Chemistry of Matter

Properties and Interactions of Elements

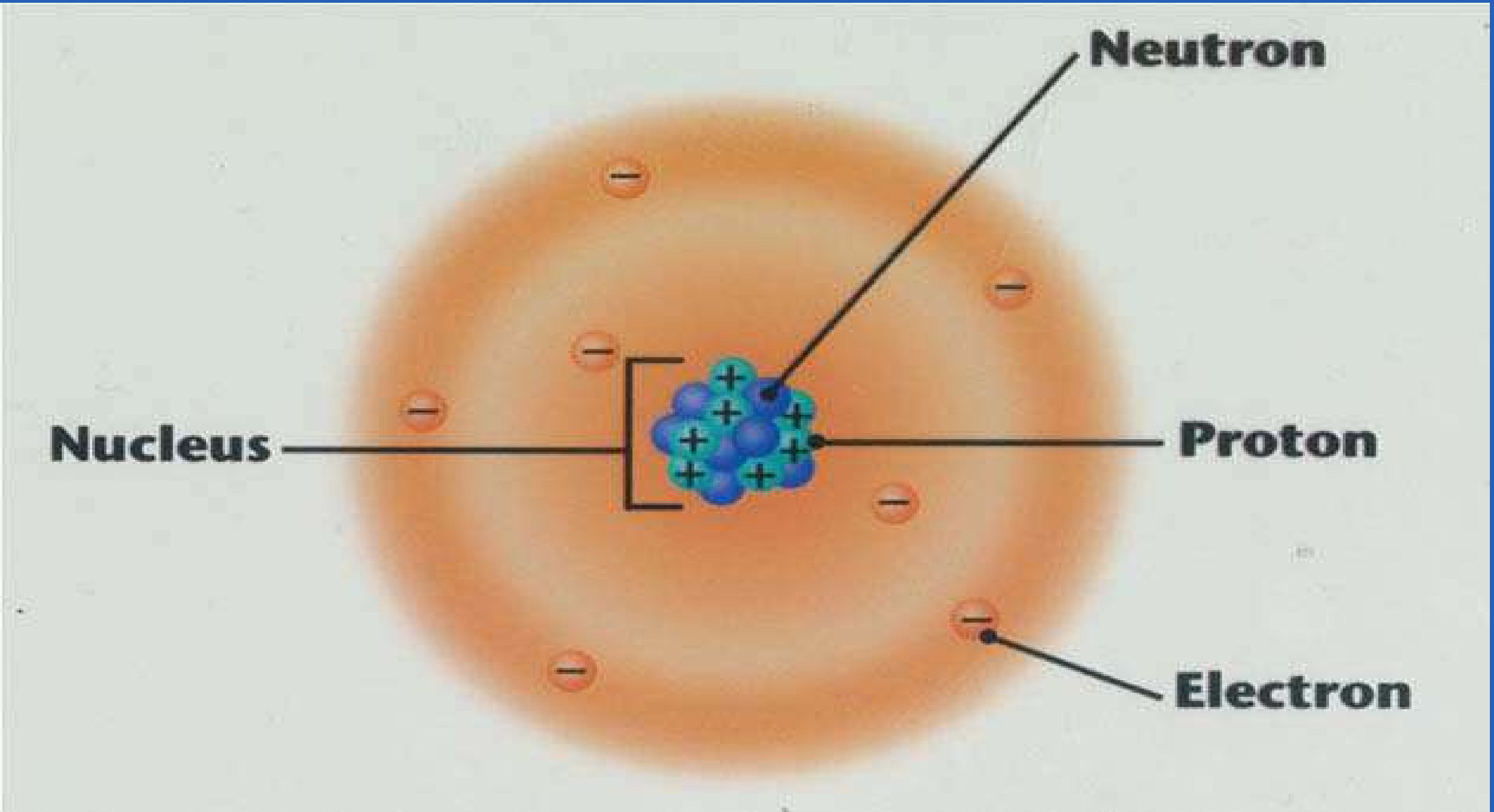
MS State Objectives 2.a. and 2.b.

Elements

- Elements are substances that cannot be broken down into simpler substances.
  - Made up of only one type of atom
  - Basic building blocks of matter
- The smallest particle of an element is an atom.

Review

- How many protons does this element have?
- How many electrons does this element have?
- What is the atomic mass?



