Name: ________________________________ Date: _____________________ Block: _________

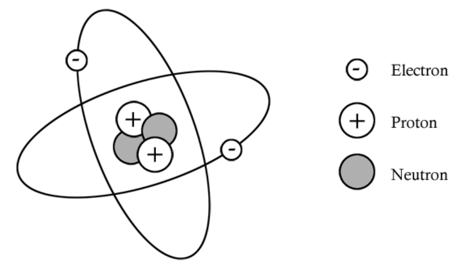
SECTION 1: REVIEW

Atom: ____

Proton: ______________________ charged particle in the _________________ of an atom; has a mass of ___.

Neutron: _______________________ particle in the ____________________ of an atom; has a mass of ______.

Electron: ________________________ charged particle in ___________________________________ surrounding the nucleus of the atom; very ______________ (mass of ______).



	Protons (p)	Neutrons (n)	Electrons (e)
Atom (neutral)			
Ion (charged)			

Ion: an atom or molecule with an ___________________________________; formed by _______________________ ______________________________________. Examples: ____

The Periodic Table tells you which ion(s) an atom can form.

- **Cation:** ____________________ charged ion (e.g. Ca^{2+}, Cr^{3+}, NH_4^+); forms when electrons are __________ (Example: magnesium atom can ____ to form the Mg^{2+} ion)
- **Anion:** ____________________ charged ion (e.g. N^{3-}, S^{2-}, PO_4^{3-}); forms when electrons are __________ (Example: sulfur atom can ____ to form the S^{2-} ion)
- **Multivalent metals** can form ______________________________________; example: _________________
- Carbon and neon do not form ions.
- **Polyatomic ion** is a ______________ of covalently bonded atoms with a charge. E.g. NH_4^+ is the ammonium ion.

In-Class Practice Questions:

Subatomic Particles of Atoms			
	protons	neutrons	electrons
Al			
Mg			
B			
Ti			
Ca			
F			
Cl			
Ar			
Zn			

Subatomic Particles of Ions				
	protons	neutrons	electrons	Type (Cation or Anion?)
Mg^{2+}				
Ti^{3+}				
O^{2-}				
As^{3-}				
phosphorus ion				
lithium ion				
manganese(IV) ion				
cobalt(III) ion				

More Practice:

1) Why do atoms have the same number of protons and electrons?

2) Explain why you need to subtract atomic number from atomic mass to calculate the number of neutrons in an atom.

3) Why do atoms and ions have the same number of protons and neutrons, but different numbers of electrons?

4) Why do ions never have the same number of protons as electrons?

5) To form an anion, does an atom have to gain or lose electrons? Why?

6) When a calcium atom becomes an ion, does it have to gain or lose electrons? How many?

7) Is the chlorine ion a cation or an anion? Does it form by gaining or losing electrons?

8) Is Cr^{3+} a cation or anion?

9) Does arsenic form an ion by gaining or losing electrons? How many? How do you know?

10) Why do we call manganese a multivalent element? List 3 other multivalent elements.

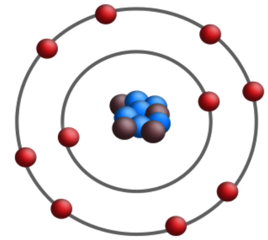
11) Subatomic Particles of Atoms and Ions

	protons	neutrons	electrons	Type (Atom, Cation, or Anion?)
N				
Br^{-}				
Zn^{2+}				
Li				
aluminium				
calcium ion				
nickel(III) ion				
potassium				

SECTION 2: MODELLING ATOMS AND COMPOUNDS

Valence Shells and Compound Formation

- The **valence shell** is the ____.
  Electrons in this shell are called **________________________________.**
- A **stable atom** has a full valence shell.
- Atoms react to form _________________ (groups of atoms bonded together) to become stable by having a ___________________________.
  - **Ionic compound**: formed when atoms ________________electrons. (e.g. NaCl, K_2O)
  - **Covalent compound**: formed when atoms _______________ electrons. (e.g. CO_2, H_2O_2)



- Valence electrons can explain reactivity.
  - The ____________________ an atom is to a full valence shell, the more ______________ it is.
  - Noble gases already have a __________________________; they do not react with other elements.

