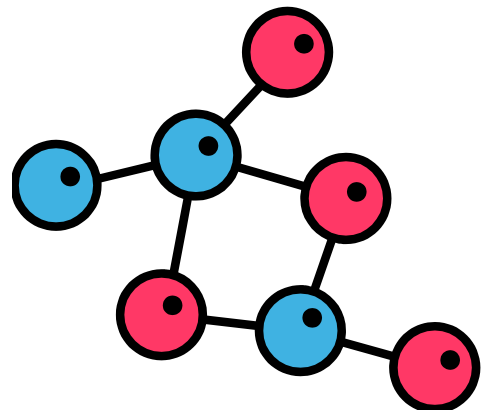
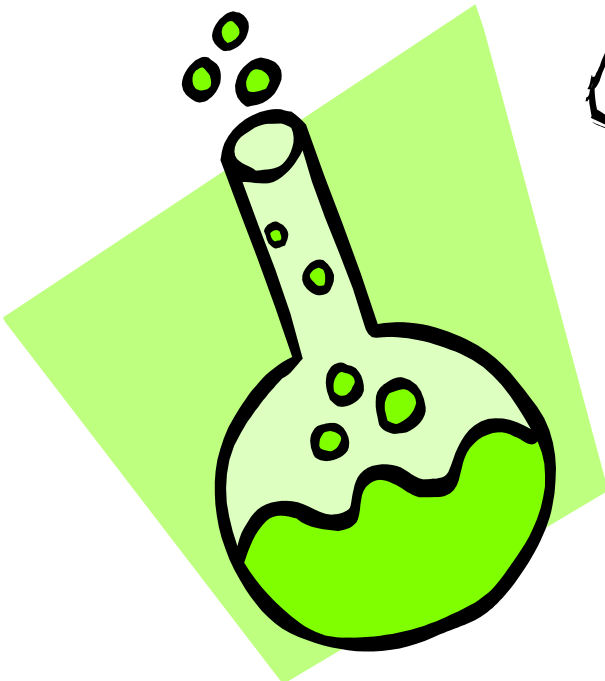
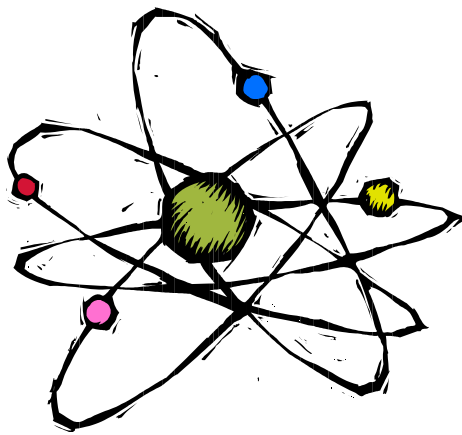


Materials Science



Chemistry Intro

What is chemistry?

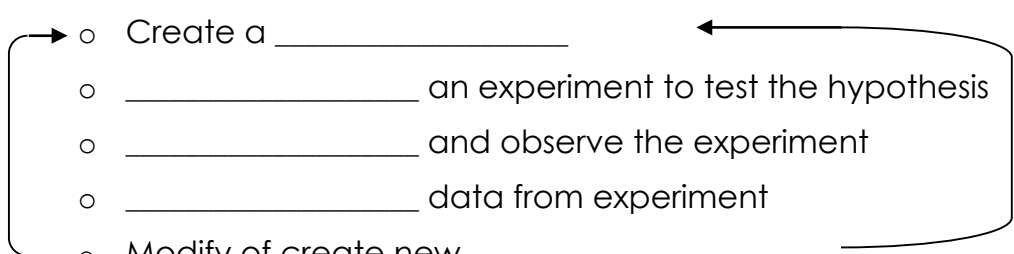
- Chemistry is the study of the composition and properties of _____.
- Matter has two general properties; it occupies _____ and has _____.

Why study chemistry?

- Chemistry can help to explain how things work.
- Chemistry may help you in your future career. Even if you are not planning on being a chemist, many jobs require a basic understanding of chemistry.
- Chemistry can help you to be an informed citizen. Knowledge of chemistry can help you to evaluate data, arrive at an informed opinion and take appropriate action.

Boat Challenge Assignment

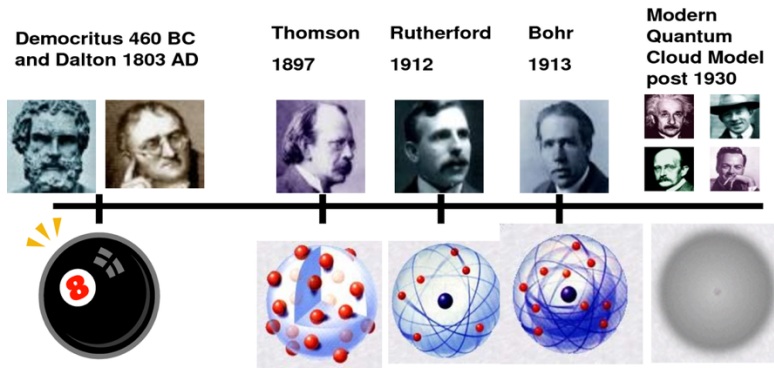
The Scientific Method:

- Scientific method is the process that scientists follow in order to perform _____ to investigate the world around them.
 - The scientific method:
 - Gather information through _____
 - Define the _____
 - Create a _____
 - _____ an experiment to test the hypothesis
 - _____ and observe the experiment
 - _____ data from experiment
 - Modify or create new _____
- 

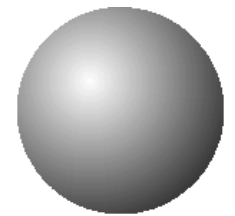
Boat Challenge Assignment

Model of the Atom

<http://thehistoryoftheatom.weebly.com/>

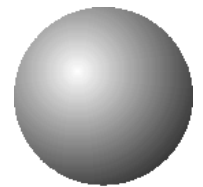


Lived from: 460-370 BC
Put forward atomic model in: 442 BC
Description of his model:



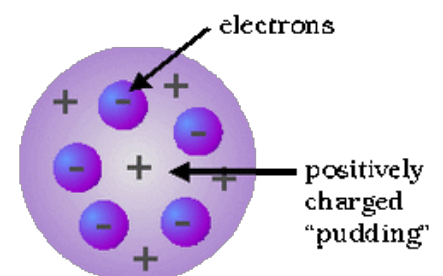
**Democritus
(400 B.C.)**

Lived from: 1766-1844
Put forward atomic model in: 1803
Nickname for his model: _____ Model
Description of his model:



**Dalton
1803-1805**

J.J. _____
Lived from: December 18, 1856 - August 30, 1940.
Put forward atomic model in: 1904
Nickname for his model: _____
 Model (or Raisin Bread Model)
Description of his model:



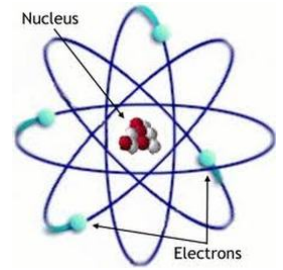
LORD ERNEST _____

Lived from: 1871- 1937

Put forward atomic model in: 1911

Nickname for his model: _____ Model

Description of his model:



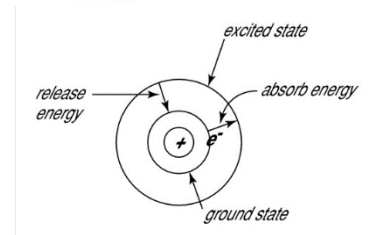
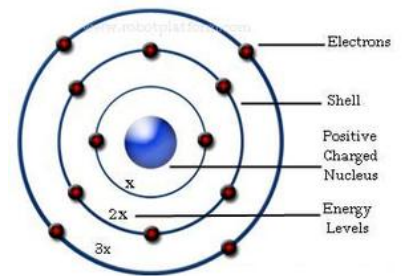
NIELS _____

Lived from: 1885 to 1962

Put forward atomic model in: 1913

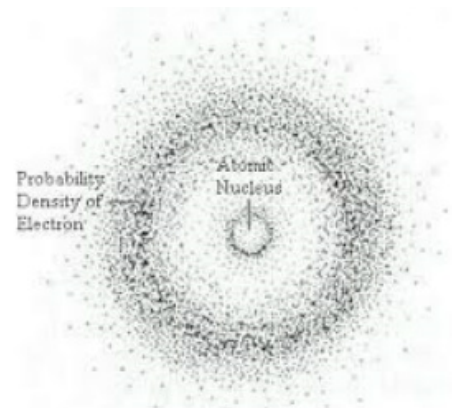
Nickname for his model: _____ Model

Description of his model:



MODERN THEORY: QUANTUM MECHANICAL MODEL

Description of this model:



Erwin _____

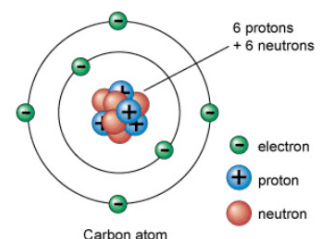
Date: 1926

Quick summary

JAMES _____

Date: 1932

Quick Summary:



See History of the atom & periodic table assignment (Q1 & 2)

About the Periodic Table

What is the periodic table?

- A way to organize _____
- Contains all elements ever discovered or _____

Development of the Periodic Table:

- The periodic table was developed by _____ (Russian Chemist). He recognized trends in properties of elements when organized by _____.
- He used these _____ to organize the periodic table.
- He was then able to use the periodic table to _____ the properties of elements that had not yet been discovered or created.

How is the periodic table organized?

- The periodic table is organized by increasing _____ number.
- It is organized into families and periods. _____ are the horizontal rows of the periodic table, and _____ (or groups) are the vertical rows of the periodic table. Most elements in a family have similar _____.

Label the periodic table

Periods and Groups & diatomic elements (elements found in pairs in nature):

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																aluminum 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			
cesium 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 [260]		rutherfordium 104 Rf [261]		dubnium 105 Db [262]		seaborgium 106 Sg [266]		bohrium 107 Bh [264]		hassium 108 Hs [269]		meitnerium 109 Mt [268]		unnilium 110 Uun [271]		ununium 111 Uuu [272]		unbiunium 112 Uub [277]		unbiquadium 114 Uuq [289]											

Metals, Non Metals Metalloids:

Hydrogen 1 1.00794																	Helium 2 4.002602		
Lithium 3 6.941	Boron 5 10.811													Carbon 6 12.011	Nitrogen 7 14.007	Oxygen 8 15.999	Fluorine 9 18.998	Neon 10 20.180	
Sodium 11 22.990	Magnesium 12 24.305													Aluminum 13 26.982	Silicon 14 28.086	Phosphorus 15 30.974	Sulfur 16 32.06	Chlorine 17 35.453	Argon 18 39.948
Potassium 19 39.098	Calcium 20 40.078	Scandium 21 44.956	Titanium 22 47.887	Vanadium 23 50.942	Chromium 24 51.996	Manganese 25 54.938	Iron 26 55.845	Cobalt 27 58.933	Nickel 28 58.693	Copper 29 63.546	Zinc 30 65.38	Gallium 31 69.723	Germanium 32 72.63	Arsenic 33 74.922	Selenium 34 78.96	Bromine 35 79.904	Krypton 36 83.80		
Rubidium 37 85.468	Sr 87.62	Yttrium 39 88.906	Zirconium 40 91.224	Niobium 41 92.906	Molybdenum 42 95.94	Technetium 43 98	Ruthenium 44 101.07	Rhodium 45 102.91	Palladium 46 106.42	Silver 47 107.87	Cadmium 48 112.41	Indium 49 114.82	Tin 50 118.71	Antimony 51 121.76	Tellurium 52 127.6	Iodine 53 126.905	Xenon 54 131.29		
Cesium 55 132.91	Ba 137.33	* 57-70	Lanthanum 57 138.91	Hafnium 72 178.49	Ta 180.95	W 183.84	Re 186.21	Os 190.23	Ir 192.22	Pt 195.08	Au 196.97	Hg 200.59	Tl 204.38	Pb 207.2	Bi 208.98	Po 209	At 210	Rn 222	
Francium 87 223	Ra 226	* 89-102	Lr 261	Rf 261	Db 262	Sg 266	Hs 277	Mt 273	Uun	Uuu	Uub							Uuq	

* Lanthanide series

** Actinide series

Lanthanide series	57	58	59	60	61	62	63	64	65	66	67	68	69	70
	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb
	138.91	140.12	140.91	144.24	144.91	150.36	151.96	157.25	158.93	162.50	164.93	167.26	168.93	173.05
Actinide series	89	90	91	92	93	94	95	96	97	98	99	100	101	102
	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No
	227	232.04	231.04	238.03	237	244	243	247	247	251	252	257	259	289

