Chemistry
Chemistry is the study of the composition, _________ and structure of substances, and the changes they undergo. In order to understand matter, we must examine its _________.

Some definitions:

___________: a small "particle" made from protons, neutrons, and electrons.

___________: particles that consist of 2 or more atoms covalently bonded together.

___________: a pure substance that cannot be decomposed into simpler substances. They are made of identical atoms. ex) gold, carbon, hydrogen

___________: a pure substance made from the atoms of 2 or more elements that are chemically bonded. ex) water - H₂O; sucrose - C₁₂H₂₂O₁₁

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The Atom
The 3 principle subatomic particles are the __________________________.

<table>
<thead>
<tr>
<th>Type</th>
<th>charge</th>
<th>mass</th>
<th>location</th>
</tr>
</thead>
<tbody>
<tr>
<td>proton</td>
<td>positive</td>
<td>1 amu</td>
<td>nucleus</td>
</tr>
<tr>
<td>electron</td>
<td>no charge</td>
<td>1/1836 amu</td>
<td>orbiting nucleus</td>
</tr>
</tbody>
</table>

The mass number of an atom is the total of the protons and neutrons in the nucleus.

mass number = _________

In the above example, 6 p⁺ + 8 n⁰ = 14 t mass number of this atom is 14. Because electrons are relatively _________, their ________ can be ignored. Atoms are neutral because they have the same number of protons and electrons. An atom can become charged by adding or removing ________________ only.
Drawing Bohr Diagrams
When drawing a Bohr diagram, begin with the ________ and indicate how many protons and neutrons. Then place ________ around the nucleus on rings starting inside and working out. You must ______ each shell before moving to the ________. The shells can hold 2, 8, 18, 32, 32, 18, 8 electrons respectively.

Nuclear Symbols
This is an efficient method to show much information about that atom.

<table>
<thead>
<tr>
<th>Name</th>
<th>Symbol</th>
<th>p⁺</th>
<th>n⁰</th>
<th>e⁻</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>¹⁴⁶C⁴⁺</td>
<td>6</td>
<td>8</td>
<td>2</td>
</tr>
</tbody>
</table>

The above example is Carbon-14, an isotope of Carbon. __________ are atoms of the same element that have different numbers of __________ and therefore, different __________.

Valence Electrons
These are the electrons in the _______________. These electrons determine the __________ of the elements and can be used to predict formulas. Excluding the transition elements, the number of valence electrons increases by _____ across the period (left to right), and all elements of the same family have the _______ number of valence electrons.

<table>
<thead>
<tr>
<th>Family</th>
<th>Li</th>
<th>Be</th>
<th>B</th>
<th>C</th>
<th>N</th>
<th>O</th>
<th>F</th>
<th>Ne</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valence electrons</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
</tbody>
</table>

Lewis Diagrams
These are similar to Bohr diagrams, but show only ______________ electrons and an elemental symbol.

<table>
<thead>
<tr>
<th>Family</th>
<th>Li</th>
<th>Be</th>
<th>B</th>
<th>C</th>
<th>N</th>
<th>O</th>
<th>F</th>
<th>Ne</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electron dot</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Drawing Lewis Structures
Count the total number of __________.
Draw a skeleton structure using shared pairs of ________ to show bonding.
Use ________ for the central atom, otherwise use the least _________________ element.
_____ is always on the end, and in oxyacids, H is on ______
Add unshared pairs of electrons so that each atom (that will accept them) is surrounded by _____
Fill octets outside in; if there are extra electrons, give them to the __________ atom
Multiple pairs of electrons may be shared between 2 atoms, forming __________ and __________ bonds, to satisfy the __________ rule.
If there is more than 1 possible location for a ________ bond, use ______________ structures to show all possibilities; separate resonance structures with double arrows.
Periodic Table
The periodic table arranges the elements into vertical groups or families, as well as horizontal rows or _________. Because all elements in a family have the same number of ______________, their properties will be related and they will usually react in similar ways. The table is split by a zigzag line which separates the ___________ on the left from the ______________ on the right. Metals tend to be ________ at room temperature, shiny, good conductors of heat and electricity, ________ (can be hammered into sheets) and ____________ (can be made into a wire). Nonmetals tend to be either solid or ______ at room temperature, dull, ________ conductors of heat and electricity, brittle, and not ductile.