Practice: Identify the following as atoms/pure elements, ions, or compounds. BONUS: identify any cations, anions, and polyatomic ions.

1. Na	7. H_2	13. $Ca(OH)_2$	19. MgO_2
2. $TiCl_3$	8. Fe	14. Mn	20. Pt^{4+}
3. CH_4	9. O^{2-}	15. HSO_4^-	21. Be
4. Cu	10. I_2	16. Cu^+	22. ClO_2^-
5. Fe^{3+}	11. $Ni(OH)_3$	17. VS_2	23. CCl_4
6. H_2O	12. Mg	18. NO	24. Cl_2

Bohr Models of Atoms and Ions

	p	n	e		p	n	e
Na atom				**O atom**			
Na^+ ion				**O^{2-} ion**			
Mg atom				**Cl atom**			
Mg^{2+} ion				**Cl^- ion**			

1. Calculate the number of protons, neutrons, electrons.
2. In the nucleus:
   - ____________________________________
   - ____________________________________
3. Draw the electrons in energy shells:
   - Max electrons per shell from inside to outside: ___________________________
   - (Except in first shell), electrons are filled ***starting at top***, going ***clockwise***, singly at first then paired
4. Ions only:
   - Add _______________________ and _____________________ from periodic table

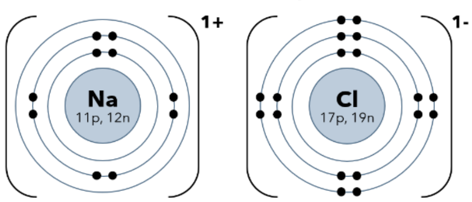
Example: sodium atom	Example: oxygen ion

Ion Formation and Ionic Compounds

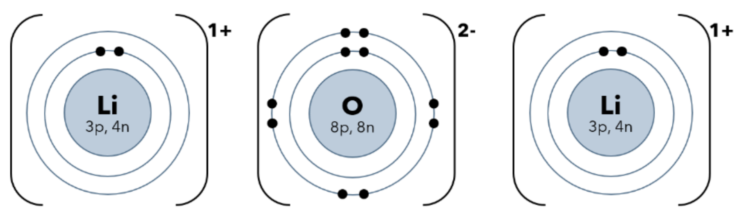
- Atoms form ions to have a **full valence shell**, just like the noble gases have.
- Electrons are negatively charged. When electrons are added, atoms become negatively charged anions. When electrons are taken away, atoms become positively charged cations.
- **Ionic compound:**
  - Forms when electrons are ____________________ from one atom to another
  - Involves a ______________ (usually metal) and an ______________ (usually non-metal) being chemically bonded together
  - Examples of ionic compounds: ____

Bohr Models of Ionic Compounds

e.g. NaCl:



e.g. Li_2O:



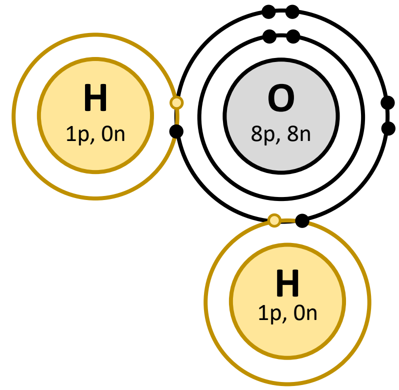
1. Determine how many of each ion is in the compound, from the subscripts.
2. Use the periodic table to find the ionic charge of each ion.
3. Draw the Bohr models of all the ions in the compound, side by side. (They should all have full valence shells.)

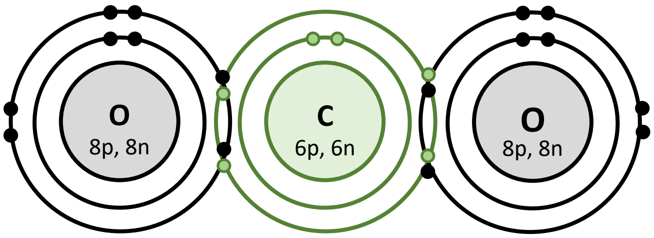
Practice: Draw the Bohr models of the following ionic compounds.

a) $MgCl_2$	b) Li_3N

Covalent Compound Formation

- Covalent compounds form when two (or more) __________ ____.
- **Lone pair**: pair of ________________________________ that is __________________ between atoms
- **Bonding pair**: ______________________________________ _________________ in a covalent compound





Bohr Models of Covalent Compounds

1. Determine how many of each atom is in the compound, from the subscripts.
2. Draw the Bohr models of the atoms. ‘Guess and check’ what covalent bonds between valence electrons will cause all atoms to have a full valence shell.
3. Redraw the Bohr model, showing the covalent bonds.

