CHAPTER 12: TOP CONFUSIONS IN ORGANIC CHEMISTRY

Do you feel confused by similar concepts in chemistry? Do you mix up terms like sulfide and sulfite, or symbols like Mn and Mg? Well, you are not alone. There are many confusing terms in organic chemistry. Here is the countdown of the most frequently confused terms and concepts:

1. Formal Charge and Oxidation Number

There are two distinct ways to account for valence electrons in molecules: formal charges and oxidation numbers. Both methods compare the number of valence electrons an atom has in its free form to the number of valence electrons the atom is assigned in a compound.

The **formal charge** is defined as the electrical charge difference between the number of valence electrons in an isolated atom and the number of electrons assigned to that atom in a Lewis structure.

The **oxidation number** of an atom is defined as the number of hypothetical charges an atom would have in a molecule (or an ionic compound) if electrons were transferred completely in the direction indicated by the difference in electronegativity.

In an ion composed of only one atom, the oxidation number of an atom equals the charge on the ion. Here is the rule for covalent molecules: *The sum of all the oxidation numbers in a molecule is equal to the charge on that molecule*.

Here are general rules for oxidation number and total charge:

A single element species has an oxidation number of zero (Na, H_2, Cl_2).

The sum of oxidation numbers of all atoms in a neutral compound must equal zero.

The sum of oxidation numbers of all atoms in an ionic compound must equal the molecule's ionic charge.

Oxygen in a compound has the oxidation number of –2, except in peroxides, *e.g.* H_2O_2 (-1).

Hydrogen in a compound has the oxidation number of +1, except in metal hydrides (-1).

2. Temperature and Heat

They are not the same. **Temperature** is a measure of the intensity of heat energy. **Heat** is a measure of the total amount of energy. An entire field is devoted to the study of heat – it is called thermodynamics.

Heat Added = (Mass)(Specific Heat Capacity)(Change in Temperature).

A glass of water and a pool of water may be at the same temperature, but they contain vastly different amounts of heat. It takes much more energy to raise the temperature of a swimming pool 10°C than it does a glass of water – the difference here is the mass, as the equation above illustrates.

3. Ionic Bond and Covalent Bond

A bond is formed from the overlapping of electrons between atoms. In one extreme, one atom takes all the electrons and the other one gets nothing – this is an example of an **ionic bond**. In the ionic bond, an electron is **transferred** completely from one atom to another. The atom donating the electron becomes positively charged, and is called a **cation**. The atom accepting the electron then becomes negatively charged, and is called an **anion**. Ionic bonds are seen mostly in inorganic compounds. An example of an ionic compound is table salt (sodium chloride, NaCl).

However, in **covalent bonds**, electrons are **shared** by two atoms to complete the octet in the outer shell for both atoms involved. It is the bond found in most organic compounds. A simple example of a covalently bonded compound is methane (CH_4).

Table 12-1 Comparison of Ionic and Covalent Bonded Compounds

Properties	Ionic Bond	Covalent Bond
Element Type	Metal-metal, nonmetal-metal	Non-metal-Non-metal
Orbital Interaction	Separate	Overlap
Electron	Total transfer of electrons	Shared electrons
Phase Change	High melting and boiling points	Low melting and boiling points
Phase	Solids at room temperature	Liquids and gases at room temperature
Bond	Strong bonds	Weak bonds
Solubility	Soluble in water	Insoluble in water
Conductivity	Conductive	Not conductive
Hardness	Hard and brittle	Soft
Compound Type	Inorganic	Organic

4. Atomic Number and Atomic Mass Number

In the periodic table, a symbol is used to designate an element, and each atom is characterized by two numbers. The **atomic number** is at the lower left of the symbol, and **atomic mass number** is at the upper left as shown below for the element carbon (C):

$${}^{12.011}_{6}\mathrm{C}$$

Atomic Number: Its value is equal to the number of protons in the nucleus. In the above example, carbon has an atomic number of 6.

Atomic Mass Number: Its value is equal to the number of protons plus the number of neutrons in the nucleus. The example of carbon shows the atom has an atomic mass number of 12.

Chemically, an atom is made of three species: **Neutrons**, **Protons**, and **Electrons.** The nucleus of the atom contains the protons and neutrons. However, for the most part chemists focus their attention on the electrons, which govern the chemical properties and reactivity of any molecule.

5. Bonding Pair and Lone Pair Electrons

These two concepts are used throughout every level of chemistry. One of the most widely used yet simple models of these concepts is the **Valence Shell Electron Pair Repulsion theory** (VSEPR), which is used to predict molecular structure based on the influence of valence electrons, including lone pairs. The basic idea is rather simple; electron pairs should be kept as far apart as possible due to their electrostatic repulsion.

Bonding Pair of Electrons: A pair of valence electrons in a molecule that is involved in bond formation.

Lone Pair (or nonbonding) of Electrons: A pair of valence electrons in a molecule that is not involved in bond formation.