Types of Bonds
There are 3 basic types of bonds: __________, __________, and __________.

1. Metallic bonds are formed between metal atoms. Their ______________ electrons are free to move throughout the material and can account for the good conductivity of metals.

2. Covalent bonds generally are formed between __________ and __________. In this type of bond, the difference in the electronegativity (ability to attract electrons) is small or zero, which means that they are pulling the valence electrons equally, and ________ them.

3. Ionic bonds are generally formed between __________ and __________, or involving polyatomic ions. In this type of bond, the nonmetal pulls electrons with so much more strength than the metal, that the metal will give its electron(s) to the nonmetal, creating a positive ion (cation) and a negative ion (anion). The electrostatic attraction holds the ions together in a ____________.

Ionic Charges
Compounds will tend to form by gaining, losing, or sharing __________ so that the valence shell of each atom is satisfied. This is known as the __________ rule, and even though there are many exceptions, it is a useful concept.
Sodium has 1 ___________ electron, and will lose that electron in a reaction to become Na\(^+\). Notice that Na\(^+\) has a full valence shell.
Chlorine has 7 valence electrons and will ____________ 1 electron to complete its octet → Cl\(^-\).

<table>
<thead>
<tr>
<th>Family</th>
<th>Li</th>
<th>Be</th>
<th>B</th>
<th>C</th>
<th>N</th>
<th>O</th>
<th>F</th>
<th>Ne</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>1+</td>
<td>2+</td>
<td>3+</td>
<td>4±</td>
<td>3–</td>
<td>2–</td>
<td>1–</td>
<td>n/a</td>
</tr>
</tbody>
</table>

Ions are named after their element, however anions have their suffix changed to "ide".

<table>
<thead>
<tr>
<th>Ca(^{2+})</th>
<th>O(^{2–})</th>
<th>Ag(^+)</th>
<th>Cl(^–)</th>
</tr>
</thead>
</table>

Many transition metals and metals to their right make more than one stable ion. In order to figure out which one is being used, you need to see a formula, or be given the type in the name. For example, copper makes 2 stable ions: Cu\(^+\) and Cu\(^{2+}\), These ions are named copper(I) and copper(II) respectively.

Polyatomic Ions

<table>
<thead>
<tr>
<th>NH(_4^+)</th>
<th>SO(_4^{2–})</th>
<th>ClO(_3^–)</th>
<th>CO(_3^{2–})</th>
<th>NO(_3^–)</th>
<th>PO(_4^{3–})</th>
<th>OH(^–)</th>
<th>CH(_3)COO(^–)</th>
<th>HCO(_3^–)</th>
</tr>
</thead>
<tbody>
<tr>
<td>chlorate</td>
<td>carbonate</td>
<td></td>
<td></td>
<td>hydroxide</td>
<td>hydrogen carbonate (bicarbonate)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Oxidation Numbers**
The distribution of ___________ in a molecule can be described by oxidation numbers, which are usually similar to the charge an atom will make. Oxidation numbers differ from charges in that they are ___________ ___________, but only a mathematical explanation of the bonding.

Some examples: oxidation states Li\(^+\), Ba\(^{2+}\), S\(^{–2}\), Cu\(^{+1}\), Br\(^{–1}\)
charges Li\(^+\), Ba\(^{2+}\), S\(^{–2}\), Cu\(^{+}\), Br\(^{–}\)

