Everything you ever wanted to know about chemistry for the mid-term,
but were afraid to ask..

Text book summary

Chapter One - Introduction

Chemistry is the study of matter and how it changes or interacts with other matter. Chemistry can be in the form of inorganic chemicals such as sodium chloride (table salt) or organic molecules such as glucose (basic sugar). Chemicals exist in different phases, which are: solids, liquids or gases, and can change from one phase to another under specific conditions. Chemistry is important in many aspects of our life, such as medicine, food production, fire prevention, commerce, environment, art, and more. Everything is chemistry in that everything is made up of matter and matter is what we are learning about.

We use science and scientific methods to measure matter. These measurements help us to understand what is happening. Matter, chemistry follows many "rules" which we can decipher and learn about. There is nothing magical about chemistry, matter reacts in certain ways but not other ways. We will use many examples to show basic concepts of chemistry. Since there are millions of different types of substances, we cannot possibly learn every single reaction, but in our class we will overview the most important ideas using varied substances.

In our class it is important to remember a key point. Paper is cheap, knowledge is valuable. This is a silly quote from your teacher, but over and over students will find themselves being close to understanding some of these concepts but getting wrong answers because they are "too smart" to work out all the details on paper. Without correct units numbers are random strings of meaningless digits, they might as well be phone numbers. If your units do not cancel correctly, that means the digits with them are in the wrong place. Existence exists (said a smart lady one day), don't write out formulas with units then just "overlook" the fact that the units that should cancel don't. You can't fake chemistry; It works. But only if you take a minute longer to do the right thing. Units are important, and you need to be able to see what you are doing on paper. Don't cheat yourself by making mistakes that you shouldn't.

Chapter Two - Matter

Matter is stuff. All stuff is matter. Anything that takes up space and has mass is matter. Matter has properties, both physical ones as well as chemical ones. A physical property is one that can be measured without changing the substance's composition, such as: phase, color, melting point, boiling point, hardness, solubility, odor, or density. These properties can help chemists identify what the substance is, or be used to separate different substances from each other.

Matter can undergo physical changes without changing the chemical composition of the substance. You can change the phase, crush, bend, dissolve, etc. them.

Matter can be pure or mixed with other matter. It is classified as follows: mixtures are physical blends of matter that can be separated by physical means. These mixtures do not have uniformity, meaning that they are not homogeneous (the same throughout). Tossed salads are mixtures, as is a jar full of sand and salt and sugar. Even shaken up these three substances will not be "perfectly" mixed into a homogeneous new substance. Mixtures are heterogeneous. Mixtures that can be homogeneous are solutions. Solutions are substances dissolved into water (or other liquids).

Compounds are when two or more substances are chemically changed into a new substance. Compounds are always pure substances, they are homogeneous. Matter made up of only one kind of pure substance are called elements, which are listed in the Periodic Table of elements. Compounds are not easily separated but most can be broken down into their components in a chemistry lab. There is a great diagram about this on page 38 in your text.

In a chemical reaction the reactants are changed into products. The properties of the reactants are unique to the substances that they are. The new product has its own properties that are not a combination of the properties of the reactants. For example, a highly reactive metal sodium will combine with the poisonous gas chlorine to form sodium chloride which is necessary for us to live. Together they are needed, separately they'd kill us. The reactants follow certain "rules" when combining. We can learn these rules and make predictions as to what will form, and how much will form (chemical naming of compounds and Stoichiometry). The Law of Conservation of Mass tells us that matter cannot be created or destroyed in a chemical reaction. The mass of the reactants equals the mass of the products. The number of atoms of reactants equals the number of atoms in the product.

Chapter Three - Measurement

We can measure two ways, qualitative measurements and quantitative measurements. A qualitative measurement considers the qualities and has no exactitude. I am a tall, smart and handsome man (I think so, and I think my wife does too!). How tall, how smart and how handsome? A qualitative measurement is hard to compare scientifically with others. Color change, for instance, is a good indicator of a chemical reaction, but what color blue did something change is another. Although qualitative measures are important, as chemistry students we will try to use quantitative measurements as a rule. A quantitative measurement has numbers and units. Five feet eight inches tall, IQ of 187 (in my dreams!) are both examples of quantitative measurements (we'll discuss % Error later on). Measuring handsomeness is more difficult to quantify.

Scientific notation, powers of ten is important mathematically. You will need this ability especially when working in moles and numbers of particles in quantities of a substance. It's in the text, please check that you grasp it.