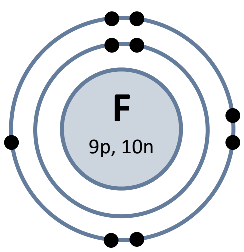
Practice: Draw the Bohr model of the following covalent compounds.

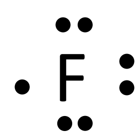
a) CH_4	b) N_2*

*Technically, N_2 is not a compound. But, it is an element that is covalently bonded to itself, so it can be drawn in the same way as a covalent compound.

Introducing Lewis Structures

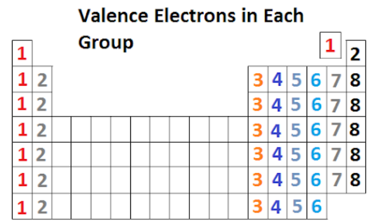
Bohr Model	**Lewis Structure**
• All electrons • All energy shells • Shows protons and neutrons • Shows a lot of information, but is clunky and time-consuming	• Only ________________ electrons (except cations) • Outermost shell only • Protons and neutrons ignored • Good at determining bonding in a __________________ compound





How do you determine the number of valence electrons in an atom?

____



Lewis Structures of Atoms

1. Write element symbol (capitalization matters!)
2. Draw valence electrons around, using the same positions as the Bohr model (i.e. clockwise, unpaired at first then paired)

Practice: Draw the Lewis structures of:

a) Mg atom	b) N atom	c) H atom	d) O atom

Lewis Structures of Ions and Ionic Compounds

Cation:

- Element symbol
- No electrons
- Square brackets and charge

Anion:

- Element symbol
- Full valence shell
- Square brackets and charge

Practice: Draw the Lewis structures for the following ionic compounds:

a) $NaCl$	b) $MgCl_2$	c) CaH_2	d) AlF_3

Lewis Structures of Covalent Compounds

Rule 1: All ____.

Rule 2: All atoms must have a ____.

1. Draw the Lewis structure of each atom.
2. Determine how many bonds each atom "needs" to complete its valence shell.
3. Guess and check with single, double, and triple bonds until your structure satisfies Rules 1 and 2.

Symbols Used in Lewis Structures	
Lone pair	:
Single bond (1 bonding pair; 2 electrons)	—
Double bond (2 bonding pairs; 4 electrons)	=
Triple bond (3 bonding pairs; 6 electrons)	≡

Example: H_2O	Example: NH_3	Example: CO_2

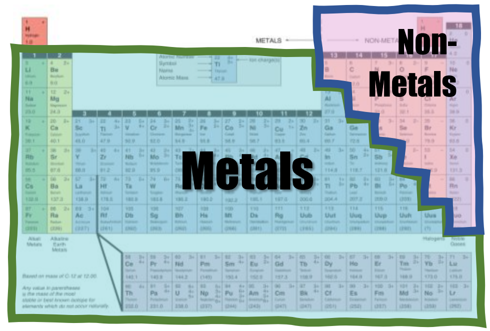
Practice: Try drawing the Lewis structures of the following covalent compounds.

HF	PF_3	CH_2O
N_2 *	CH_4	CO_2H_4 *(challenge)*

SECTION 3: IUPAC NOMENCLATURE

Ionic vs Covalent Compounds

- Ionic compounds form when **electrons are** ____________________ and ions are formed. Usually involves a __________________ **and a** ________________________.
- Covalent compounds form when two (or more) _____________________ atoms ________________________ **electrons**.



Draw a diagram to help you identify elements, ionic compounds, and covalent compounds based on its formula.

Practice: Identify the following as elements (E), ionic compounds (IC), or covalent compounds (CC).