- H
- W
- C of th

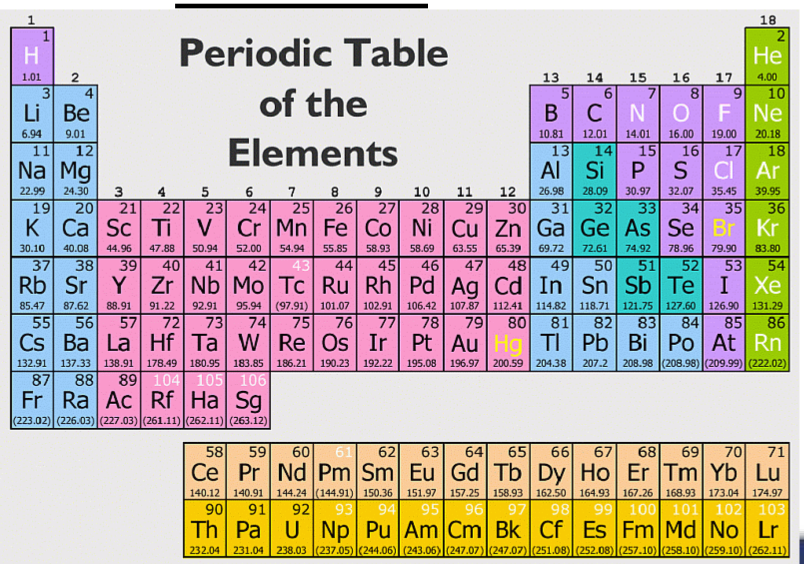
Developing the Periodic table

I	II	III	IV	V	VI	VII	VIII		
H 1.01									
Li 6.94	Be 9.01	B 10.8	C 12.0	N 14.0	O 16.0	F 19.0			
Na 23.0	Mg 24.3	Al 27.0	Si 28.1	P 31.0	S 32.1	Cl 35.5			
K 39.1	Ca 40.1		Ti 47.9	V 50.9	Cr 52.0	Mn 54.9	Fe 55.9	Co 58.9	Ni 58.7
Cu 63.5	Zn 65.4			As 74.9	Se 79.0	Br 79.9			
Rb 85.5	Sr 87.6	Y 88.9	Zr 91.2	Nb 92.9	Mo 95.9		Ru 101	Rh 103	Pd 106
Ag 108	Cd 112	In 115	Sn 119	Sb 122	Te 128	I 127			
Ce 133	Ba 137	La 139		Ta 181	W 184		Os 194	Ir 192	Pt 195
Au 197	Hg 201	Ti 204	Pb 207	Bi 209					
			Th 232		U 238				

- Dmitri Mendeleev, a Russian scientist discovered a set of patterns that seemed to apply to all elements
  - arranged the elements in order of increasing atomic mass (protons + neutrons in the nucleus)

Modern Periodic Table

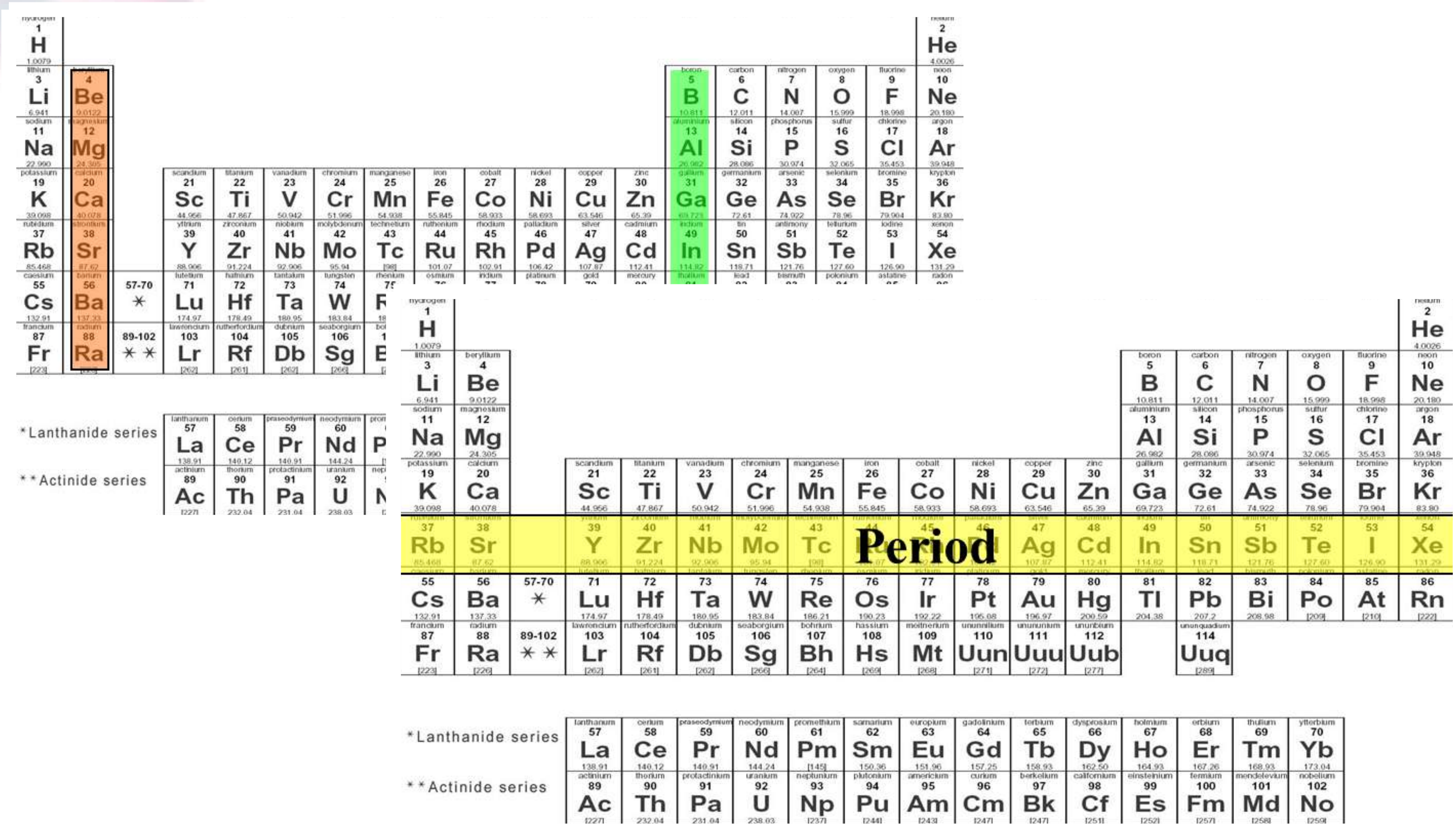
- In 1913, Henry <u>Moseley</u> discovered a way to measure the positive charge in the nucleus to determine the atomic number
  - arranged the elements by increasing <u>atomic number</u> instead of atomic mass



Periodic Table

- Arranged by increasing atomic number (proton #)
- Rows are called periods & are labeled 1-7
- There are 18 columns
  - Each column contains a group or family of elements.
  - Groups are elements that have similar physical or chemical properties.
    - Ex. All elements in group 1 are metals & react violently with water.

