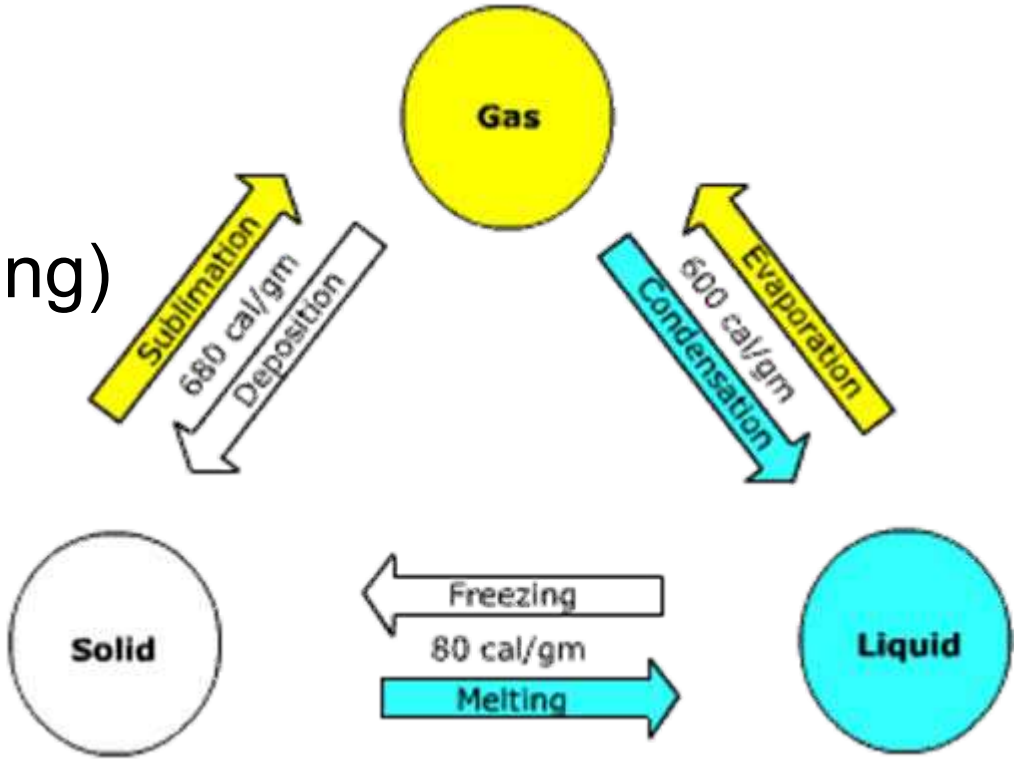
gas

Conversion Between States



Conversion Between States

- Melting
  - Solid→liquid
- Vaporization/ Evaporation (boiling)
  - liquid→gas
- Freezing
  - liquid→solid
- Condensation
  - gas→liquid
- Sublimation
  - solid→gas



Thermodynamics

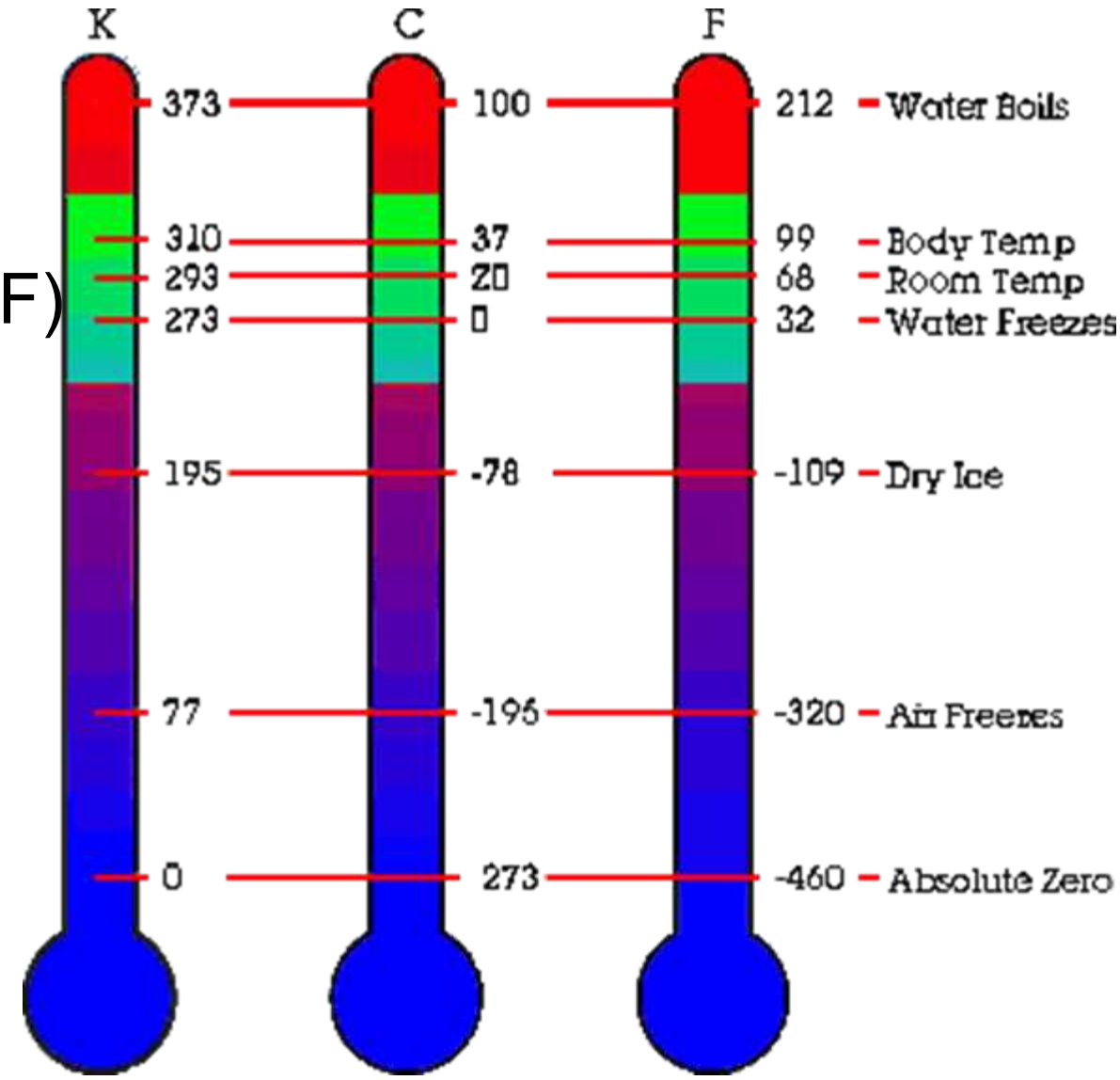
- "Movement of **Heat**"
- The study of heat and its transformation to mechanical energy.
- Applications
  - Refrigerators
  - Heat pumps
  - Insulation
  - Heat engines
  - Electric generators
  - Fireplace