Chemical	**What is it?**	**Chemical**	**What is it?**	**Chemical**	**What is it?**
PF_3		NO_2		NaOH	
$CaCl_2$		Br_2		CCl_4	
Cl_2		Mg		$MgBr_2$	

Naming Elements

An element is a pure substance containing ____.
Examples:

- Mg (_________________________)
- ______ (calcium)
- ________ (hydrogen)
- Cl_2 (_________________________)

Names of elements are found on the _______________________________. Ignore subscripts when naming.

Diatomic Elements: When in their elemental form, exist as diatomic molecules: two atoms bonding covalently to fill their valence shells.

List: ____ Memory Aid: ___________________________________

Reference

Non-metal	"-ide" Ending	Non-metal	"-ide" Ending	Non-metal	"-ide" Ending
N, nitrogen		**Cl**, chlorine		**As**, arsenic *	
O, oxygen		**Se**, selenium		**Te**, tellurium *	
F, fluorine		**Br**, bromine		**At**, astatine *	
P, phosphorus		**I**, iodine			
S, sulfur		**H**, hydrogen			

Naming Ions

	What is it?	Naming	Examples	
			Ion Name	*Ion Symbol*
Monovalent Ion	Can only make one ion (see periodic table)	Cations: write name of element	sodium	Na^{+}
			yttrium	Y^{3+}
		Anions: write name of element with "-ide" ending	bromide	Br^{-}
			oxide	O^{2-}
Multivalent Metal Ion	Can make multiple ions (see periodic table)	Must specify charge with Roman numerals	manganese(III)	Mn^{3+}
			manganese(IV)	Mn^{4+}
			copper(I)	Cu^{+}
			vanadium(V)	V^{5+}
Polyatomic Ion	Group of non-metal atoms covalently bonded with an ionic charge	Spelling counts!!!! (Copy from table)	ammonium	NH_4^{+}
			phosphate	PO_4^{3-}
			phosphite	PO_3^{3-}

Practice: Complete the table with the names and chemical formulas (including charges) of the following ions. Identify as monovalent (Mono), multivalent metal (Multi), or polyatomic (Poly).

Ion Formula	Ion Name	Type
Mn^{4+}		
K^{+}		
CO_3^{2-}		
HSO_4^{-}		
Se^{2-}		
NO_3^{-}		
Br^{-}		
OH^{-}		
Ti^{3+}		
NH_4^{+}		
Mg^{2+}		
	hypochlorite	
	sulfide	
	iodide	
	perchlorate	
	nickel(II)	
	chromium(III)	
	hydride	
	hydroxide	
	cyanide	
	gold(I)	

Naming Ionic Compounds

1) Write the ____________________, first.
   - For monovalent ions, do not write the ion charge.
   - For multivalent metals, determine the ion charge through ___________________________________.

     Then, put the ion charge in __________________ _______________________, in brackets.

   - If the cation is polyatomic, write it exactly the way it is written in the table.
2) Write the anion with _________________________________ (unless it is polyatomic.)

Charge Balancing (to find the charge of a ____________________________ metal ion)

1) Write out all the ions you have. Leave the charge blank on the multivalent metal.
2) *Rule: The total number of ________________ charges in an ionic compound must equal the total number of ________________ charges.* Determine the charge on the metal ion.
3) Write the compound name. Specify the ion charge on the multivalent metal using brackets and Roman numerals.

Examples:	
NaCl	$Mg(OH)_2$
Cr_2O_3	$Ti_2(CrO_4)_3$

Writing Formulas of Ionic Compounds

	Version 1 1. Write down each ion with its charge. 2. Add more of the ions to balance the charges: the total number of positive and negative charges must be equal. 3. Write your formula with subscripts.	Version 2 1. Write down each ion with its charge. 2. Write the chemical formula by writing the cation first and the anion second. Then, "criss-cross" the charges to become the subscripts. 3. Reduce the subscripts if both divisible by the same number.
calcium phosphide		
chromium(II) hydroxide		

Prefixes Reference (no need to memorize)			
Arabic Numeral	*Prefix*	*Arabic Numeral*	*Prefix*
1		6	
2		7	
3		8	
4		9	
5		10	

Covalent Compounds with Special Names (memorize):
NH_3 = ammonia H_2O = water CH_4 = methane