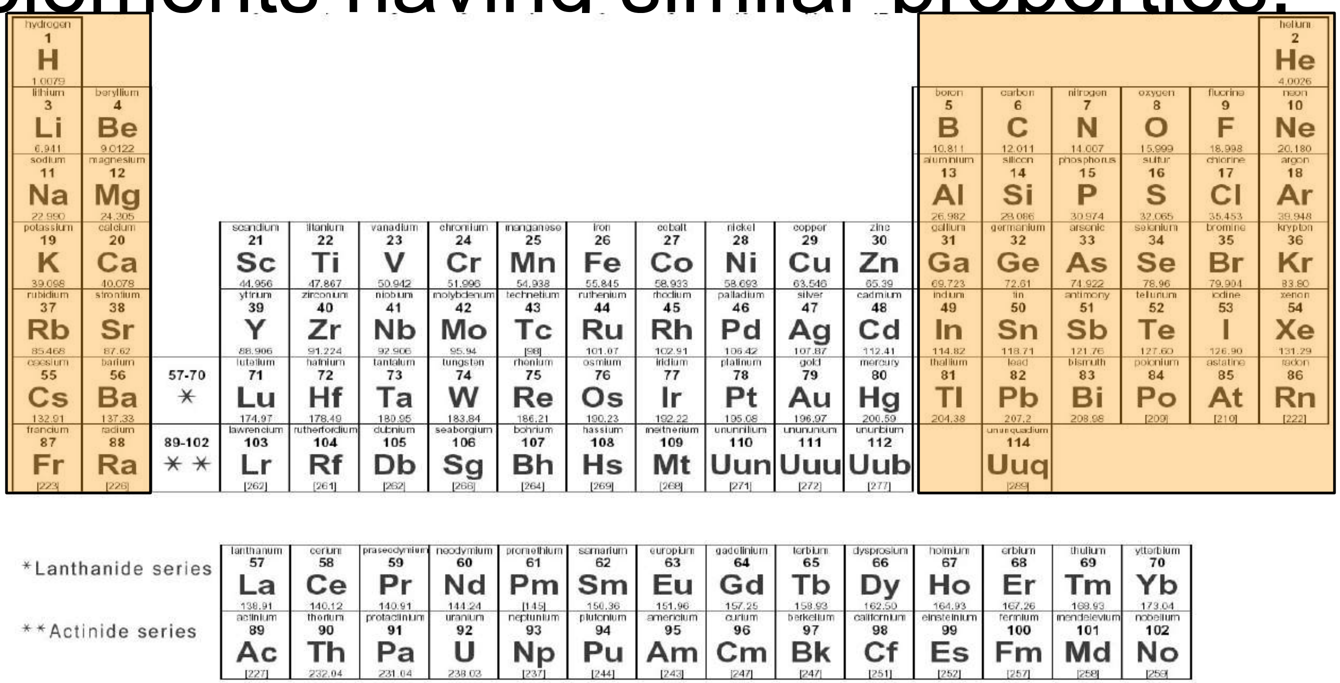
Groups and Periods



Groups/Families

- Groups 1 and 2 along with Groups 13 and 18 are called the <u>representative</u> elements.

  -elements having similar properties.



Groups/Families

- Groups 3 to 12 are called the <u>transition</u> metals.

hydrogen 1 H 1.0079																		helium 2 He 4.0026
lithium 3 Li 6.941	beryllium 4 Be 9.0122												boron 5 B 10.811	carbon 6 C 12.011	nitrogen 7 N 14.007	oxygen 8 O 15.999	fluorine 9 F 18.998	neon 10 Ne 20.180
sodium 11 Na 22.990	magnesium 12 Mg 24.305												aluminium 13 Al 26.982	silicon 14 Si 28.086	phosphorus 15 P 30.974	sulfur 16 S 32.065	chlorine 17 Cl 35.453	argon 18 Ar 39.948
potassium 19 K 39.098	calcium 20 Ca 40.078		scandium 21 Sc 44.956	titanium 22 Ti 47.867	vanadium 23 V 50.942	chromium 24 Cr 51.996	manganese 25 Mn 54.938	iron 26 Fe 55.845	cobalt 27 Co 58.933	nickel 28 Ni 58.693	copper 29 Cu 63.546	zinc 30 Zn 65.39	gallium 31 Ga 69.723	germanium 32 Ge 72.61	arsenic 33 As 74.922	selenium 34 Se 78.96	bromine 35 Br 79.904	krypton 36 Kr 83.80
rubidium 37 Rb 85.468	strontium 38 Sr 87.62		yttrium 39 Y 88.906	zirconium 40 Zr 91.224	niobium 41 Nb 92.906	molybdenum 42 Mo 95.94	technetium 43 Tc [98]	ruthenium 44 Ru 101.07	rhodium 45 Rh 102.91	palladium 46 Pd 106.42	silver 47 Ag 107.87	cadmium 48 Cd 112.41	indium 49 In 114.82	tin 50 Sn 118.71	antimony 51 Sb 121.76	tellurium 52 Te 127.60	iodine 53 I 126.90	xenon 54 Xe 131.29
caesium 55 Cs 132.91	barium 56 Ba 137.33	57-70 *	lutetium 71 Lu 174.97	hafnium 72 Hf 178.49	tantalum 73 Ta 180.95	tungsten 74 W 183.84	rhenium 75 Re 186.21	osmium 76 Os 190.23	iridium 77 Ir 192.22	platinum 78 Pt 195.08	gold 79 Au 196.97	mercury 80 Hg 200.59	thallium 81 Tl 204.38	lead 82 Pb 207.2	bismuth 83 Bi 208.98	polonium 84 Po [209]	astatine 85 At [210]	radon 86 Rn [222]
francium 87 Fr [223]	radium 88 Ra [226]	89-102 * *	lawrencium 103 Lr [illegible]	rutherfordium 104 Rf [illegible]	dubnium 105 Db [illegible]	seaborgium 106 Sg [illegible]	bohrium 107 Bh [illegible]	hassium 108 Hs [illegible]	meitnerium 109 Mt [illegible]	ununnilium 110 Uun [illegible]	unununium 111 Uuu [illegible]	ununbium 112 Uub [illegible]		ununquadium 114 Uuq [289]				