Solids Liquids and Gases (@ room temp):

hydrogen 1																		helium 2																	
1 H																		2 He																	
lithium 3																		beryllium 4																	
3 Li																		4 Be																	
boron 5																		carbon 6																	
5 B																		6 C																	
nitrogen 7																		oxygen 8																	
7 N																		8 O																	
fluorine 9																		neon 10																	
9 F																		10 Ne																	
sodium 11																		magnesium 12																	
11 Na																		12 Mg																	
aluminum 13																		silicon 14																	
13 Al																		14 Si																	
phosphorus 15																		sulfur 16																	
15 P																		16 S																	
chlorine 17																		argon 18																	
17 Cl																		18 Ar																	
potassium 19																		calcium 20																	
19 K																		20 Ca																	
scandium 21																		titanium 22																	
21 Sc																		22 Ti																	
vanadium 23																		chromium 24																	
23 V																		24 Cr																	
manganese 25																		iron 26																	
25 Mn																		26 Fe																	
cobalt 27																		nickel 28																	
27 Co																		28 Ni																	
copper 29																		zinc 30																	
29 Cu																		30 Zn																	
gallium 31																		germanium 32																	
31 Ga																		32 Ge																	
arsenic 33																		selenium 34																	
33 As																		34 Se																	
bromine 35																		krypton 36																	
35 Br																		36 Kr																	
rubidium 37																		strontium 38																	
37 Rb																		38 Sr																	
yttrium 39																		zirconium 40																	
39 Y																		40 Zr																	
niobium 41																		molybdenum 42																	
41 Nb																		42 Mo																	
technetium 43																		ruthenium 44																	
43 Tc																		44 Ru																	
rhodium 45																		palladium 46																	
45 Rh																		46 Pd																	
silver 47																		cadmium 48																	
47 Ag																		48 Cd																	
indium 49																		tin 50																	
49 In																		50 Sn																	
antimony 51																		tellurium 52																	
51 Sb																		52 Te																	
bismuth 53																		polonium 54																	
53 Bi																		54 Po																	
thallium 55																		lead 56																	
55 Tl																		56 Pb																	
thallium 57																		lead 58																	
57 Cs																		58 Ba																	
lanthanum 59																		cerium 60																	
59 La																		60 Ce																	
praseodymium 61																		neodymium 62																	
61 Pr																		62 Nd																	
promethium 63																		samarium 64																	
63 Pm																		64 Sm																	
europium 65																		gadolinium 66																	
65 Eu																		66 Gd																	
terbium 67																		dysprosium 68																	
67 Tb																		68 Dy																	
holmium 69																		erbium 70																	
69 Ho																		70 Er																	
thulium 71																		ytterbium 72																	
71 Tm																		72 Yb																	
lutetium 73																		hafnium 74																	
73 Lu																		74 Hf																	
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75 Ta																		76 W																	
rhenium 77																		osmium 78																	
77 Re																		78 Os																	
iridium 79																		platinum 80																	
79 Ir																		80 Pt																	
gold 81																		mercury 82																	
81 Au																		82 Hg																	
thallium 83																		lead 84																	
83 Tl																		84 Pb																	
bismuth 85																		polonium 86																	
85 Bi																		86 Po																	
thallium 87																		lead 88																	
87 Cs																		88 Ba																	
lanthanum 89																		cerium 90																	
89 La																		90 Ce																	
praseodymium 91																		neodymium 92																	
91 Pr																		92 Nd																	
promethium 93																		samarium 94																	
93 Pm																		94 Sm																	
europium 95																		gadolinium 96																	
95 Eu																		96 Gd																	
terbium 97																		dysprosium 98																	
97 Tb																		98 Dy																	
holmium 99																		erbium 100																	
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lutetium 103																		hafnium 104																	
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iridium 109																		platinum 110																	
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113 Tl																		114 Pb																	
bismuth 115																		polonium 116																	
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thallium 117																		lead 118																	
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tennessine 119																		darmstadtium 120																	
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bohrium 121																		hassium 122																	
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133 Rg																		134 Cn																	
darmstadtium 135																		tennessine 136																	
135 Ds																		136 Ts																	
bohrium 137																		hassium 138																	
137 Bh																		138 Hs																	
meitnerium 139																		darmstadtium 140																	
139 Mt																		140 Ds																	
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roentgenium 237																		copernicium 238																	
237 Rg																		238 Cn																	
darmstadtium 239																		tennessine 240																	
239 Ds																		240 Ts																	
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darmstadtium 247																		tennessine 248																	
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meitnerium 251																		darmstadtium 252																	
251 Mt																		252 Ds																	
roentgenium 253																		copernicium 254																	
253 Rg																		254 Cn																	
darmstadtium 255																		tennessine 256																	
255 Ds																		256 Ts																	
bohrium 257																		hassium 258																	
257 Bh																		258 Hs																	
meitnerium 259																		darmstadtium 260																	
259 Mt																		260 Ds																	
roentgenium 261																		copernicium 262																	
261 Rg																		262 Cn																	
darmstadtium 263																		tennessine 264																	
263 Ds																		264 Ts																	
bohrium 265																		hassium 266																	
265 Bh																		266 Hs																	
meitnerium 267																		darmstadtium 268																	
267 Mt																		268 Ds																	
roentgenium 269																		copernicium 270																	
269 Rg																		270 Cn																	
darmstadtium 271																		tennessine 272																	
271 Ds																		272 Ts																	
bohrium 273																		hassium 274																	
273 Bh																		274 Hs																	
meitnerium 275																		darmstadtium 276																	
275 Mt																		276 Ds																	
roentgenium 277																		copernicium 278																	
277 Rg																		278 Cn																	
darmstadtium 279																		tennessine 280																	
279 Ds																		280 Ts																	
bohrium 281																		hassium 282																	
281 Bh																		282 Hs																	
meitnerium 283																		darmstadtium 284																	
283 Mt																		284 Ds																	
roentgenium 285																		copernicium 286																	
285 Rg																		286 Cn																	
darmstadtium 287																		tennessine 288																	
287 Ds																		288 Ts																	
bohrium 289																		hassium 290																	
289 Bh																		290 Hs																	
meitnerium 291																		darmstadtium 292																	
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darmstadtium 295																		tennessine 296																	
295 Ds																		296 Ts																	
bohrium 297																		hassium 298																	
297 Bh																		298 Hs																	
meitnerium 299																		darmstadtium 300																	
299 Mt																		300 Ds																	
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301 Rg																		302 Cn																	
darmstadtium 303																		tennessine 304																	
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315 Mt																		316 Ds																	
roentgenium 317																		copernicium 318																	
317 Rg																		318 Cn																	
darmstadtium 319																		tennessine 320																	
319 Ds																		320 Ts																	
bohrium 321																		hassium 322																	
321 Bh																		322 Hs																	
meitnerium 323																		darmstadtium 324																	
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roentgenium 325																		copernicium 326																	
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meitnerium 339																		darmstadtium 340																	
339 Mt																		340 Ds																	
roentgenium 341																		copernicium 342																	
341 Rg																		342 Cn																	
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345 Bh																		346 Hs																	
meitnerium 347																		darmstadtium 348																	
347 Mt																		348 Ds																	
roentgenium 349																		copernicium 350																	
349 Rg																		350 Cn																	
darmstadtium 351																		tennessine 352																	
351 Ds																		352 Ts																	
bohrium 353																		hassium 354																	
353 Bh																		354 Hs																	
meitnerium 355																		darmstadtium 356																	

