Unit 2 Notes Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Measurement, Atoms, Date \_\_\_\_\_\_\_\_\_\_\_\_ Block \_\_\_\_ Molecules & Ions

### Knowledge/Understanding Goals:

### Recall definitions of atoms, subatomic particles, ions, etc.

* Understand the theoretical structure of the atom.
* Recall the rules for naming compounds and writing chemical formulas.

### Skills:

* Solve average atomic mass problems
* Be able to properly name and write the chemical formula for any binary compound
* Identify the atomic components to any atom/ion/isotope

### Notes:

**Atomic Structure**

* All matter is composed of particles called atoms, which give matter \_\_\_\_\_\_\_\_\_\_\_\_\_\_.



atom:

nucleus:

proton: a subatomic particle found in the nucleus of an atom.

neutron: a subatomic particle found in the nucleus of an atom.

electron: a subatomic particle found *outside* the nucleus of an atom.

charge: positive and negative charges cancel each other out, so the \_\_\_\_\_\_\_\_\_\_\_\_ charge of an atom is the difference between the number of positive charges (\_\_\_\_\_\_\_\_\_\_\_\_) and negative charges (\_\_\_\_\_\_\_\_\_\_\_\_\_) it has.

For example,

neutral atom:

ion:

* Remember, the ONLY way to form an ion is to gain or lose \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_! If you change the number of protons, you change the element!
* Atoms usually form ions to become \_\_\_\_\_\_\_\_\_\_\_ with the nearest noble gas, giving them 8 valence electrons. This is commonly referred to as the “\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_” and is not applicable to transition metals.

**Periodic Table**



element symbol: a one- or two-letter abbreviation for an element. (New elements are given temporary three-letter symbols.) The first letter in an element symbol is always capitalized. Other letters in an element symbol are always lower case. *This is important to remember.*

For example, Co is the element cobalt, but CO is the compound carbon monoxide, which contains the elements carbon and oxygen.

atomic number:

mass number:

* + The mass number reported on the periodic table is the \_\_\_\_\_\_\_\_\_\_\_\_\_ mass of all of that element’s \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
	+ That is why we see most elements having a mass number with values out the thousandths place, even though the proton/neutron masses are whole numbers (1 amu).

isotopes:

* + Isotopes are described by their mass numbers.
		1. For example, carbon-12 has 6 protons and 6 neutrons, which gives it a mass number of \_\_\_\_\_.
		2. Carbon-14 has 6 protons and 8 neutrons, which gives it a mass number of \_\_\_\_.

Isotopes =

Ions =

isotopic symbol: a shorthand notation that shows information about an element, including its \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, and \_\_\_\_\_\_\_\_\_\_\_\_\_. For example, the symbol for a sodium-23 ion with a 1+ charge would be:

\*Note: the charge should read 1+

Ionic Charge: 1+

Oxidation State: +1



This notation shows the element symbol for sodium (Na) in the center, the atomic number (11, because it has 11 protons) on the bottom left, the mass number (23, because it has 11 protons + 12 neutrons = 23 amu) on the top left, and the charge (1+, which means it lost one of its electrons in a chemical reaction) on the top right.

Let’s explore atomic composition and what determines which isotopes occur naturally.

[Building Atoms Activity: http://phet.colorado.edu/en/simulation/build-an-atom](http://phet.colorado.edu/en/simulation/build-an-atom)

Isotope Stability: The nuclear stability of an isotope describes the interaction of two competing forces in the nucleus:

* + Four basic forces in nature:
		1. Strong force is the strongest of the four. However, it also has the shortest \_\_\_\_\_\_\_\_\_\_\_\_\_\_, meaning that particles must be extremely close before its effects are felt.



* + Strong force holds together the subatomic particles of the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (protons and neutrons). These particles are collectively called \_\_\_\_\_\_\_\_\_\_\_).
		1. Like charges repel and unlike charges attract.