*Lanthanide series	lanthanum 57 La 138.91	cerium 58 Ce 140.12	praseodymium 59 Pr 140.91	neodymium 60 Nd 144.24	promethium 61 Pm [145]	samarium 62 Sm 150.36	europium 63 Eu 151.96	gadolinium 64 Gd 157.25	terbium 65 Tb 158.93	dysprosium 66 Dy 162.50	holmium 67 Ho 164.93	erbium 68 Er 167.26	thulium 69 Tm 168.93	ytterbium 70 Yb 173.04
**Actinide series	actinium 89 Ac [227]	thorium 90 Th 232.04	protactinium 91 Pa 231.04	uranium 92 U 238.03	neptunium 93 Np [237]	plutonium 94 Pu [244]	americium 95 Am [243]	curium 96 Cm [247]	berkelium 97 Bk [247]	californium 98 Cf [251]	einsteinium 99 Es [252]	fermium 100 Fm [257]	mendelevium 101 Md [258]	nobelium 102 No [259]

How Elements Interact

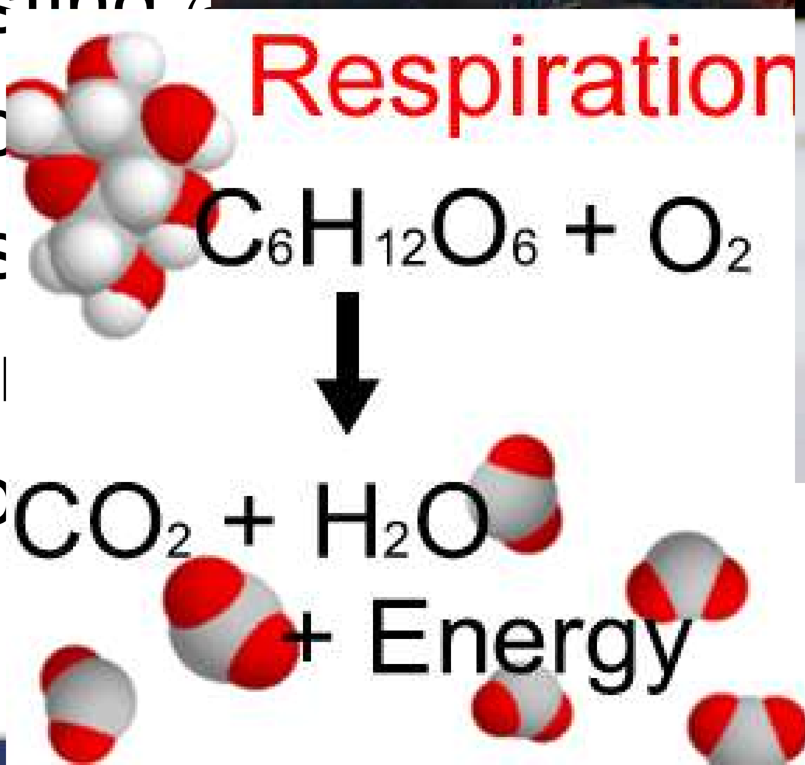
State Objective 2.a.

Physical vs. Chemical Change

- Physical change occurs when the physical properties are changed, such as size or shape.
  - Ex. Folding a piece of paper or a change in the state of matter: solid, liquid, gas
- Chemical change occurs when the chemical properties of the substance cause a change producing a new substance (the atoms have rearranged)

Examples of Chemical Reactions

- Food spoiling
- Combustion
- Rusting
- Pho
- Res
- Tar
- Foo



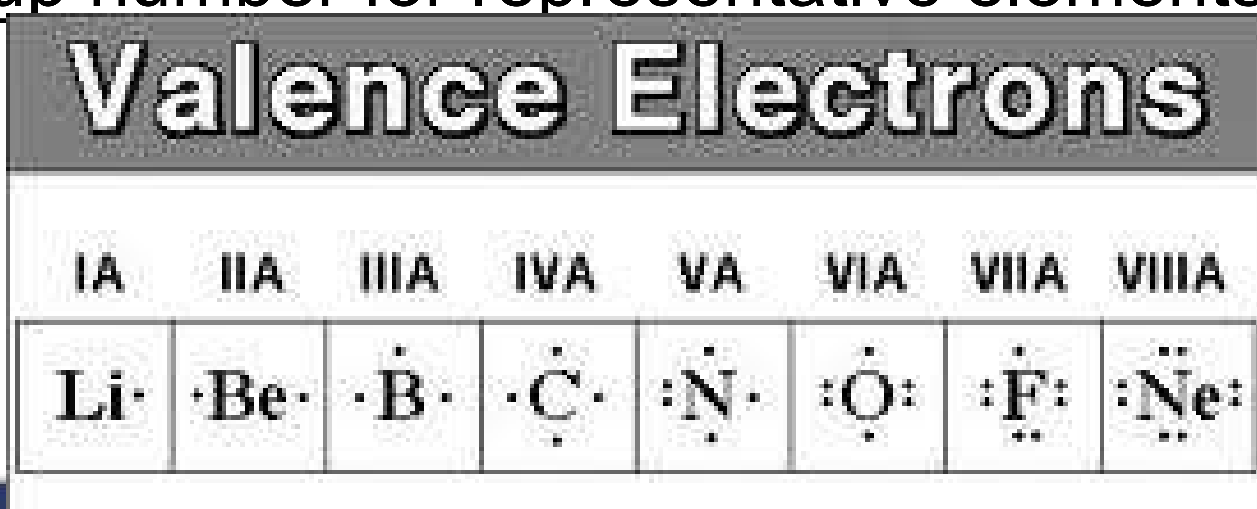
Interaction Between Elements:

If there are 110+ elements, how is it possible to have millions of different substances?