Accuracy, precision and error are all words and concepts to know. To be accurate means to be very close to the actual value. If your bathroom scale says you weigh in at 150 pounds and the expensive doctor scale says you are really 149 pounds, you could say that your scale is pretty accurate. If you weigh yourself on your nine friends' scales when you visit them, and each time their scales say 145 pounds, those scales are not accurate but since they all read the same weight they are called precise. The difference between the measured amount and the actual amount is called the error. The error for the first scale is just one pound. The error for your friends' scales is 5 pounds. We often use %Error in our class. That is the mathematical percent of how far off your measurement is. The formula is on the back of your reference table. The unit of your answer is ALWAYS percent. The units of your measurements cancel from numerator and denominator. A negative percent error means your measurement is below the actual value, a positive percent error means you measured too more than the actual value.

Significant figures is part of the measurement that shows how exact you measured. When measuring you read your scale (ruler, thermometer, graduated cylinder, etc.) to the unit you can see on the scale of the tool, plus an estimation of one more place. If your thermometer reads in degrees centigrade, any temperature you measure should be to the tenth of a degree. (what you read, plus one more place). When using numbers in mathematical operations, your answer cannot lose exactitude nor gain any. Your answers in equations are limited to the number of significant figures in your problem, no more and no less. Rules for significant figures is in the textbook.

Units in class are almost always metric. Sometimes we need to convert from the common English units, such as pounds or inches, to use our formulas. Metric units are almost always the ones we need to do our math. Temperature is measured in centigrade, but can be in Kelvin as well. Mass is almost always grams, but you need to look at the units in the math to be sure which to use.

Writing out your units is key to making sure your math works correctly. Omitting the units leaves you with phone numbers rather than useful measurements. Be sure to write out your units with plenty of space to make sure you cancel them correctly.

Density is a physical property of all matter. It is the measure of mass over volume for any substance. Higher density liquids sink while lower density liquids float on each other. Higher density solids sink in liquids. Water has a density of 1.00 gram/cm^3 or 1.00 gram/mL. For pure water 1g = 1cm^3 . Density measurements for most elements are on your reference tables. You should be able to determine the density of any substance by using the density formula (also on your reference table). If you know the density and mass you should be able to determine the volume of the substance, or solve for the missing mass if you know the density and the volume.

Temperature is technically a measure of the kinetic energy. Heat is energy, and energy causes movement of molecules. The more kinetic energy the higher the temperature. We use thermometers to measure this energy. Fahrenheit scales are common in our real life, but we will use centigrade (or Celsius) instead. Water freezes at 0ºC while it boils at 100ºC. We can also measure in the absolute zero scale known as Kelvin. Table A shows the connection between centigrade and Kelvin. You should be able to convert between these two scales when necessary.

Chapter Four - Problem Solving

It's the math now. You should be familiar with scientific notation and the rules of adding, subtracting, dividing and multiplying with scientific notation. You should know these rules well enough to do this math on paper, or at least know how to use your fancy calculators to do this math. The problem with only knowing how to use the calculators is this, on the regents exam you can only use a four function calculator which will not have a second function EE mode. Learn the rules or else.

We also learn here the concept of dimensional analysis. With this process we easily convert one measurement into other units. These can be simple one step conversions such as grams to moles, or inches to yards. Dimensional analysis can also let you string together three or many more conversions in a row. If all the units cancel (numerator to denominator) you can make major changes to units without changing their absolute values (such as miles to millimeters, or gallons to cubic centimeters). There are rules that you must follow which boil down to this one rule: Make Sure Your Units Cancel Every Step Of The Problem. You can do many one step conversions, or one long multistep problem and get the same answer. Keep significant figures in mind whenever doing mathematics. All conversion factors in dimensional analysis equal ONE, because the value of the numerator equals the value of the denominator. This is the case only when the units are included. 12 inches is the same as 1 foot but 12 does not equal 1 of course. It's the units that allows the numbers to become equal. It's all about units. Paper is cheap, knowledge is valuable when doing math. Don't squeeze your mind or your math. Spread it out so you can see exactly what you are doing.

Make sure you recognize metric proportions (Table C) and understand the powers of ten that puts them in these proportions. Know how to convert from one metric unit to another. Basic metric to English conversions are not required by NYS Regents, but knowing that ONE POUND equals 454 grams is important to remember. There are 2.54 cm in one inch. There are 1.06 L in one quart. 212ºF is the same as 100ºC. Knowing this will make you a better person (trust me).