If you consider that the nucleus of all atoms, except hydrogen, contain more than one proton, and each proton carries a positive charge, then why would the nuclei of these atoms stay together? The protons must feel an \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ repulsive force from the other neighboring protons.



This is where the strong nuclear force comes in. The strong nuclear force is created between nucleons by the exchange of particles called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

* + If a proton or neutron can get \_\_\_\_\_\_\_\_\_\_\_ enough to another nucleon, the exchange of mesons can occur, and the particles will stick to each other.
	+ If they can't get that close, the strong force is too \_\_\_\_\_\_\_\_\_ to make them stick together, and other competing forces (usually the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ force) can influence the particles to move apart.
	+ This explains…

[Nuclear Stability Video: https://youtu.be/yTkojROg-t8](https://youtu.be/yTkojROg-t8)

There also appears to be a relationship between stability and the \_\_\_\_\_\_\_\_ of protons and neutrons in the nucleus.

* For smaller elements (up to about calcium), the most stable nuclear composition appears to be a \_\_\_\_\_\_\_ ratio of protons to neutrons.
* Larger elements gradually start to move towards a \_\_\_\_\_\_\_ ratio of protons and neutrons. (50% more neutrons)
* Unstable nuclear ratios are typically \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ because they are likely to undergo \_\_\_\_\_\_\_\_\_\_ until they reach a more stable configuration. (We will discuss alpha/beta/gamma decay in a later unit)

A complete understanding of the importance of a specific ratio is still unclear; however the instability caused by increasing the number of neutrons to unbalance the ratio can be attributed to the nuclear \_\_\_\_\_\_\_\_\_\_\_\_\_ increasing to a size where neighboring nucleons are too far apart to allow \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ attraction.

Try It! Work on the Ions/Isotopes Practice Worksheet

**Atomic Theory**

* Rutherford: Prior to Rutherford’s gold foil experiment, it was believed that all of the components of an atom were occupying the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (Plum-Pudding Model, Thomson) that we now refer to as the nucleus.



[Gold Foil Animation: http://www.mhhe.com/physsci/chemistry/essentialchemistry/flash/ruther14.swf](http://www.mhhe.com/physsci/chemistry/essentialchemistry/flash/ruther14.swf)

<http://phet.colorado.edu/en/simulation/rutherford-scattering>

Experiment Results Summary

* +
* Bohr: Experiments showed \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ amounts of energy were \_\_\_\_\_\_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ from atoms when they were exposed to electromagnetic energy. His model depicts quantized energy levels as circular orbitals that electrons occupy, rather than an electron cloud.



[Emission Animation: http://spiff.rit.edu/classes/phys301/lectures/spec\_lines/Atoms\_Nav.swf](http://spiff.rit.edu/classes/phys301/lectures/spec_lines/Atoms_Nav.swf)

Experiment Results Summary

* Quantum Mechanical Model: Experiments and accredited scientists will be discussed at a later time.



Theory Summary

**\*\*Nucleon and quark knowledge is not required knowledge for the AP test, it’s just awesome and the forefront of chemistry/quantum physics.\*\***

[Hadron Collider: http://home.web.cern.ch/topics/large-hadron-collider](http://home.web.cern.ch/topics/large-hadron-collider)

**Compounds**

**Formulas:** A chemical formula gives the elemental composition of a compound. There are several ways of writing chemical formulas:

molecular formula:

*E.g.,* the molecular formula for acetone is:

structural formula:

*E.g.,* the structural formula for acetone is:

condensed structural formula:

*E.g.,* some condensed structural formula for acetone are:

Condensed structural formulas are commonly used in organic chemistry.

**Ions:** Ions of the *s* and *p* block\* gain or lose \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ to end up with a noble gas configuration. *E.g.,* halogens (F, Cl, Br, I) \_\_\_\_\_\_\_\_ an electron, and alkali metals (Li, Na, K, Rb, Cs) \_\_\_\_\_\_\_ an electron.