- Compounds are substances that form when two or more elements combine from a chemical change.
  - Ex. NaCl (Sodium Chloride)
  - The properties of compounds are different from the properties of the elements that make up the compound
- A molecule is the smallest particle of a substance with the same properties of that substance. Ex. H_2O (water)
  - Each molecule behaves like water, if the molecule is divided, Hydrogen and oxygen no longer behave like water

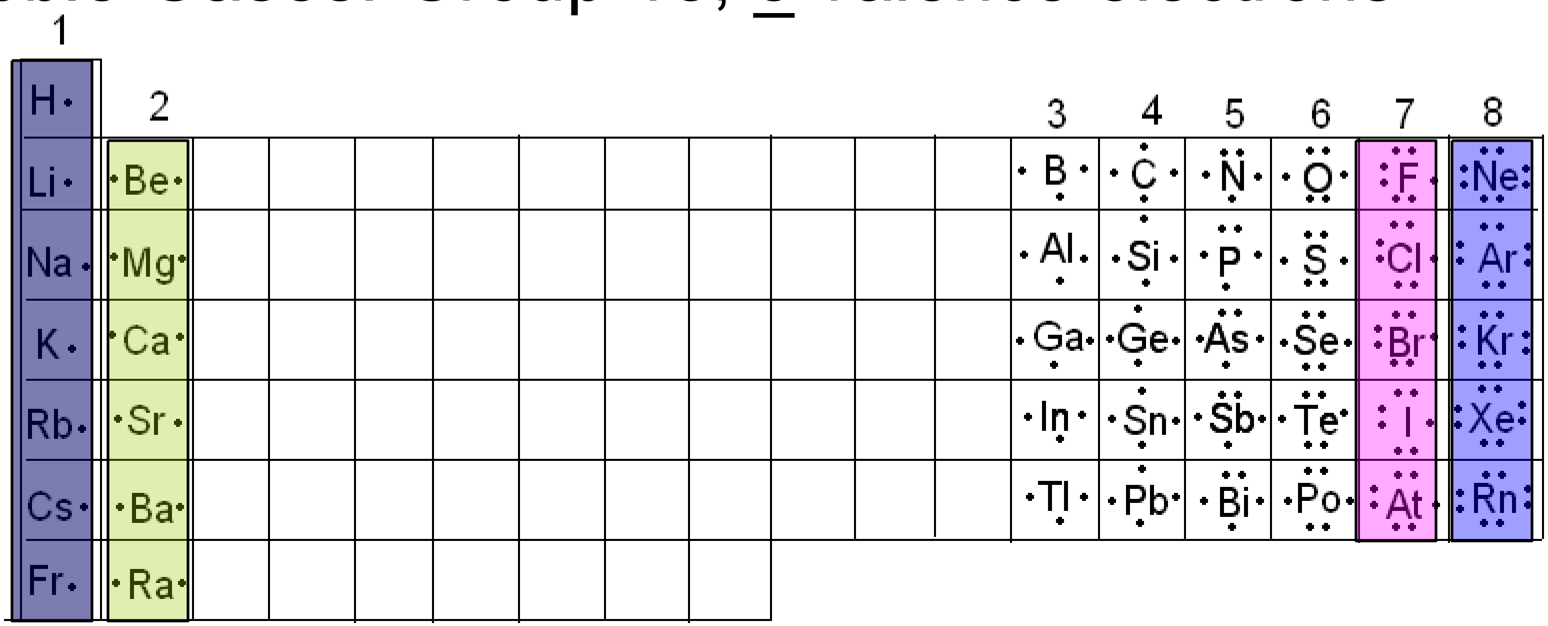
How do Elements Interact in Chemical Changes?

- Chemical properties of elements are determined by the number of electrons in the outer most energy level called valence electrons
  - Valence electron number is determined by the group number for representative elements



Element Families have similar chemical properties

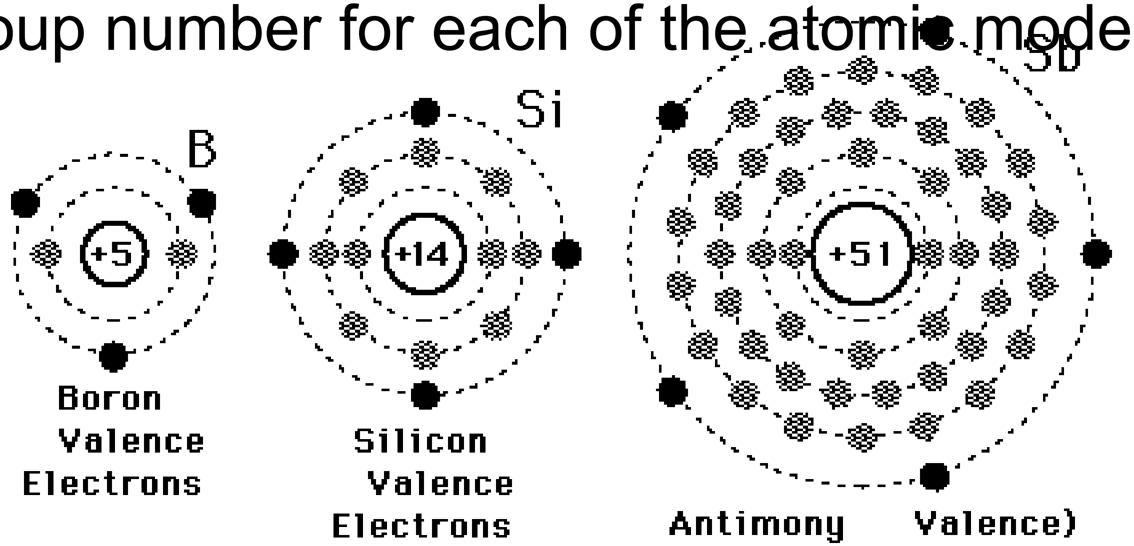
- Alkali Metals: Group 1; 1 valence electron
- Alkaline Earth Metals: Group 2; 2 valence electrons
- Halogens: Group 17; 7 valence electrons
- Noble Gases: Group 18; 8 valence electrons



Practice

Use the periodic table to answer the questions.

1. How many valence electrons does sodium have?
2. How many electrons are found in the electron cloud of an atom of chlorine?
3. What is the group number for each of the atomic models below?