**Formulas From Names**

**Ionic compounds** (________ + __________; Polyatomic Ions)
The ions can be derived from the names. Then, using subscripts to balance charges, a formula can be obtained. Recall: all compounds must have a net ionic charge of _______. The charges can be found by the group on the periodic table, from ____________, or from memory (ions).
barium fluoride  \[ \text{LCM} = 2 \quad 1(Ba^{2+}) = +2 \]
\[ \text{Ba}^{2+} \quad \text{F}^{-} \rightarrow \text{________} \]

boron hydroxide  \[ \text{B}^{3+} \quad \text{OH}^{-} \rightarrow \text{________} \quad \text{polyatomic ions need brackets if use more than 1} \]

uranium (VI) oxide  \[ \text{U}^{6+} \quad \text{O}^{2-} \rightarrow \text{________} \]

Molecular compounds (Nonmetal + Nonmetal)
If the compound name has a prefix(es), it is molecular. Simply turn the prefixes into subscripts for that element. If there is no prefix, it is single. DO NOT SWITCH ________________.
1-mono  5-penta  9-_______
2-_______  6-_______  10-deca  Prefixes for binary molecular compounds
3-tri   7-hepta
4-_______   8-_______

dinitrogen trioxide  \[ \rightarrow \text{________} \]
iodine pentafluoride  \[ \rightarrow \text{________} \]
tetraphosphorous decoxide  \[ \rightarrow \text{________} \]

Give the formula for the following compounds:
1. sodium chloride  11. sodium chlorate  21. sulfur trioxide
2. calcium fluoride  12. calcium nitrate  22. dinitrogen tetroxide
3. magnesium sulfide  13. aluminum sulfate  23. carbon tetraiodide
4. aluminum oxide  14. silver phosphate  24. diphosphorous pentachloride
5. zinc oxide  15. ammonium chloride  25. carbon dioxide
6. chromium(II) oxide  16. iron(II) hydroxide  26. beryllium nitrate
7. copper(II) bromide  17. nickel(III) acetate  27. phosphorous(V) fluoride
8. manganese(VII) oxide  18. titanium(IV) carbonate  28. cobalt(III) sulfate
9. tin(IV) iodide  19. sodium bicarbonate  29. dihydrogen monoxide
10. iron(III) oxide  20. uranium(III) oxide  30. potassium hydroxide

Naming Compounds
Ionic Compounds (Metal + Nonmetal ; Polyatomic Ions)
Name using the names of the ions.
\[ \text{MgCl}_2 \rightarrow \text{________} \quad \text{Al}_2\text{O}_3 \rightarrow \text{________} \]
If there are polyatomic ions, name them in full.
\[ \text{Na}_2\text{CO}_3 \rightarrow \text{________} \quad \text{(NH}_4\text{)}_2\text{SO}_4 \rightarrow \text{________} \]
If there are metals that have more than one oxidation state, use roman numerals to represent which charge was used. To find this, work back from the known anion. We always know the anion charge because the more electronegative element (on the right) gets its group charge.
\[ \text{Fe}_2\text{O}_3 \rightarrow \text{iron( ) oxide} \quad ? \quad -2 \]
\[ \text{Fe}_2\text{O}_3 \quad +6 \quad -6 \quad \text{Fe is +3, iron (III) oxide} \]
\[
\begin{align*}
\text{SnCl}_4 & \rightarrow \text{Sn}^{4+} \text{ Cl}^- \\
\text{Cu(C}_2\text{H}_3\text{O}_2)_2 & \rightarrow \text{Cu}^{2+} \text{ C}_2\text{H}_3\text{O}_2^- \\
\text{MnO}_2 & \rightarrow \text{Mn}^{4+} \text{ O}^{2-}
\end{align*}
\]

Molecular Compounds (nonmetals + nonmetals)

1) the prefix method → give prefixes to show number of each atom in the molecule.

\[
\begin{align*}
\text{P}_2\text{O}_5 & \rightarrow \text{___________________} \\
\text{As}_2\text{S}_3 & \rightarrow \text{___________________}
\end{align*}
\]

Do not include “mono” on the first ion, but always on the second.

\[
\begin{align*}
\text{CO}_2 & \rightarrow \text{___________________} \\
\text{N}_2\text{O} & \rightarrow \text{___________________}
\end{align*}
\]

Name the following formulas:

1. LiCl 11. Ba(OH)_2 21. SO_2
2. K_2S 12. Na_2SO_4 22. CS_2
3. Sr_3N_2 13. C_53PO_4 23. N_2O_4
5. ZrF_4 15. Rb_2S 25. P_4O_10
7. FeO 17. Cu(ClO_3)_2 27. NH_4HCO_3
9. Mn_3N_2 19. NH_4F 29. H_2SO_4
10. CrO_3 20. Fe_2(CO_3)_3 30. BF_3

Naming Common Organic Compounds

Shown is a list of prefixes used to name _______________________.