To predict the geometrical structure of simple molecules, you can use the following simple rules:

AX_2 – Linear

AX_3 – Trigonal Planar

AX_4 – Tetrahedron; **AX_3E** – Trigonal Pyramid; **AX_2E_2** - Bent

AX_5 – Trigonal Bipyramid

AX_6 – Octahedron

A – Central Atom; X – Bonding Pair; E – Lone Pair

Note: In the more sophisticated molecular orbital theory, there are also two similar named concepts – bonding molecular orbitals and antibonding molecular orbitals. However, these two are very different concepts (delocalized and molecular in nature) than the pair (localized and atomic in nature) in VSEPR theory.

6. Entropy (S) and Enthalpy (H)

If you understand the difference between these two concepts, you will understand thermodynamics, which is a very important subject in chemistry.

Entropy (ΔS): A measure of the randomness or disorder of a system. Both the second and third laws of thermodynamics deal with the concept of entropy.

Enthalpy (ΔH): The reaction energy that is dispersed from the system to the surroundings.

The sum of these two terms leads to the concept of free energy (ΔG), the basis of energy considerations of all chemical reactions: $\Delta G = \Delta H - T\Delta S$.

If $\Delta G < 0$, the reaction is spontaneous.

If $\Delta G > 0$, the reaction will not be spontaneous.

If $\Delta G = 0$, the reaction is at its equilibrium.

7. Oxidation and Oxidizing Agent

These are some of the most confusing terms in chemistry. You must clearly understand the definitions of these terms in order to learn redox (reduction-oxidation) reactions.

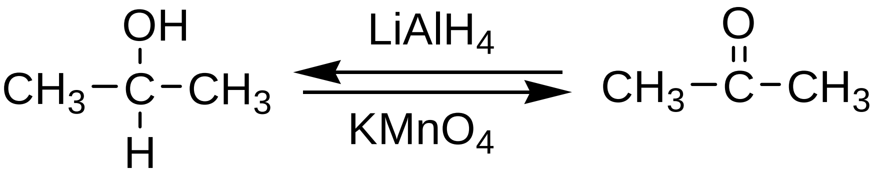
Oxidation – The process of losing electrons (increase in oxidation number). Organic chemists tend to think of oxidation in slightly different terms. For an organic substrate, oxidation usually involves the addition of oxygen (or another heteroatom) or the removal of hydrogens from the molecule.

Oxidizing Agent – The species that undergoes reduction (decrease in oxidation number) as it accepts electrons from the substrate being oxidized.

Reduction – The process of gaining electrons (decrease in oxidation number). With organic substrates, reduction usually involves the addition of hydrogens or the removal of oxygen (or another heteroatom).

Reducing Agent – The species that undergoes oxidation (increase in oxidation number) as it donates electrons to the substrate being reduced.

In the example below, the alcohol on the left is being oxidized to the ketone using potassium permanganate, a potent oxidizing agent. While the alcohol is oxidized, the potassium permanganate becomes reduced. The reverse reaction involves reducing the ketone to the alcohol using a reducing agent known as lithium aluminum hydride. While the ketone is reduced, the lithium aluminum hydride is oxidized.

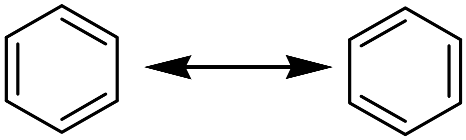


$$CH_3-\underset{H}{\overset{OH}{C}}-CH_3 \underset{KMnO_4}{\overset{LiAlH_4}{\rightleftharpoons}} CH_3-\overset{O}{\overset{\|}{C}}-CH_3$$

Note: An oxidation number is a number used to keep track of the redistribution of electrons during chemical reactions. The sum of the oxidation numbers of all atoms in a neutral compound is zero.

8. Resonance (↔) and Equilibrium (⇆)

Resonance (A ↔ B): When resonance exists in a molecule, two or more equivalent Lewis structures can be drawn for that molecule. These structures will differ only in the placement of their electrons. The two-headed arrow shows that an electronic structure of a molecule can be represented by more than one resonance structures.



Two Resonance Structures of Benzene

Equilibrium (A ⇆ B): In terms of concentration, when equilibrium is reached, the concentration of all species on both sides of an equation has reached a constant with time. The double arrow shows that a reaction can occur in either direction. When in equilibrium, the rates of the forward and reverse reactions are the same.

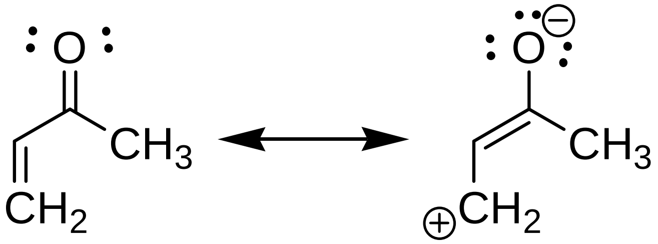
$$2H_2O \rightleftharpoons H_3O^{\oplus} + {}^{\ominus}OH$$

Dissociation of Water at Equilibrium

9. Resonance Structure and Resonance Hybrid

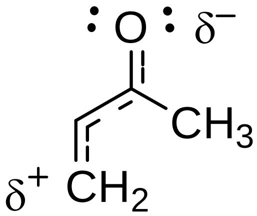
In the theory of resonance, there are two types of structures that can be drawn for certain molecules and ions.