* Lanthanide series

** Actinide series

Lanthanide series	57	58	59	60	61	62	63	64	65	66	67	68	69	70
	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb
	138.91	140.12	140.91	144.24	144.91	150.36	151.96	157.25	158.93	162.50	164.93	167.26	168.93	173.05
Actinide series	89	90	91	92	93	94	95	96	97	98	99	100	101	102
	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No
	227	232.04	231.04	238.03	237	244	243	247	247	251	252	257	259	289

Valence Electrons

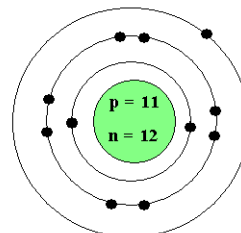
What are they?

- Valence electrons are those that are in the _____ electron shell (valence shell) of an atom. The valence shells are the outermost s and p orbitals. The outermost s and p orbitals are the highest _____ orbitals of an atom.
- Valence electrons determine how an element _____ with other elements.
 - The _____ valence electrons an atom has, the less stable it is and the more likely it is to react.
 - The _____ valence electrons an atom has, the more stable it is and the less likely it is to react. Something that is unlikely to react is called _____.

Octet Rule:

- The most valence electrons an atom can have is 8, because that is a full valence (2 electrons in the s orbital, 6 electrons in the p orbital). All atoms would like to have 8 valence electrons because then they are stable. This is called the _____ rule (or the rule of 8).
 - Exceptions:
 - Hydrogen and helium can only have 2 electrons in their valence shell (1s).
 - _____ metals (+ a few others) are also exceptions because orbitals can hybridize. We will not be learning about hybridized orbitals in this course.

NOTE: 8 valence electrons and 0 valence electrons both make for stable atoms because with 0 valence electrons, they essentially do have 8 because the next valence shell below the one that was emptied is full...



Easy Way to Determine Number of Valence Electrons:

- Group 1 has ____ valence electron, group 2 has ____ valence electrons, groups 3 to 12 are transition metals so we don't need to determine the number of valence electrons they have, group 13 has ____ valence electrons, group 14 has ____ valence electrons, group 15 has ____ electrons, group 16 has ____ electrons, group 17 has ____ electrons, group 18 has ____ electrons.

Lewis dot diagrams

- Electron-dot formula* method or _____ *Formula* method is used to represent the number of _____ in the valence shell.
 - The core is represented by the _____ for the element; valence electrons are represented by _____.
 - The symbol is assumed to have _____ sides and the valence electrons are distributed around the sides.
 - When we distribute valence electrons, we first place _____ dot on each of the four sides before we locate _____ of electrons on any one side. Usually no more than _____ electrons can be placed on any one side.

Examples:

calcium

selenium

bromine

Finish Assign 1 & Valence Electrons, Ions & Lewis dot Assignment (columns 1 & 4)

Intramolecular Forces

- Intra" is latin for "_____".
- Intramolecular forces are forces **within** a molecule or compound holding it _____.
- Atoms want to have a _____ valence shell, because then they will be stable. Atoms can fill or empty their valence shell by sharing, gaining or losing _____.
- There are three types of intramolecular forces we will discuss: metallic bonding, _____ bonding and covalent bonding.

1. Metallic Bonds

Formation of metallic bonds

- Metals are made up of _____ with loosely held valence electrons.
- The valence electrons of a pure metal can be modeled as a "_____" of electrons.
- The electrons are able to _____ freely from one part of the metal to another.
- Metallic bonds are the forces of attraction between free floating valence electrons and the positively charged metal ions.

Properties of Metals:

- The “sea of electrons” can help to explain the properties of metals.
- Good conductors of electricity
 - because charges (electrons) can _____ in the metal.
- Metals are ductile (can be drawn into wires) and malleable (bendable/moldable)
 - because the metal cations are surrounded by electrons (“sea”) so when force is applied, the electrons act as a _____ or insulator preventing the positively charged ions from getting too close. This means protons will not repel to cause breaking but rather move and glide _____ one another allowing the metal to _____.
- Metals form crystalline structures
 - because they are made of _____ which naturally like to have a close packed arrangement (similar to how fruit stacks at the grocery store).

Alloys

- Alloys are a mixture of two or more _____ where at least one of those elements is a _____.
- Alloys often have _____ properties than the metals that make them up
- Ex. Sterling silver (92.5% silver and 7.5% copper) is _____ and _____ than pure silver, but still soft enough to make jewelry or silverware.
- Steels are important alloys with a wide range of useful properties such as _____.

2. Ionic Bonding

- One way an atom will _____ it's valence shell is through ionic bonding (creating ions)
- Ionic bonding occurs when a _____ bonds with a _____
- Ionic bonding occurs when there is a complete _____ of one or more electrons from one atom to another.
- You can predict the _____ of the ion created through ionic bonding based on the number of valence electrons it contains. (**remember electrons are negatively charged**)

Element	Number of Valence e-	e- gain/lose to fill octet	Charge with full valence
Oxygen			
Sodium			
Hydrogen			

Formation of Ions:

- When an atom loses or gains electrons it forms an _____ (this is ionic bonding).
- An ion is an atom or group of atoms with an overall _____.
- Usually atoms on the left of the staircase (metals) _____ electrons, forming _____ with a _____ charge.
- Atoms on the right of the staircase (non-metals) tend to _____ electrons, forming _____ with a _____ charge.
- The cations and anions combine together in a ratio that _____ their charge
- Since cations and anions have opposite charges, they are _____ each other. This attraction, called electrostatic force, holds them together in an ionic bond.
- An atom and an ion are very different.
 - Example: **Table** Some differences in chemical and physical properties for sodium ion and sodium atom.

Property	Na atom	Na ⁺ ion
charge		
pure form		
reaction with water		
conductivity		

Elements with multiple ionic charges:

- _____ elements are ones that can form more than one stable ion. Most _____ metals are multivalent.
- Multivalent elements are ones that occur on your common ion sheet _____ (ex. Copper, iron, tin)
- When naming elements containing these compounds we use _____ to distinguish which ion is used.

Polyatomic ions:

- _____.
- Polyatomic ions often have complicated sounding names which makes them seem dangerous or synthetic but many polyatomic ions occur naturally.