Chapter Five - Atoms and Atomic Structure

In the beginning there were atomos, so declared Democritus the Greek philosopher who gave matter some thought one day. He was not a scientist but a thinker. He did no experiments and logically came to this conclusion. Atomos was what you would get if you cut a thing in half over and over again until you reached to ultimately small part of a substance that could no longer be cut in half. Remarkable idea (although wrong). It held up for thousands of years. Atomos of all substances, fish, rocks, people, etc., made logical sense to Democritus. Since even you already know about atoms, molecules, compounds, etc., you understand so much more than he did, you realize that most substances are made up of chemical compounds made of the 113 or so pure elements in specific combinations. He was smart and wrong, and would likely have made a great guest for dinner.

Finally in the late 1700's John Dalton decided to invent modern chemistry using experiments. He wrote up the basis of atomic theory. His ideas that transformed chemistry included: elements are composed of tiny, indivisible particles called atoms (from the Democritus idea), atoms of the same element are identical and atoms of different elements are different from each other, atoms can mix together or chemically combine into new compounds in simple whole number ratios, and finally, chemical reactions occur when atoms of one element are separated from or combined with atoms of other elements, but are not "turned into" atoms of other elements. This was not a bad set of thoughts considering he was doing his thinking in a barn in England right around the time Washington and Jefferson were plotting the separation of the American colonies from Mother England.

Dalton was smart and it took nearly 100 years in the mid to late 1800's for a guy named JJ Thompson to come up with the next step. He used a cathode ray tube (see page 109 in text) to discover the electron. He put this electron into the positive "pudding" of the atom. His model, the "plum pudding" model made the leap forward that atoms have a positively charged portion with negatively charged electrons embedded into it.

In 1911 Ernest Rutherford came up with what I believe is one of the top 10 experiments of all time, the gold foil experiment. By shooting a beam of alpha particles (helium nuclei, 2 protons, 2 neutrons, no electrons) at a thin sheet of gold foil, most of these particles passed directly through untouched, hitting a fluorescent screen (so he knew that they hit and where). Some particles were deflected and some even bounced back. He determined that atoms (in this case of gold) were made up of dense, positively charged matter centrally located, while electrons seemed to fly around some distance away (relatively far from the nucleus but very small in actual distance we can measure). The nucleus was positively charged (or else the positive alpha particles should have stuck to the gold nuclei) and dense enough to be able to knock the alpha particles in different directions.

Rutherford did have a big problem that he could not solve though. His electrons flew around the nucleus but seemed not to ever lose energy which makes no sense, and they have no apparent attraction for the positively charged nucleus. Why didn't they collapse into the center of the atom? Lucky for him his student Neils Bohr was more mathematically gifted and put these electrons is specific orbitals, and assigned them specific energy levels. As long as they stayed in the orbitals they never lost energy and didn't have to fall into the nucleus.

In 1866 (during the Civil War in America) protons were discovered. In 1932 James Chadwick discovered the neutron. These momentous discoveries deserve more but we will let this note suffice.

Atoms have different numbers of protons, electrons and neutrons. Protons are positively charged, electrons of course are negative, and neutrons have no electrical charge. All atoms have an atomic number on the Periodic Table of Elements. The atomic number indicates how many protons an atom has, which is always equal to the number of electrons. The positive and negative charges balance each other, making ALL ATOMS NEUTRAL. Atoms also have neutrons, located in the nucleus with the protons. Nuclei are positively charged (protons being + plus neutral neutrons is net positive). The atomic mass of an atom is made up of protons and neutrons, the mass of electrons is thought to be zero in our course. Electrons do in fact have some mass and this mass is real, but is so small that for our purposes we discount it as negligible. Each proton and each neutron (in our class) is said to have mass of one atomic mass unit (amu). Add the protons and neutrons to get an atom's atomic mass.

To determine the number of neutrons, subtract the atomic number from the atomic mass. The mass left over represents the mass of the neutrons. Neutron number can be the same as the number of protons but does not have to be.