The general formula for ______________________ (single bonded hydrocarbons) is C_nH_{2n+2} and they end in ‘-______________’.

Ex. Propane

Octane

Acids and Bases

There are a few ways to define acids and bases. We will use the Arrhenius definitions:

**Acids**

An acid is a substance that, when dissolved in water, increases the _________ ion concentration.

\[
\text{HCl}(g) + \text{H}_2\text{O}(l) \rightarrow \text{H}_3\text{O}^+(aq) + \text{Cl}^-(aq)
\]
In water, HCl dissociates (splits) into its ions $H^+$ and $Cl^-$. $H^+$ attracts other molecules so strongly, that it doesn't normally exist alone. $H^+$ forms a covalent bond to $H_2O$ to form hydronium $H_3O^+$. Acids have a _______ taste (acidus, L. - sharp). Some acids react with _________ to release hydrogen gas, and many conduct an electric current (electrolyte).

Strong acid are strong electrolytes. Many acids are ___________: will destroy body tissue and clothing. Many are also _____________.

Some common acids:

<table>
<thead>
<tr>
<th>Binary acids</th>
<th>Oxyacids</th>
</tr>
</thead>
<tbody>
<tr>
<td>HF</td>
<td>hydrofluoric acid</td>
</tr>
<tr>
<td>HCl</td>
<td>________________</td>
</tr>
<tr>
<td>HBr</td>
<td>hydrobromic acid</td>
</tr>
<tr>
<td>HI</td>
<td>________________</td>
</tr>
<tr>
<td>H$_2$S</td>
<td>hydrosulfuric acid</td>
</tr>
<tr>
<td>H$_2$CO$_3$</td>
<td>acetic acid</td>
</tr>
<tr>
<td>HNO$_3$</td>
<td>nitric acid</td>
</tr>
<tr>
<td>H$_3$PO$_4$</td>
<td>sulfuric acid</td>
</tr>
</tbody>
</table>

Binary acids contain ___________ and one of the more electronegative elements. Oxyacids contain hydrogen, _______________ and a third element, usually a nonmetal.

**Bases**

A base is a substance that, when dissolved in water, increases the __________ ion concentration.

$$NaOH_{(s)} - H_2O \rightarrow Na^+_{(aq)} + OH^-_{(aq)}$$

A base will either dissociate into _____ ions, like sodium hydroxide, or it will remove a hydrogen from water, leaving OH$^-$ ions, like ammonia.

$$NH_3_{(aq)} + H_2O_{(l)} \rightarrow NH_4^+_{(aq)} + OH^-_{(aq)}$$

Bases have a _________ taste, and like acids, will conduct electric current. Dilute bases feel _______________, such as soap. Many bases are ______________: will attack skin and tissues, causing severe burns.

**pH Scale**

To describe how acidic or how basic a solution is, we use the pH scale. The equation for pH is

$$pH = -\log [H_3O^+]$$

Hydronium ion concentrations can range from _______ to _______ mol/L. Using this equation, we can describe the [H$_3$O$^+$] on an easier scale. pH ranges from ______ (very acidic) to _______ (very basic), with _______ being neutral.

**Neutralization Reactions**

Acids and bases will react with each other to ______________ both species.

$$HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$$

Note that the products are ___________, and that both a ________ and ________ are formed. A salt is an ionic compound composed of a __________ from a base and an __________ from an acid. Concentrations, amounts, and strengths of acids and bases should be matched for complete neutralization.