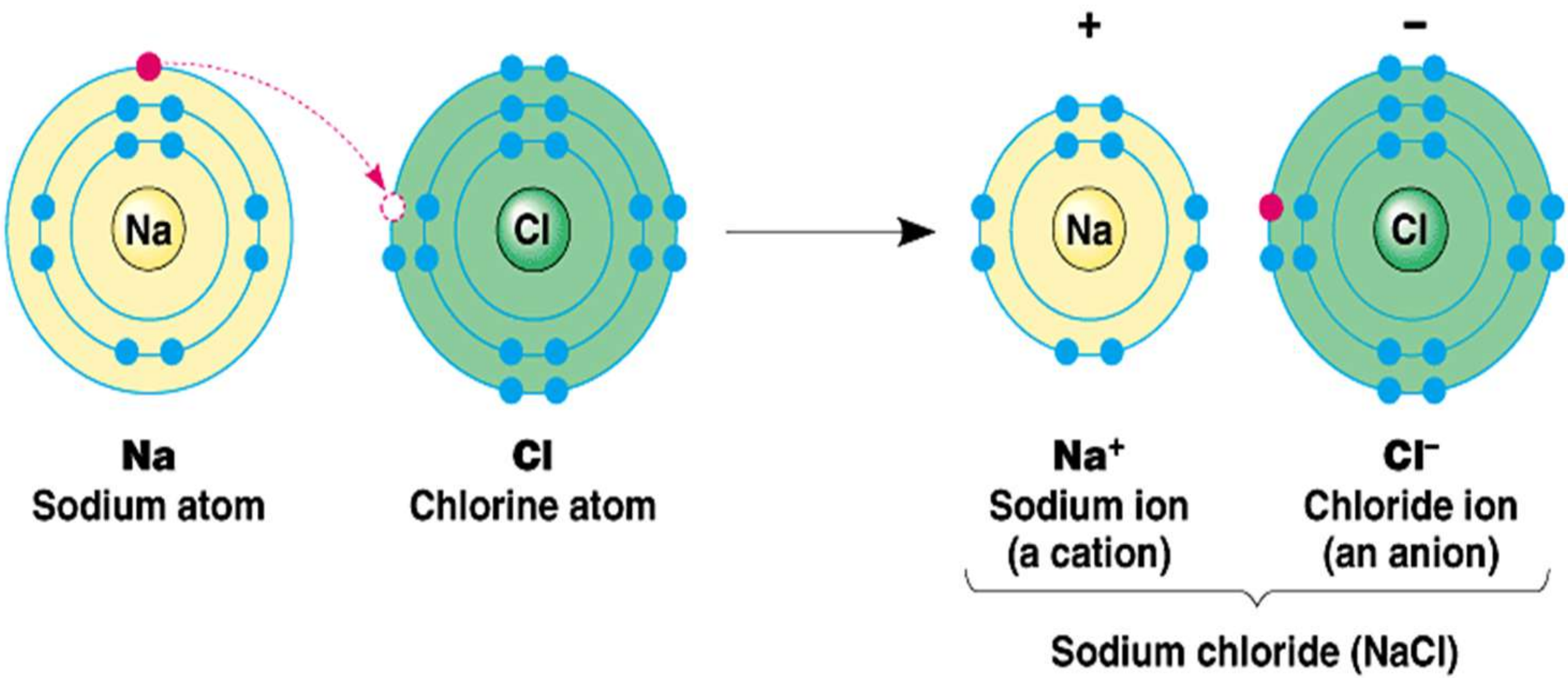
Chemical Bonds

- Elements bond to other elements to become stable by having a full valence shell.
  - Most elements need 8 valence electrons to become stable
- Elements will become stable by losing, gaining, or sharing valence electrons
  - Elements that lose electrons become positively charged ions.
  - Elements that gain electrons become negatively charged ions.
- Types of bonding:
  - Ionic
  - Covalent

Ionic Bonding

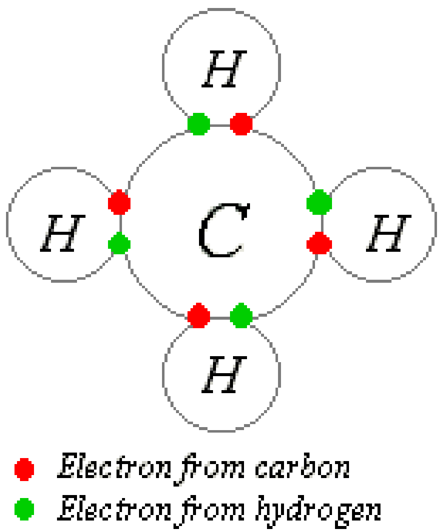
- Ionic bonding is when a strong attraction occurs between oppositely charged ions to hold them close together to become stable (like two magnets)
  - Ion: an atom that no longer has a neutral charge because it has lost or gained an electron
  - Typically between a metal & non-metal
  - Ex. $Na^{+}Cl^{-}$