Dalton said all atoms of the same element were identical. He did not think up isotopes. Isotopes are atoms with the same chemical properties, the same number of protons and electrons as each other, but they have different numbers of neutrons. Since neutrons are neutral, and have little to do with any chemical properties, isotopes are chemically identical but not of the same mass. The atomic masses on the periodic table are mostly long decimal digits with units of amu. That is because even though each type of isotope has an exact whole number of protons and neutrons, giving each one a simple whole number mass, the proportions of the isotopes are not in whole number proportions. The atomic numbers on the periodic table represent the "average" of all types of isotopes taking in consideration their proportions as well. Figuring out the average atomic masses of elements from their known isotopes is required. To do this, multiply the proportion by the mass for each isotope, then add the masses together. The total is the "average atomic mass" for the element.

When looking at the atomic mass of any element, for example look at element number 33 Arsenic, let us examine the numbers and make sense of them all. Number 33 means this atom has 33 protons and 33 electrons. The atomic mass of As is 74.9216 amu. That means we will round it to the nearest whole number so we'd say the mass of one atom of arsenic is 75 amu. Since the total atomic mass is the mass of protons and neutrons, 75 total amu's minus 33 that are protons leaves you will 42 amu's that must be the neutrons. Electrons have no mass to count in our class. 75 amu is of course different than 74.9216 amu, this can be explained by isotopes. All the isotopes of As have an average atomic mass of 74.9216, but each particular isotope has a whole number mass since it's made up of only whole numbers of protons, neutrons and electrons. The proportions of each kind of isotope lead to decimal masses on the periodic table. The isotope most common of As must be 75 amu, since the average atomic mass is closest to that whole number mass.

The amu mass is based upon the isotope of Carbon called Carbon-12. One twelfth of this isotope is equal to the mass of ONE AMU. Carbon-12 is the particular isotope of the atom carbon that we base atomic mass.

The elements are arranged into the Periodic Table of Elements designed by the Russian scientist Demetri Mendeleev. He put the elements into a strangely shaped but clearly organized table so that elements with certain properties would be in the same vertical columns called groups. Groups are vertical, periods are horizontal rows. Page 124 of the text shows these sections of the table, which you need to recognize: alkali metals, alkaline earth metals, transitional metals, other metals, non-metals including the noble gases. Inner transitional metals are placed below the table and are the "Hawaii and Alaska" of the table, they don't fit where they belong so they are quite literally stuck at the bottom where they can be added in, like the two last states on a map of our country. Hydrogen is apparently in group 1, but is not attached, as it is not a metal even though it has many similar properties to group one metals.

Metalloids are elements that follow the dark steps between metals and non-metals. Any element that touches that step line are either metals or not, but have some crossover properties. Silicon for example is clearly a non metal but has remarkable luster, which is a metallic property. Note, aluminum and polonium are both metals that touch this line, but are NOT METALLOIDS. Sometimes in order to make an orderly table that works there are some exceptions, this happens to be two exceptions to "a rule" of this table.

Electrons are negatively charged and are in equal number to the number of protons in any atom. That makes the atoms all electrically neutral. The electrons are not in the nucleus, rather they quite literally fly around in what used to be called orbits (like planets circling the sun). Modern atomic models make this pathway that electrons follow obsolete, now we understand that electrons are flying around in "electron clouds", that 90% of the time electrons are somewhere in the cloud, but that they do not follow specific pathways like planets do. The electron cloud model is more a statistical concept than an actual physical one.

Electrons are located in orbitals, and each orbital has specific energy levels associated with them. The closer to the nucleus the lower the energy level. Electrons fill up the lowest energy levels first, and as electrons are added (with subsequently larger and of course different kinds of atoms) higher energy levels are filled next. Some larger orbitals have sub orbitals which adds to complexity, but that is not in this course material.

The number of electrons that fit into orbitals, the electron configurations, are as follows: the lowest energy level fits just 2 electrons. The next orbital fits up to 8. Third orbital can be full at 8 electrons as well, but can also fit up to 18 and be full at 18 electrons. The larger size allows for this fact.

Sometimes electrons can gain energy from outside the atom (heat, light, electricity, etc.) and this will allow the energized electrons to jump up to higher energy orbitals than usual. Atoms usually have all electrons in the lowest energy level possible, which is called the ground state. When one or more electrons have the energy to jump to higher than usual orbitals these atoms are said to be in the excited state. The gain of energy provides the energy to get electrons into higher orbitals. This state does not last long, and when the electrons return to the ground state, they give off the energy than had just gained. This energy that is given off can often be measured as visible light. This visible light is called spectra, and is unique to particular atoms (or molecules) that get excited, because the electrons jump from and to particular orbitals, and when they return to their normal ground states they emit a particular amount of energy that is the same all the time.