Lewis Dot diagrams for ions

1. Determine the number of _____ the ion has (look at how many the neutral atom would have and how many electrons were gained or lost based on the charge).
2. Draw your Lewis dot structure
3. Place _____ around the diagram with the charge outside the bracket in the top right corner.

Examples:



Valence Electron, Ions & Lewis dot Assignment (complete all columns)

Lewis dot for the Formation of Ionic Bonds:

- Example: Sodium Chloride
 - Sodium has 1 valence electron and would like to lose one, chloride has 7 valence electrons and would like to gain one, so an ionic bond will occur where one sodium atom will give its valence electron to a chlorine, making the sodium have a +1 charge and chlorine/chloride have a -1 charge. Since the atoms are now a cation and an anion, they are attracted to one another.
 - Lewis drawing:
- Not all ionic compounds are created from cations and anions with a 1:1 ratio.
- Example: Aluminum Bromide
 - Lewis Drawing:

See Ionic Compound Lewis Assignment

RECALL FROM PREVIOUS STUDIES

CHEMICAL FORMULA:

- To determine the chemical formula of a compound you look at charges and determine what the lowest number ratio the cation and anion could pair up in to cancel their charges.
- Remember subscripted numbers indicate the number of atoms/ions present.
- The cation should always be written first followed by the anion.
 - Ex: Aluminum sulfide
- If a compound contains a polyatomic ion where more than one is present, parenthesis are used to indicate how many polyatomic ions there are.
 - Ex. Calcium phosphate
- If using criss cross method, remember to always reduce. Ionic compounds are written as formula units which is the whole number ratio of ions.
 - Ex. Barium sulfate

NAMING:

- To name a binary ionic compound simply write the name of the metal and then the name of the nonmetal with an "ide" ending (subscripted numbers do not need to be included in the name as long as there is only one possible charge).
 - Ex. MgBr_2
- To name ions containing a polyatomic ion, simply write the name of the cation and then the name of the anion (do not need to change the endings).
 - Ex. Na_3PO_4
- If you are naming a compound with a multivalent element, use roman numerals to indicate which ion is present.
 - Ex. FePO_4

<https://www.youtube.com/watch?v=U7wavimfNFE>

Structure of Ionic Compounds:

- Looking at the structure of ionic compounds can help us to understand their _____
- Ionic compounds form rigid arrangements of ions called a _____
- Different sized ions pack together to form different _____ crystals
- An ionic compound contains a huge number of positive and negative ions in a fixed ratio (_____).

Properties:

- _____ solids at room temperature
 - because their bonds resist being stretched
- _____ melting and boiling points
 - because they are held together by strong electrostatic forces (ionic bonds)
- Crystals made of ionic compounds can be easily _____
 - because when an outside force strikes a crystal it can offset the lattice making positively charged particles sit next to other positively charged particles. Since positives repel one another the crystal breaks.
- Conduct electricity when _____ (molten) but not as _____.
 - When molten the ions are able to move around and carry charges (conduct electricity).
- Conduct electricity when _____.
 - When dissolved in water, water pulls the ions out of the crystalline lattice. Since they are then able to move about freely, they can then carry a charge and conduct electricity.

3. Covalent Bonds

- Another way for atoms to fill their valence shell is through _____
- Covalent bonding occurs between a _____ and a _____.
- Covalent bonding occurs when electrons are _____ between two atoms.
- Covalent bonds can occur as single, double or triple bonds
 - Single bonds occur when _____ pair of electrons is shared between two atoms (each atom donating 1 electron to share)
 - Double bonds occur when _____ pairs of electron are shared between two atoms (each atom donating two electrons to share)
 - Triple bonds occur when _____ pairs of electrons are shared between two atoms (each atom donating three electrons to share)
- You can predict the number of covalent bonds needed based on the number of valence electrons an atom contains. (**remember electrons are negatively charged**)

Element	Number of Valence e-	e- needed to fill octet	Possible bonds created
Oxygen			
Nitrogen			
Carbon			

Molecules and Molecular Compounds

- A molecule is a neutral group of atoms _____ together through covalent bonds.
- Noble gases have full valence shells naturally so they are the only _____ elements.
- There are 7 diatomic elements that occur in pairs in nature:
_____.
- Determining the chemical formula of a molecule is more difficult than with an ionic compound because there can be _____ compounds possible for the same two elements depending on the types of bonds that form.
- Unlike ionic compounds, covalent molecules molecular formula is not _____ to the lowest ratio. It represents the exact number of atoms that combine to form exactly one molecule.

Lewis Dot for the Formation of Molecular Compounds

- When given the chemical formula, you can use lewis dot structures to represent the bonding and show the structural formula for a molecule.
- Start by drawing out the lewis dot for each of the atoms involved. Then determine where the electrons will share in order for all atoms to bond together
- If you have a chemical formula where there is one atom of one element and several atoms of a different element, usually the element with one atom is in the middle surrounded by the others.
 - Ex: F_2
- Ex. HCN
- Ex. NH_3 Notice that an unshared pair can affect the shape of the molecule.

RECALL FROM PREVIOUS STUDIES

NAMING MOLECULES:

- Binary compounds:** These are compounds that contain only _____. When naming binary compounds we use _____ to indicate the amount of each element present.

1	2	3	4	5	6	7	8	9	10
Mono*	di	tri	tetra	penta	hexa	hepta	octa	nona	deca

*Mono is only used for the second element in a compound.

Ex. CO_2

P_4O_{10}

CF_4

CHEMICAL FORMULA:

Use the prefix to determine the number of each element and then write it down:

Dinitrogen trioxide

Diphosphorus pentoxide

Electronegativity:

- Electronegativity is the ability of an atom to _____ electrons to it when bonded
- The electronegativity scale was created by _____ in 1922 to help develop a better understanding of chemical bonds
- We can compare electronegativity values between atoms to determine the type of _____ that will form between them.

- An element with a _____ electronegativity value is really good at attracting electrons and an element with a low electronegativity is not.
- In general, electronegativity _____ as you move from left to right across the periodic table and _____ as you move from top to bottom.