Ionic Bonding

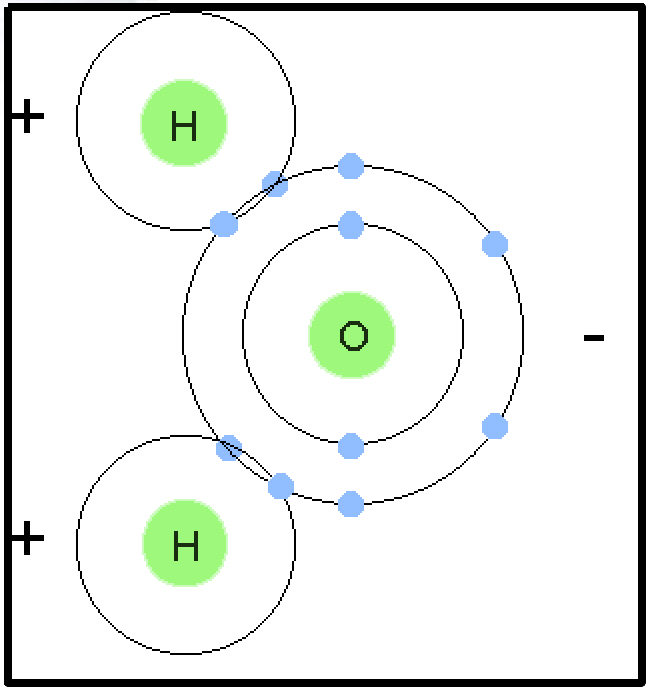


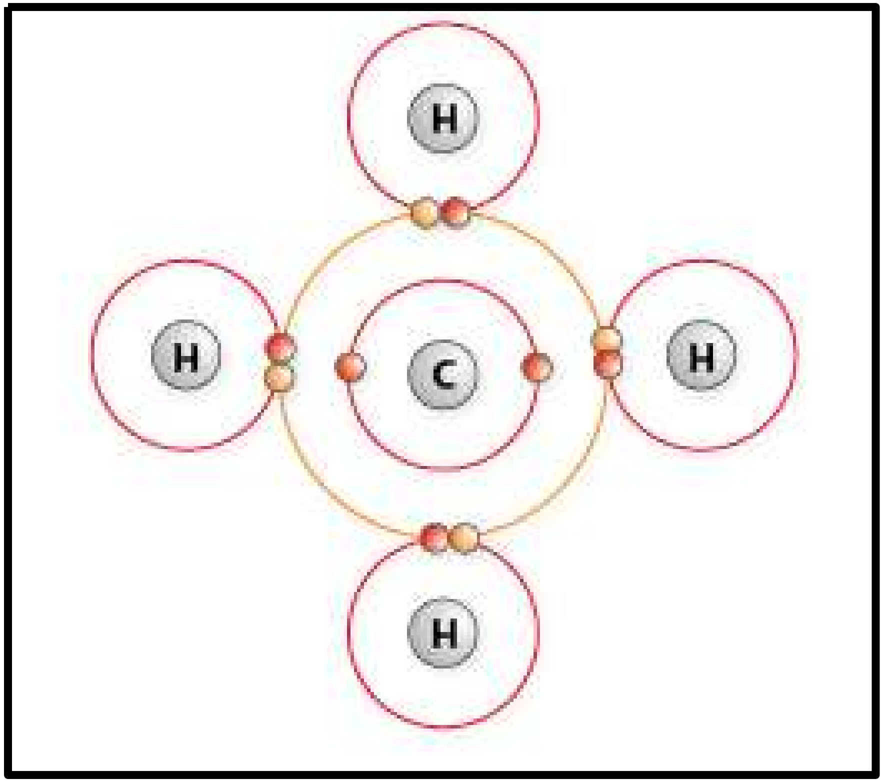
Covalent Bonding

- Covalent bonds are chemical bonds that form from atoms that share valence electrons to become stable
  - Occurs between two or more nonmetals
  - Ex. H_2 , Cl_2 , H_2O , $C_6H_{12}O_6$



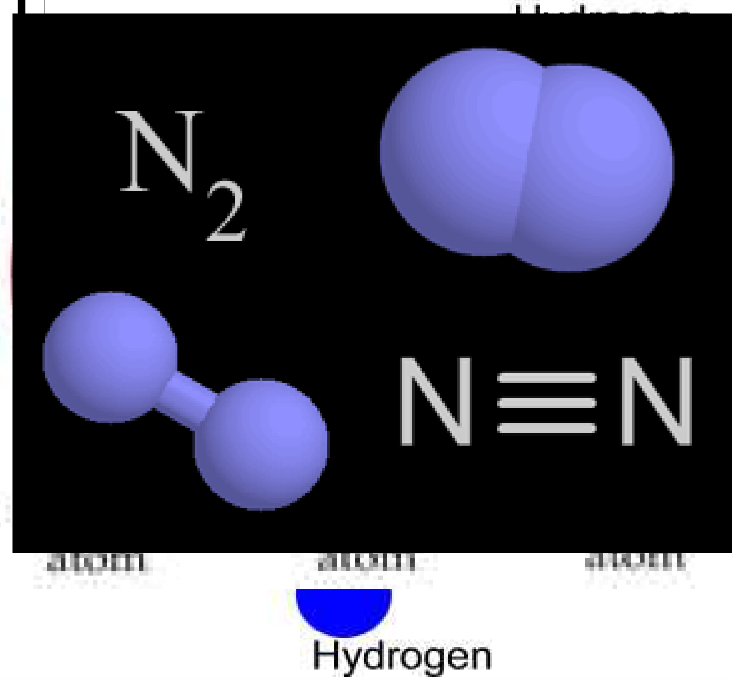
Covalent Bonding





Chemical Formulas

- Chemical formulas show a combination of chemical symbols & numbers that indicate which elements & how many atoms of each element are present in a compound
  - H_2O (Water)
  - $C_6H_{12}O_6$ (Sugar/glucose)
  - O_2 (Oxygen Molecule)
  - CO_2 (Carbon Dioxide)
  - N_2 (Nitrogen Molecule)



Subscript: # of atoms

Chemical Equations

- A process that produces a chemical change is called a chemical reaction.
  - Reactants are substances that exist before the reaction begins
  - Products are substances that form as a result of the reaction
- Chemical equations tell chemists the reactants, products, and proportions of each substance present in a reaction (like a recipe)
  - Ex. $2H_2 + O_2 \longrightarrow 2H_2O$

    Reactant ***Product***

Law of Conservation of Mass

- The Law of Conservation of Mass states that mass (matter) can neither be <u>created</u> nor <u>destroyed</u>.
  - Therefore, <u>atoms</u> are never lost or created during a chemical reaction.
- Chemical equations must be <u>balanced</u> in order to show the <u>same</u> number of atoms for each element on th[...]nt & product side of the equation.