Spectra can be observed with refractive lenses, and the pattern of colors and the distances between colors create a specific pattern that can be recognized as unique to a particular atom or molecule. This uniqueness allows scientists to peer into space and determine what compounds and elements can be found on distant stars and planets. The spectra are the same throughout the universe, as they are unique to specific kinds of matter, and can be read through a telescope as well as with funny in class refractive lenses.

Spectra are only seen when the electrons jump back down to the ground state, giving off the energy that they'd gained previously. Getting excited is not a chemical reaction, and neither is returning to the ground state. It does not mean a gain or loss of electrons, just a rearrangement of them temporarily.

Chapter Six - Ionic Bonding & Molecular

Atoms will combine with other atoms to form new substances, called compounds. Compounds can be formed between metals and non metals, or two non-metals. Metals do not usually combine together chemically. Because metals have a variety of chemical properties (that is why they are found in many different groups on the periodic table) they will combine in various ways with non metals. They will be named particular ways as well. Non metals combine together in different ways than the metal-non-metal pairings and we will name them accordingly. Of course more than two kinds of atoms can combine together, there are only about 113 elements (types of atoms) but many millions of compounds that they form into, and likely many more millions that have not yet been discovered.

Atoms have particular electron configurations which are clearly labeled on your periodic tables. Only noble gases have "complete" outer orbitals, they have a sort of "perfect" balance. This accounts for their lack of making compounds. They are called noble gases as a sort of insult, as the nobility of years ago would not mingle with the commoners, the noble gases do not make compounds with the more "common" elements. Earlier the noble gases were also known as inert gases for their total lack of ability to form compounds, but modern chemists have found that some of the larger noble gases, Krypton and Xenon, can make some compounds under unusual conditions. They are no longer inert but they remain mostly disinterested in making compounds.

All other atoms like to be neutral, with their positive protons balanced with the negative electrons. But, they'd love to be like the noble gases, to have complete outer orbitals. Since love trumps like, chemistry moves forward. Atoms in group one all have the same number of electrons in their outer most orbital, that being one. Since each of them would love to have a complete outer orbital more than they like being neutral, they tend to form what are called ions. Ions are atoms with a different number of electrons than the number of protons they have. The ions are therefore electrically charged. Atom number 11, sodium has an electron configuration of 2-8-1 (eleven electrons total). To complete that outer orbital would take the gain of seven more electrons, which is hard to do compared to losing the one outermost electron, leaving the second orbital full. Easy is easier than hard, so sodium atoms will often shed their last electron, leaving themselves with a complete outer second orbital and a net charge of +1. All atoms in group one make a +1 ion.

Group 2 atoms all have 2 electrons in their outermost orbital, and since it's easier to lose 2 electrons than to gain six, they all tend to form into +2 ions, having 2 more positive protons than the new number of electrons. Groups 3 to12 do some complicated switches which I will get to soon. Working back from group 18, noble gases have no tendency to gain or lose electrons since they already have complete outer orbitals, hence make no ions. Group 17 (F, Cl, Br, I, and At) all have seven electrons in the outer orbital. It's much simpler to gain one than lose seven, so these atoms will gain an electron to fill up the outer orbital. This makes them all have a net electrical charge of -1 (one extra negative electron compared to the number of protons). Group 16 will all make -2 ions. Group 15 will make -3 ions. Group 14 are special as they can just as easily gain four as lose four electrons to fill the outer most orbital, so they can make either +4 ions or -4 ions. Group 13 will be able to lose 3 electrons easiest so they become +3 ions.

Transitional metals are special in that many of them can make different kinds of ions, depending upon how many electrons they lose. The reasons why they lose different numbers of electrons in different situations is outside the scope of our course, but they do. They have to be looked at individually after we learn a bit more below.

When a positive ion is formed, it is called a cation. Cations are positive ions, atoms that have lost some negative electrons leaving them with a net positive (+) charge. Anions are the opposite, atoms which have gained electrons to form complete outer orbitals gain negative charge. Negative ions are called anions and have a net negative (-) charge.

When compounds are formed by different ions coming together they form into neutral ionically bonded compounds. NIBC means that the cations charges are balanced by the negative charges of the anions. When naming these there are rules to follow. Cations are always said first, anions second. The atom name of the cation is said as is, the anion name ending changes to -ide. For example: sodium makes a +1 cation, chlorine makes a -1 anion. They form sodium chloride (not sodium chlorine) and the one (+) is balanced by the one (-) charge. They become neutral in a 1:1 ratio, so sodium chloride is written as NaCl and is neutral.