Temperature

- Tells us how warm or cold an object is relative to some standard.
- A measure of the average **kinetic** energy of a substance.
- Temperature is measured using a **thermometer**.
  - How does a thermometer work?

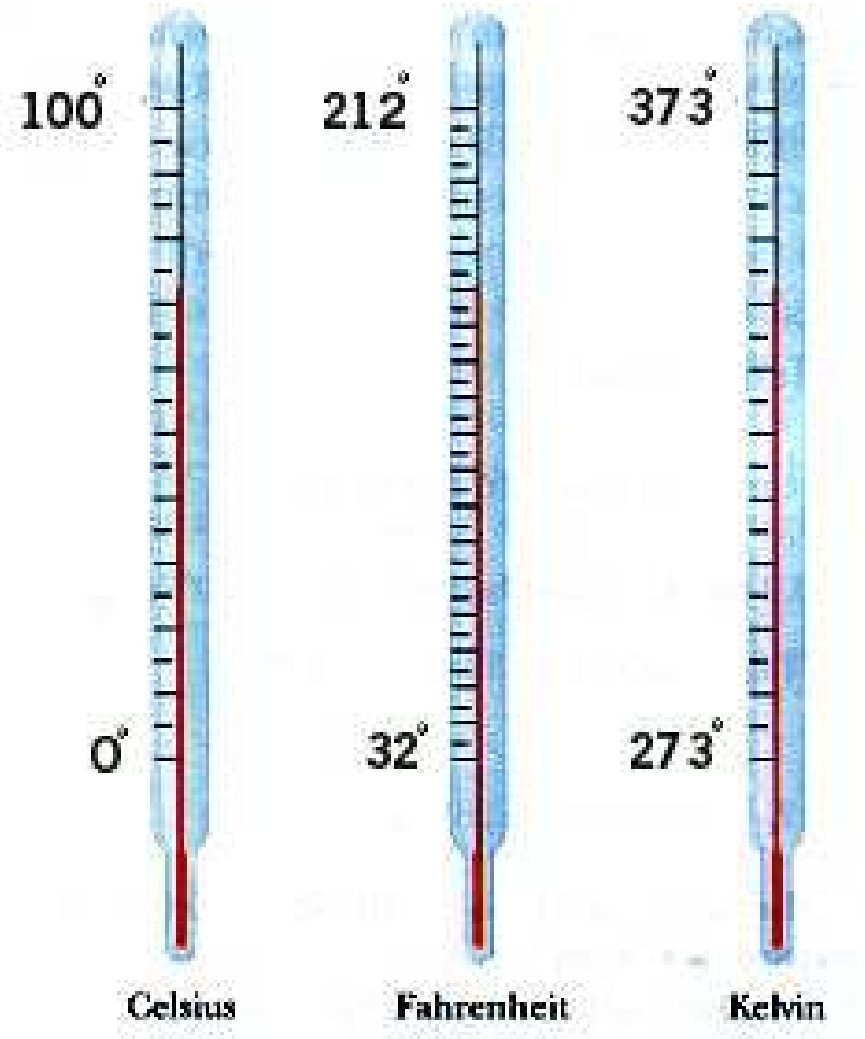
Temperature Scales

- Celsius (^{0}C)
- Fahrenheit (^{0}F)
- Kelvin (K)



Important Temperatures

- Absolute Zero
  - 0K
- -Freezing Point H_2O
  - 0^0C
  - 32^0F
- Boiling Point H_2O
  - 100^0C
  - 212^0F



What Causes Temperature?

- Kinetic-Molecular Theory
  - Matter made up of tiny particles that are always in **motion**.
  - As the particles gain energy, they move **faster**.
  - Faster moving particles have greater *average kinetic energy*.
  - The more kinetic energy particles have, the greater the temperature of the object or substance.