* + Ions that gain electrons have a negative charge (\_\_\_\_\_\_\_\_\_\_\_\_). Ions that lose electrons have a positive charge (\_\_\_\_\_\_\_\_\_\_\_\_\_\_).
	+ Polyatomic ions consist of covalently \_\_\_\_\_\_\_\_\_\_\_\_\_ atoms. You need to memorize the names, formulas, and charges of common polyatomic ions.

\*Common charges formed by transition metals (oxidation states) will be discussed later.

**Ionic compounds:** Made of cations (positive ions) and anions (negative ions).

* Every compound has a \_\_\_\_\_\_\_\_\_ of cations to anions that result in a net charge of \_\_\_\_\_\_\_\_\_\_ (balanced charges!).
	+ For example, the compound formed from calcium (Ca2+) and phosphate (PO43−) ions would have the formula \_\_\_\_\_\_\_\_\_\_\_\_\_\_. The 3 ions of Ca2+ have a total charge of +6, and the two ions of PO43−have a total charge of −6.

*The formula of every neutral ionic compound must always have balanced charges.*

* If an ionic compound is \_\_\_\_\_\_\_\_\_\_\_\_\_ in water, it will \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ into individual ions. *E.g.,* there is no such thing as NaCl (aq). When NaCl dissolves in water, it splits into \_\_\_\_\_\_ ions and \_\_\_\_\_\_ ions. This solution of positive and negative ions conducts electricity, and is called an \_\_\_\_\_\_\_\_\_\_\_.
* Ionic compounds are soluble in water if the sum of all of their attractions to the \_\_\_\_\_\_\_\_\_\_ molecules is greater than their attraction to \_\_\_\_\_\_\_\_\_\_\_\_\_. A good rule of thumb (though there are exceptions) is that almost all compounds with alkali metal and halogen ions are \_\_\_\_\_\_\_\_\_\_\_. Most (but not all) compounds that contain ions with charges \_\_\_\_\_\_\_\_\_\_\_\_\_ than +/-1 typically form \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

**Molecular Compounds:** made of all \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ elements.

* Molecular formulas for compounds can vary greatly since non-metals can take-on multiple different \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. Therefore, the formula must be derived from the \_\_\_\_\_\_\_\_\_ (covered below) rather than simple ion charge balancing.
	+ Overall charge (\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_) should still be neutral, just like with ionic compounds…unless it’s a polyatomic ion group.
* Complex molecular compound formulas are usually written out as structural formulas (ie CH3OH or CH3COCH3) to help discern the atomic arrangement.

**Nomenclature (Naming Compounds)**

Ionic Compounds: The name of an ionic compound is simply the name of the cation (positive ion) followed by the name of the anion (negative ion).

Acid Nomenclature: Chemically, acids behave like ionic compounds in which the cation is H+. (Ionic compounds \_\_\_\_\_\_\_\_\_\_\_\_\_\_; acids are covalent compounds that \_\_\_\_\_\_\_\_\_\_\_\_. However, in both cases the result is ions in solution.) Acid names are based on the name of the \_\_\_\_\_\_\_\_\_\_\_.

* If the anion name ends in “—ide”,
* If the anion name ends in “—ate”,
* If the anion name ends in “—ite”,

## Molecular (Non-metal) Nomenclature: Molecular compounds (made of all non-metals) are named by describing the molecular formula, using \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ for the numbers.

## You will need to memorize the number prefixes for the numbers 1–10.

* E.g., P2O5 is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\*\*Note that the prefix “mono—“ is never used with the \_\_\_\_\_\_\_\_\_\_\_ element. SO3 is simply \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. However, “mono—“ is always used when there is only one of the latter element. *E.g.,* N2O is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

* CO (carbon monoxide) is an easy-to-remember example that shows when to use “mono—“ and when not to.

Formulas and names are always listed from lowest to highest \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (electropositive to electronegative), except in the case of organic compounds (carbon compounds other than oxides and carbonates), which have their own rules.

Organic Nomenclature: Organic compounds (molecular compounds containing carbon) have their own naming system, which will be addressed later in this course.