Calcium makes a (Ca^{+2}) charged cation and can also combine with the chloride anion (Cl^{-1}). In order to be a NIBC it will take 2 chloride anions to balance the single double positive calcium cation. They form into calcium chloride, written as $CaCl_2$.

Cation name for the atom first, then change the anion name to end in -ide second. Make sure that the positive and negative charges are balanced by adding subscripts in your chemical formula.

When transitional metals such as Iron combine with anions, iron can make a +2 or a +3 cation. Since when these form into a compound with oxygen (for example) both would be iron oxide, which cannot be since they form into 2 different compounds with different properties. To manage this problem we have the stock naming method for transitional metals.

Fe^{+2} + O^{-2} ---> FeO which is neutral. This reaction shows iron with a +2 cation and forms into what is called iron (II) oxide. The roman numerals indicate what cation of iron was in this compound (the +2 ion gets the II roman number)

But if it were Fe^{+3} + O^{-2} ---> Fe_2O_3 which is also neutral and would be called iron (III) oxide. The cation difference is noticed by the roman numbers, and that is how to tell the two kinds of iron oxide apart.

Roman numerals are used whenever a transitional metal can make more than one kind of cation. Mn can make four different ones (II, III, IV, and VII) while Nb makes two (III and V). Zinc is a transitional metal that does not make more than one cation and so the roman numeral is not needed, if Zn is an ion it is only a +2 cation.

We do not use roman numerals for group one metal ions because they only make +1 ions all the time. Group 2 metals do not get roman numerals either since they only make +2 ions always.

Anions do not get roman numerals ever. They are only for transitional metals in ionic compounds, and only if that particular transitional metal can make more than one kind of cation.

When molecular compounds combine from 2 non-metals coming together they do not combine as an ionic compound, but rather as one called covalent. The electrons are not lost and gained by the pairs of atoms, rather the valence electrons are shared. Since both atoms need to try to complete the outer orbitals and there are not enough electrons to just all the atoms' outer orbitals, a sharing situation arises. Hydrogen can only fit two electrons in its outermost orbital, otherwise all other covalent compounds aim to get eight electrons in their outer orbits by sharing.

Compounds such as carbon dioxide or sulfur trioxide are examples of 2 non-metals combined. We use the Greek prefixes to name these compounds, which in order from 1 to 10 are: mono, di, tri, tetra, penta, hexa, septa, octa, nona, and deca. When naming the first part of the compound, if it is a single atom we omit the mono- prefix, like our first two examples: carbon dioxide or sulfur trioxide (rather than mono carbon dioxide or mono sulfur trioxide). Carbon dioxide has one carbon bonded to 2 oxygen atoms. Sulfur trioxide has one sulfur with three oxygen atoms.

Molecular compounds (2 non-metals combine together soon)
When we combine two non-metals, the combinations that are possible are outlined using the selected oxidation numbers from the periodic table.

Let's look at all the combinations of carbon and oxygen... carbon has three oxidation states listed while oxygen has only one. These oxidation numbers must pair together to add to zero to form a compound. Only ratios that make zero can exist.

The negative four (-4) oxidation number of carbon cannot combine with the -2 of oxygen (two negatives cannot add to zero), so we just don't use the -4, it can't work with oxygen.

A +2 carbon combines with the -2 oxygen in a 1:1 ratio to form CO or carbon monoxide. The +4 carbon can combine to the -2 oxygen is a 1:2 ratio, forming CO_2 or carbon dioxide.

carbon	oxygen	possible compounds	names
-4 +2 +4	-2	--- CO CO_2	--- carbon monoxide carbon dioxide

If we examine carbon and fluorine compounds, we see carbon has the three oxidation numbers, fluorine has one a -1. Let's see how they combine...

The -4 carbon oxidation number cannot combine with the -1 fluorine, so we leave that out.

The +2 carbon can combine with two of the -1 fluorine atoms in a 1:2 ratio.

The +4 carbon can combine with four of the -1 fluorine atoms in a 1:4 ratio.

carbon	fluorine	possible compounds	names
-4 +2 +4	-1	--- CF_2 CF_4	--- carbon di-fluoride carbon tetra-fluoride

Occasionally some atom pairs with have more than one combination of oxidation numbers that yields the same ratios of atoms. If the same ratio comes up more than once, we only need list it one time.