Electronegativity difference	Most probable bond type
0.0-0.4	Nonpolar covalent
0.4-1.0	Moderately polar covalent
1.0-1.7(ish)	Very polar covalent
>1.7	ionic

Electronegativity values of the elements (Pauling scale)																	
H 2.1																	He
Li 1.0	Be 1.5																Ne
Na 0.9	Mg 1.2																Ar
K 0.8	Ca 1.0	Sc 1.3	Ti 1.5	V 1.6	Cr 1.6	Mn 1.5	Fe 1.8	Co 1.8	Ni 1.8	Cu 1.9	Zn 1.6	Ga 1.6	Ge 1.8	As 2.0	Se 2.4	Br 2.8	Kr 3.0
Rb 0.8	Sr 1.0	Y 1.2	Zr 1.4	Nb 1.6	Mo 1.8	Tc 1.9	Ru 2.2	Rh 2.2	Pd 2.2	Ag 1.9	Cd 1.7	In 1.7	Sn 1.8	Sb 1.9	Te 2.1	I 2.5	Xe 2.6
Cs 0.7	Ba 0.9	La 1.1	Hf 1.3	Ta 1.5	W 1.7	Re 1.9	Os 2.2	Ir 2.2	Pt 2.2	Au 2.4	Hg 1.9	Tl 1.8	Pb 1.8	Bi 1.9	Po 2.0	At 2.2	Rn 2.4
Fr 0.7	Ra 0.7	Ac 1.1															
Ce 1.1	Pr 1.1	Nd 1.1	Pm 1.1	Sm 1.1	Eu 1.1	Gd 1.1	Tb 1.1	Dy 1.1	Ho 1.1	Er 1.1	Tm 1.1	Yb 1.1	Lu 1.2				
Th 1.3	Pa 1.5	U 1.7	Np 1.3	Pu 1.3	Am 1.3	Cm 1.3	Bk 1.3	Cf 1.3	Es 1.3	Fm 1.3	Md 1.3	No 1.3	Lr				

Non Polar Bonds

- If both atoms have an equal (or approximately equal) _____ on the electrons (same electronegativity), the bond is considered to be non-polar.
- Diatomic molecules are non-polar because they are made up of two atoms of _____ element with the same electronegativity and therefore both atoms have equal pull on electrons.
- Ex. Cl₂

Electronegativity difference:

Polar Bonds

- When two covalently bonded atoms have a significant electronegativity difference (between 0.4 and 1.7) the electrons are shared _____.
- The atom with the higher electronegativity attracts electrons _____ and therefore gains a slightly _____ charge. The atom with the lower electronegativity gains a slightly _____ charge.
- The slightly positive and slightly negative parts of the molecule are called poles. Because polar covalent molecules contain a positive pole and a negative pole, they are called _____.
- Ex. HCl

Electronegativity difference

- Since many molecules have more than one bond we have to consider _____ in a molecule to determine polarity.
- The shape of a molecule determines the polarity of the molecule. If the molecule contains polar bonds and the shape is _____ the molecule will be non polar. If there is _____ the molecule could be polar.

• Ex. CO₂

vs

H₂O

See Polarity Assignment

VSEPR

What do the molecules really look like?

Next we will look at what a molecule looks like in 3 dimensional space. We use molecular _____ and VSEPR Theory. VSEPR stands for _____.

The VSEPR theory determines the _____ of a molecule by looking at the electrons surrounding the central atom and whether they are shared pairs of lone pairs (bonding or non-bonding pairs).

Determine Molecular geometry using VSEPR:

1. Determine the lewis dot formula
2. Determine the total number of electron pairs around the central atom
3. Use the table provided to determine the electron pair geometry
4. Use the table provided to determine the shape
5. Use the diagram chart to draw a 3D diagram

VSEPR Chart			
Total pairs of e ⁻ around central atom	Number of bonded pairs	Electron Pair geometry	Molecular geometry
2	2	Linear	Linear
3	2	Trigonal Planar	Bent
3	3	Trigonal Planar	Trigonal Planar
4	2	Tetrahedral	Bent
4	3	Tetrahedral	Trigonal Pyramidal
4	4	Tetrahedral	Tetrahedral
5	2	Trigonal Bipyramidal	Linear
5	3	Trigonal Bipyramidal	T-Shaped
5	4	Trigonal Bipyramidal	Seesaw
5	5	Trigonal Bipyramidal	Trigonal Bipyramidal

6	2	Octahedral	Linear
6	3	Octahedral	T-Shaped
6	4	Octahedral	Square Planar
6	5	Octahedral	Square Pyramidal
6	6	Octahedral	Octahedral

VSEPR Geometry 3D diagrams:



Going into the page



Coming out of the page



In plane with the page

E = Central Atom

X = Bonded Atom

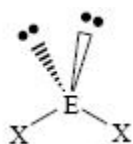
•• = Unbonded pair of electrons

VSEPR Geometries					
Steric No.	Basic Geometry 0 lone pair	1 lone pair	2 lone pairs	3 lone pairs	4 lone pairs
2	 Linear				
3	 Trigonal Planar	 Bent or Angular			
4	 Tetrahedral	 Trigonal Pyramid	 Bent or Angular		
5	 Trigonal Bipyramid	 Sawhorse or Seesaw	 T-shape	 Linear	
6	 Octahedral	 Square Pyramid	 Square Planar	 T-shape	 Linear

Examples:

Oxygen has _____ pairs of electrons around it, _____ are bonded _____ are lone, so it has a geometry of _____.

The 3D drawing for tetrahedral bent is:



So you just need to fill in the atoms where they belong:



PCl_3 has _____ pairs of electrons around it, _____ of the pairs are bonded. This means that PCl_3 has a geometry of _____.

Sometimes in a double or triple bond you have to assume that the atom has only one shared pair of electrons in order to get the proper geometry.



Even though this actually has _____ shared pairs of electrons and all are bonding electrons, the shape is linear. In this molecule we pretend that Carbon has _____ pairs of electrons and both are bonded.

Molecules that Break the Octet Rule:

Normally assume that atoms want to have _____ valence electrons, however sometimes atoms like to have more. In situations like this we say that the atom _____ the octet rule. In this class you will always be told if an element breaks the octet rule.



Xe has _____ valence electron and Fluorine has _____,

This molecule has _____ pairs of electrons around it, and _____ of them are involved in bonds so it's geometry is _____.

3D drawing:

Balloon Molecules Assignment

Create the molecules assigned to your group using the balloons provided. There are different coloured balloons. Assign one colour to represent the bonded electron pairs and the other to represent the lone electron pairs. Make sure you specify which is which.

Create your molecules so that it is stable enough to get knocked over and still maintain its shape. You will be provided with tape and balloons. After you have created your molecule with the balloons, label it with masking tape and your names. You then need to make a 3 dimensional drawing of each of your molecules (not drawings of the balloons). Use the dashed and solid lines to represent the atoms that go into the page and the atoms that come out of the page. Each member of your group should submit a drawing of both molecules. On the paper you hand in, write down which balloon colors represent bonded electrons and which represent lone pairs. Don't forget your names!

When you have finished building and drawing your molecules, you need to find a space on the counter and place all of your molecule representations together. You can then work on the "VSEPR" assignment.

(See VSEPR assignment)

Intermolecular Forces

- Inter is latin for "_____"
- These are the forces that occur between _____ (rather than within).
- Intermolecular forces are _____ than intramolecular forces.
- The two types of intermolecular forces we will look at are Van Der Waals and hydrogen bonds.