Balancing an Equation

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

C=1		C=1
H=4	=	H=4
O=4		O=4

Chemistry of Matter

Forming Acids & Bases

State Correlation 2b

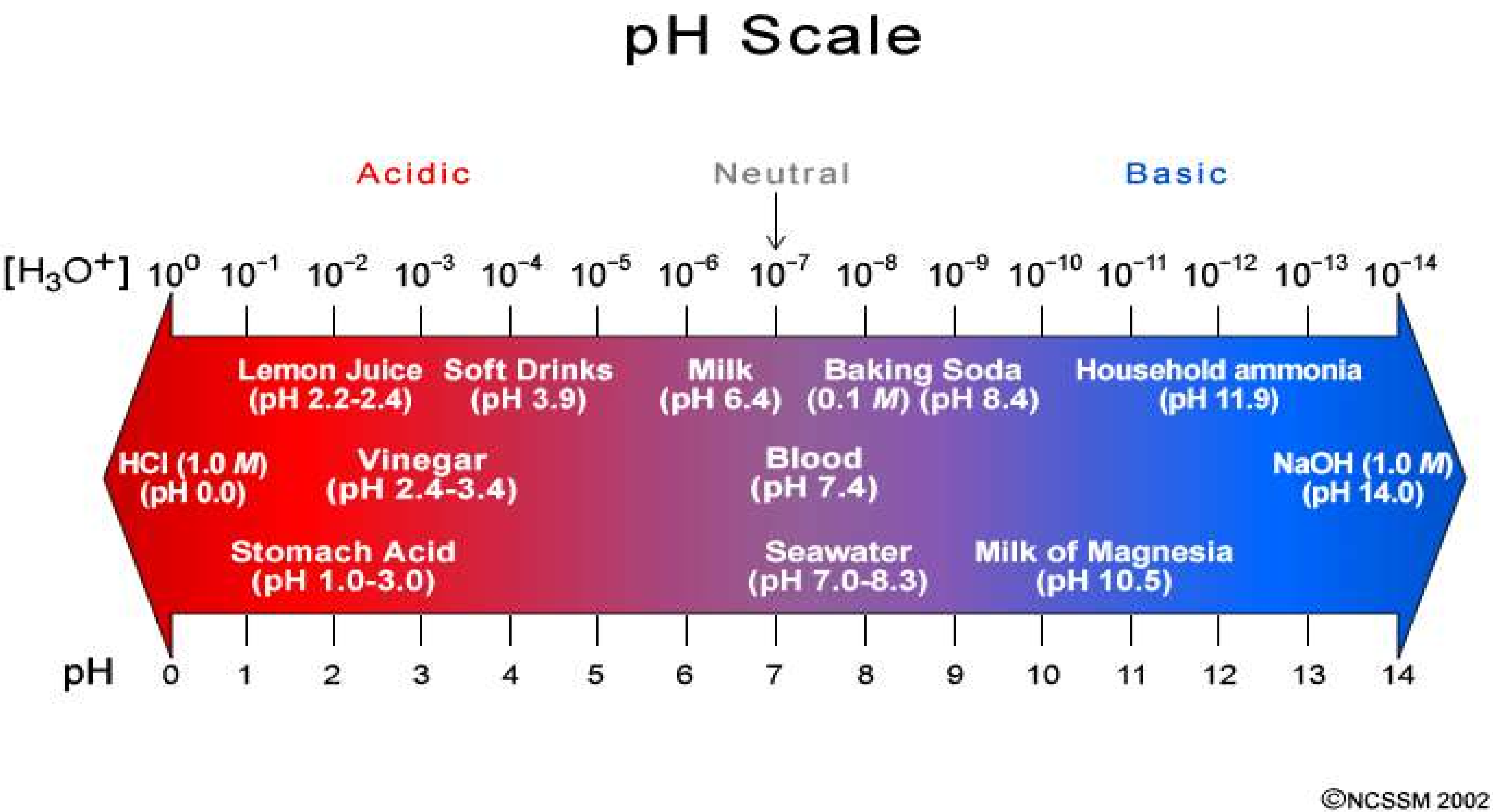
Properties of Acids & Bases

- An acid is a compound that produces hydrogen ions in water (H^+)
  - The greater the concentration of H ions produced, the stronger the acid
    - Tastes sour
    - Reacts with non-metals
    - Have a pH **<** 7
    - Turn blue litmus paper red
- Examples: HCl, H_2SO_4, HNO_3

Properties of Acids & Bases

- A base is any compound that produces hydroxide ions (OH^-) in water.
  - The greater the concentration of OH^- produced, the stronger the base.
    - Taste bitter & feels slippery
    - Reacts with metals
    - Have a pH **>** 7
    - Turn red litmus paper blue
- Examples: NH_3, NaOH, $NaHCO_3$

pH Scale



pH Scale
Acidic
Neutral
Basic
[H3O+] 10^0 10^-1 10^-2 10^-3 10^-4 10^-5 10^-6 10^-7 10^-8 10^-9 10^-10 10^-11 10^-12 10^-13 10^-14
Lemon Juice (pH 2.2-2.4)
Soft Drinks (pH 3.9)
Milk (pH 6.4)
Baking Soda (0.1 M) (pH 8.4)
Household ammonia (pH 11.9)
HCl (1.0 M) (pH 0.0)
Vinegar (pH 2.4-3.4)
Blood (pH 7.4)
NaOH (1.0 M) (pH 14.0)
Stomach Acid (pH 1.0-3.0)
Seawater (pH 7.0-8.3)
Milk of Magnesia (pH 10.5)
pH 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
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Predicting Acids & Bases using the Periodic Table

- Acids form when hydrogen chemically combines with certain nonmetals.
  - All halogens (group 17) form acids when combined with hydrogen
    - Ex. Fluorine & hydrogen (HF)

Predicting Acids & Bases using the Periodic Table

- Bases form when a hydroxide ion (OH^-) joins with a metal
- The metals in group 1 (alkali metals) and group 2 (alkaline earth metals) readily form bases with hydroxide ions
  - EX. KOH
  - EX. $Ca(OH)_2$

1	2
3 Li Lithium	4 Be Beryllium
11 Na Sodium	12 Mg Magnesium
19 K Potassium	20 Ca Calcium
37 Rb Rubidium	38 Sr Strontium
55 Cs Cesium	56 Ba Barium
87 Fr Francium	88 Ra Radium