Naming Covalent Compounds

1. Write the first element.
2. Write the second element with ____________________________.
3. Add **prefixes** to show how many of each element there is.
    - *Do not add "____________" to first element.*
    - *If adding "mono-" to "-oxide", write "________________________" instead.*

Examples:
O_2F_2
PF_3
N_2O

Practice:	
S_2O_5	NO
Cl_3O_7	CCl_4
CBr_2	P_2S_6

Chemical Formulas of Binary Covalent Compounds

1. Identify the elements involved. Write their __________________.
2. Use the ________________ to determine the number of each element in the compound. Write as ________________.

Examples:
tetraphosphorus pentaoxide
nitrogen triiodide
selenium difluoride

Practice:	
nitrogen trioxide	tricarbon disulfide
triphosphorus tetraoxide	boron trifluoride
iodine pentafluoride	xenon hexafluoride

SECTION 4: BALANCING CHEMICAL EQUATIONS

Chemical Equation Vocabulary

Reactants: what ________________________ the reaction; on the ____________ side of the reaction arrow
Products: what ________________________ the reaction; on the ____________ side of the reaction arrow

$$Zn + 2HCl \rightarrow ZnCl_2 + H_2$$

	Definition and Example	Example
Word Equation	uses ______________ to describe reactants and products	zinc + hydrogen chloride → zinc chloride + hydrogen
Skeleton Equation	uses ______________________________ to describe reactants and products	$Zn + HCl \rightarrow ZnCl_2 + H_2$
Balanced Chemical Equation	uses ________________________ and chemical formulas to describe reactants and products in their correct ________________	$Zn + 2HCl \rightarrow ZnCl_2 + H_2$

Why Balance?

- Chemical "recipes": how much do you put in? how much do you expect to yield?
- **Law of Conservation of Mass**: no atoms are ever created or destroyed
- Balancing chemical formulas involves adding ________________________ in front of elements and compounds until ____ ____.

Tips for Balancing

- **Goal: the number of atoms of each element in the reactants equals the products.**
- Change coefficients only. Never add or change subscripts.
- Balance atoms in compounds first. Save elements for last.
- If the same ________________________________ appears in the reactants *and* products, you can often treat it as a ____________________________________ instead of splitting it up.
- At the end, reduce all coefficients to lowest whole-number terms.
- Note: ____ if there is only "____" of that element or compound.

Trick for Combustion Reactions (e.g. #10-12 below)

1. Balance every atom except oxygen.	___ C_6H_{14} + ___ O_2 → ___ CO_2 + ___ H_2O
2. Find out how many oxygen atoms you need the __O_2 to contribute. Divide that number by 2. This is your *temporary* coefficient for O_2.	___ C_6H_{14} + ___ O_2 → ___ CO_2 + ___ H_2O
3. You are not allowed to have fractional coefficients in your final answer. Multiply all the coefficients by 2.	___ C_6H_{14} + ___ O_2 → ___ CO_2 + ___ H_2O

Practice: Balance the following chemical reactions.

1. ___ N_2 + ___ H_2 → ___ NH_3
2. ___ $NaCl$ + ___ F_2 → ___ NaF + ___ Cl_2
3. ___ Ag_2O → ___ Ag + ___ O_2
4. ___ P + ___ O_2 → ___ P_2O_5
5. ___ $NaBr$ + ___ CaF_2 → ___ NaF + ___ $CaBr_2$
6. ___ $FeCl_3$ + ___ $NaOH$ → ___ $Fe(OH)_3$ + ___ $NaCl$
7. ___ H_2SO_4 + ___ $NaNO_2$ → ___ HNO_2 + ___ Na_2SO_4
8. ___ CO_2 + ___ H_2O → ___ $C_6H_{12}O_6$ + ___ O_2
9. ___ HCl + ___ $CaCO_3$ → ___ $CaCl_2$ + ___ H_2O + ___ CO_2
10. ___ C_3H_8 + ___ O_2 → ___ CO_2 + ___ H_2O
11. ___ C_6H_{14} + ___ O_2 → ___ CO_2 + ___ H_2O
12. ___ C_8H_{18} + ___ O_2 → ___ CO_2 + ___ H_2O