A. Van Der Waals

- The two weakest intermolecular forces are both classified as Van Der Waals forces

Dipole Interactions

- This is when one polar molecule is _____ to another polar molecule
- The slightly negative atom from one polar molecule is _____ to a slightly positive atom from another polar molecule.
- These dipole interactions are similar to _____ bonds, but much weaker

Dispersion Forces:

- These are the _____ intermolecular force
- Dispersion forces occur between both polar and nonpolar molecules.
- When the moving electrons happen to be _____ on the side of the molecule closest to a neighboring molecule their electrical forces influence the neighboring molecules electrons to be momentarily more on the opposite side. This shift causes a _____ attraction between the two molecules.

- Dispersion forces generally get stronger as the number of electrons in the molecule increases.

B. Hydrogen Bonds

- Hydrogen bonds are weak bonds formed by the attractions of slightly negative atoms to the slightly positive _____ when bonded covalently.
- Hydrogen bonds occur between hydrogen, and _____, _____, _____.
- Hydrogen bonds are also called _____
- Because hydrogen has a low electronegativity, when it pairs up with one of the high electronegativity elements _____, a highly polar molecule is created.
- Hydrogen bonds are a very strong dipole force.
- Hydrogen bonds are weaker than covalent bonds but _____ than van der Waals.
- Hydrogen bonds help to explain the high melting and boiling point of water, the low density of ice, the unusually high surface tension of water and the unusually high heat capacity of water.

Properties of Covalent Compounds:

- Intermolecular interactions affect the physical properties of covalent compounds

Molecular Solids:

- Most covalent compounds have _____ melting and boiling points compared to ionic compounds.

Network Solids:

- Some covalent compounds have _____ melting points or decompose without melting at all. These stable substances are network solids, where all of the atoms are covalently bonded to one another.
- Melting a network solid would require _____ covalent bonds throughout the entire solid.

<https://youtu.be/PVL24HAesnc>

See Intermolecular Forces Assignment

Properties Summary:

Type of Solid	Interaction	Properties	Examples
Ionic	I _____	<ul style="list-style-type: none"> • _____ Melting Point, • _____, • _____, • Often _____ in water. 	NaCl, MgO
Metallic	_____ Bonding	<ul style="list-style-type: none"> • _____ Hardness and Melting Point (depending upon strength of metallic bonding), • _____, • usually not _____. 	Fe, Mg
Molecular	_____ Bonding, _____ Dispersion	<ul style="list-style-type: none"> • _____ Melting Point, • _____, • can be _____. 	H ₂ , CO ₂
Network	_____ Bonding	<ul style="list-style-type: none"> • _____ Melting Point, • _____, • _____, • tend not to _____ in water. 	Some forms of C, SiO ₂

Bond types summary:

<https://youtu.be/QXT4OVM4vXI?list=PL8dPuualJXtPHzzYuWy6fYEaX9mQQ8oGr>

See Types of Solids Assignment

Name: _____

Boat Challenge

The Challenge:

As a group build the best boat. Your boat must be able to float in a sink of water as well as support the weight of at least one can of vegetable soup.

Your boat will be made out of aluminum foil. Be sure to think about your design before you build it. You will have one trial boat and then be given a chance to adjust your design and create a new boat.

Design: Draw a picture of your initial boat design and your redesigned boat design.



Analysis:

1. Why did you decide on the design you used? _____

2. Did your initial design work well? Explain why or why not. _____

3. How did you adjust your design to improve it? Why did you adjust it the way you did? _____

4. What designs worked best in the class? What elements of the design made them work well? Why? _____

5. How did this challenge relate to what scientists and engineers do? _____

6. What was your thinking process throughout this task? (how did you come up with your design? How did you decide what to do to improve it). _____

7. How was the process you went through with this task similar to the classic “scientific method”? ← *wait to answer this until we have learned about the scientific method* _____

8. Do you think that the scientific method is the only process that should/can be used to do scientific research? Explain. _____

Name _____

History of the Atom & the Periodic Table

1. Explain why we study the historical development of the model of the atom (give at least 2 reasons)
2. Draw and label the current model of the atom:
3. Describe the arrangement of the periodic table with regards to the following:
 - a. Metals and non-metals
 - b. Solids, liquids and gases
 - c. Valence Electrons
4. In your own words, explain why an empty valence shell is equivalent to a full valence shell.

Name: _____

Valence Electron, Ions & Lewis dot Assignment

Complete the following table:

Name	# of valence electrons	# of electrons to gain or lose	Common charge	Lewis dot for neutral atom	Lewis dot for common ion
Aluminum					
Argon					
Beryllium					
Boron					
Carbon					
Chlorine					
Fluorine					
Helium					
Hydrogen					
Lithium					
Magnesium					
Neon					
Nitrogen					
Oxygen					
Phosphorus					
Silicon					
Sodium					
Sulfur					

Describe two ways an ion forms from an atom:

Name: _____

Ionic Compound Lewis Assign:

Use the Lewis formulas for atoms to determine which ions and ionic compounds will form when the following elements combine:

1. Lithium and Fluorine
2. Calcium and chlorine
3. Magnesium and oxygen
4. Aluminum and iodine
5. Calcium and phosphorus
6. Sodium and nitrogen
7. Why do nonmetal atoms tend to form anions when they react to form compounds?

Name: _____

Covalent and Ionic Bonding Assignment

Classify the following compounds as ionic (metal + non-metal), covalent (non-metal + non-metal) or both (compound containing a polyatomic ion), then name the compound using IUPAC naming rules.

1. CaCl_2 _____

2. CO_2 _____

3. H_2O _____

4. BaSO_4 _____

5. K_2O _____

6. NaF _____

7. Na_2CO_3 _____

8. CH_4 _____

9. SO_3 _____

10. LiBr _____

Name: _____

Covalent Bonding Lewis Dot Assignment

Draw the lewis dot structure for the covalent molecules created from the elements below. Be sure to draw the lewis dot in 2 steps, to show how the electrons are involved in bonding.

1. H_2

2. O_2

3. N_2

4. CO_2

5. H_2O

6. HNO_3

7. Explain why neon is monatomic but chlorine is diatomic.

Name: _____

Polarity Assignment

- How must electronegativities compare is a covalent bond between them is polar?
- Using only their relative position on the periodic table, arrange the following elements in order of increasing electronegativity: K Cs Br Fe Ca F Cl
- Predict what type of bond (non-polar covalent, polar covalent, or ionic) would form between the following:
 - Ca-S
 - H-F
 - P-H
 - C-Cl
 - C-O
 - Li-Cl
 - N₂
 - NH₃
 - H₂O
 - FeO
 - MgCl₂
- Determine whether the following molecules are polar or non polar:
 - Hydrogen bromide, HBr
 - Nitrogen gas, N₂
 - Hydrogen sulfide, H₂S
 - Ethane, C₂H₆
 - Tetrachloroethene, C₂Cl₄
 - Phosphine PH₃

Name: _____

VSEPR Assign

Determine the electron pair geometry and the molecular geometry for the following, then draw the 3D structure of the molecule:

Follow Octet:



Break the Octet:



Name: _____

Intermolecular Forces Assignment

Determine whether the following molecules will have polar bonds, dipole interactions, dispersion forces, or H-bonds. Be sure to include all forces (i.e. there may be more than one that applies), If the molecule is polar, draw the dipole(s).

1. NH_3

2. I_2

3. CH_4

4. O_2

5. H_2O

6. HBr

7. HOOH

8. CH_3Cl

9. Depict a hydrogen bond between a water molecule and an ammonia molecule.

Name: _____

Types of Solids Assignment

Determine if the following compounds are metallic solids, ionic solids, network atomic solids, molecular solids, or amorphous solids based on their properties. These are all actual chemical compounds.

- 1) This material forms crumbly crystals and has a melting point of 16.6° Celsius. It has a low density in solid form.
_____ (acetic acid)
- 2) This material forms very hard colorless crystals. It does not dissolve in water and burns at high temperatures.
_____ (diamond, C-C bond)
- 3) This material forms colorless crystals that have a melting point of 661° C. It is hard, brittle, and dissolves well in water.
_____ (sodium iodide)
- 4) This material forms silver crystals that do not dissolve in water and have a melting point of 1414° C. This material is very hard and is not a good conductor of electricity.
_____ (silicon)
- 5) This material is hard and melts at a temperature of 1610° C. It dissolves only with difficulty in very reactive acids and doesn't conduct electricity when molten. It forms colorless crystals.
_____ (quartz)
- 6) This material is soft and doesn't form crystals. It has a melting point of 660° C. It doesn't dissolve in water. It is used as a structural material in the construction of airplanes and rockets.
_____ (aluminum)

Name: _____

OPTIONAL PRIOR KNOWLEDGE PRACTICE QUESTIONS

Determining Number of Atoms

Determine the number of atoms in each of the following compounds:

1. KCl: _____

2. NaCl: _____

3. CaCl₂: _____

4. KNO₃: _____

5. H₂SO₄: _____

6. CaCO₃: _____

7. C₂H₆: _____

8. MgCl₂: _____

9. NH₄Br: _____

10. Ca₃(PO₄)₂: _____

11. Al(OH)₃: _____

12. Hg₂Cl₂: _____

13. (NH₄)₃PO₄: _____

14. As₂(SO₄)₅: _____

15. Zn₃(PO₄)₂: _____

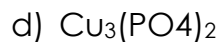
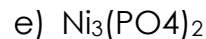
Criss Cross Method

Determine the chemical formula for the compounds created by the combination of the ions below.

	Cl ⁻	O ²⁻	PO ₄ ³⁻	OH ⁻
Na ⁺				
Mg ²⁺				
NH ₄ ⁺				
Fe ³⁺				

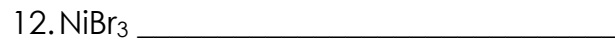
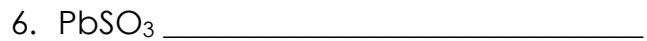
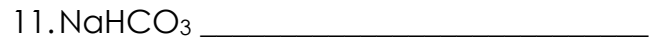
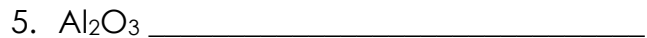
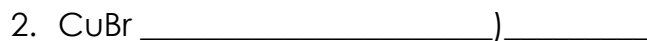
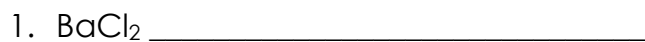
Determining Charges:

1. What is the charge of the metal in the following compounds?



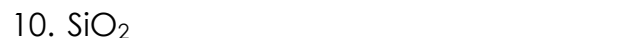
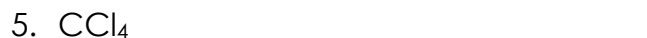
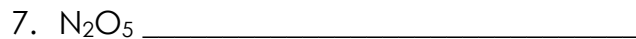
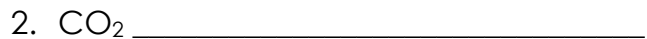
Naming Ionic Compounds Assignment

Name the following ionic compounds using Roman Numerals where necessary:



Naming Covalent Compounds Assignment

Name the following compounds using the prefix method:



Writing Formulas from Names Assignment

Write the chemical formula for the compounds listed below:

- | | |
|---------------------------------------|-------------------------------------|
| 1. Sodium chloride _____ | 11. Ammonium phosphate _____ |
| 2. Carbon tetrachloride _____ | 12. Iron (II) oxide _____ |
| 3. Dihydrogen monoxide _____ | 13. Iron (III) oxide _____ |
| 4. Iron (II) fluoride _____ | 14. Carbon monoxide _____ |
| 5. Magnesium sulfate _____ | 15. Magnesium hydroxide _____ |
| 6. Dinitrogen pentoxide _____ | 16. Copper (II) sulfate _____ |
| 7. Phosphorous trichloride _____ | 17. Lead (IV) chromate _____ |
| 8. Copper (I) carbonate _____ | 18. Potassium permanganate _____ |
| 9. Potassium hydrogen carbonate _____ | 19. Sodium hydrogen carbonate _____ |
| 10. Sulfur trioxide _____ | 20. Aluminum sulfite _____ |

Naming Ionic and Covalent Compounds

- | | |
|--|--|
| 1. CrCl_2 _____ | 14. N_2O_3 _____ |
| 2. Ba_3P_2 _____ | 15. BeS _____ |
| 3. FeCl_3 _____ | 16. MnO _____ |
| 4. N_2O_4 _____ | 17. FeSO_4 _____ |
| 5. CS_2 _____ | 18. $\text{Al}(\text{OH})_3$ _____ |
| 6. $\text{Be}(\text{NO}_3)_2$ _____ | 19. PCl_5 _____ |
| 7. AuCl_3 _____ | 20. $\text{CuC}_2\text{H}_3\text{O}_2$ _____ |
| 8. PBr_5 _____ | |
| 9. KMnO_4 _____ | |
| 10. OF_2 _____ | |
| 11. PCl_3 _____ | |
| 12. $\text{Zn}_3(\text{PO}_4)_2$ _____ | |
| 13. NH_4NO_3 _____ | |