Resonance Structure: Lewis structures that differ from one another only in the position of their electrons. A single resonance structure does not adequately represent a molecule. These structures are also known as **resonance contributors**.



Resonance Structures of Methyl Vinyl Ketone

Resonance Hybrid: A Lewis structure that is a compilation of the various **resonance contributors** for a molecule or ion. Resonance hybrids better represent a molecule or ion's structure than the individual resonance contributors.



Resonance Hybrid of Methyl Vinyl Ketone

10. Spectroscopy and Spectrometry

Spectroscopy: The study of the interaction between electromagnetic radiation and matter. A computer plot of this interaction is called a **spectrum** (or spectra in the plural). Some common spectroscopies used by organic chemists include infrared (IR) spectroscopy, nuclear magnetic resonance (NMR) spectroscopy, and ultraviolet-visible (UV-Vis) spectroscopy. All give important information about the structure of organic molecules.

Spectrometry: The measurement of the interaction between electromagnetic radiation and matter. A machine that performs such measurements is called a **spectrometer**. Mass spectrometry is a valuable tool used by organic chemists to determine molecular composition, formula and structure.

11. Exergonic and Exothermic

Exergonic: A process that is accompanied by a negative change in the Gibbs free energy ($\Delta G < 0$) and therefore is thermodynamically favored.

Exothermic: A reaction that gives off heat to its surroundings ($\Delta H < 0$).

Endogonic: A process that is accompanied by a positive change in the Gibbs free energy ($\Delta G > 0$) and therefore is not thermodynamically favored.

Endothermic: A reaction that absorbs heat from its surroundings ($\Delta H > 0$).

As you can see from the above definitions, exergonic and endergonic refer to free energy changes (ΔG) while exothermic and endothermic refer to changes in the internal energy of molecules measured as heat given off or absorbed (also known as enthalpy, ΔH).

The free energy takes into account not only changes in internal energy but also changes in entropy that may accompany a reaction. For most ordinary simple chemical reactions, the entropy factor is not great, so chemists usually speak about enthalpy.

12. pH versus pK_a

pH: A measure of the acidity or alkalinity of a solution that is calculated by the following equation:

$pH = -\log a_{H^+}$

where a_{H^+} is the activity of hydrogen ions in the solution.

pK_a: A measure of a molecule's propensity to give up or accept a hydrogen ion (H^+) and is calculated by the following equation:

$pK_a = -\log K_a$

where K_a is the acid dissociation constant.

The pK_a allows one to compare the acidity of two different compounds.

CHAPTER 13: SPECIFIC CHALLENGES OF ORGANIC CHEMISTRY

Many students find organic chemistry particularly difficult. There is a big misconception that it is just like biology and requires a lot of memorization. Students who approach the course in this manner will typically have trouble achieving success. The best way to learn this subject is to master the basic concepts and the fundamental reactions (including understanding their mechanism), and then apply this knowledge to solving problems.

As you probably already know, organic chemistry is essentially the chemistry of one element—carbon. Carbon makes up approximately 95% of all known chemicals. In fact, there are over two million known organic compounds. Organic chemists seek to learn about the reactions of these carbon-containing compounds, understand the reaction mechanisms, and then apply this knowledge to the synthesis of other compounds.

In the sections that follow, you will read about some of the new topics you will learn in your organic chemistry course. You will also learn general rules and concepts that can help cut your memorization in half and help you when you get stuck on a problem from your homework or exam.

Condensed Description of Organic Chemistry

There is an overwhelming amount of content that must be covered in a typical organic chemistry course. Regardless of the textbook used, the flow of an introductory organic chemistry course is typically the same.

The course always starts with a review of relevant topics initially introduced in general chemistry. These topics range from electronic structure to acid-base theory. This material is very important as it forms the foundation for the following chapters in the book.

Most organic chemistry textbooks organize their remaining material according to functional group, so every subsequent chapter will focus on a new functional group, its nomenclature, ways to synthesize the group, the reactions typical of the functional group, and the step-by-step mechanism of the key reactions.

What are functional groups? Functional groups are specific groups of atoms that impart characteristic reactivity to the molecules that contain them. The simplest functional group, the hydrocarbons, consists of just hydrogen and carbon atoms. Adding additional elements, like nitrogen, oxygen or halogens, introduces new types of functional groups. It is important that students learn their names, their structures, and their properties. Being able to identify a functional group, and having an idea of how it should behave in a reaction, is an invaluable skill in organic chemistry.

Students taking an organic chemistry course will also learn about spectroscopy. Spectroscopy is the study of the interaction between electromagnetic radiation and matter. Techniques that might be covered in the lecture include infrared (IR) spectroscopy, ultraviolet-visible (UV-Vis) spectroscopy, nuclear magnetic resonance (NMR) spectroscopy, and mass spectrometry.

Spectroscopy and spectrometry allow chemists to obtain structural information about the compounds they synthesized in lab or discovered in nature.

The textbooks usually end the course with several chapters on the different types of biological molecules that contain carbon. Examples include proteins, lipids, carbohydrates, DNA, and RNA.

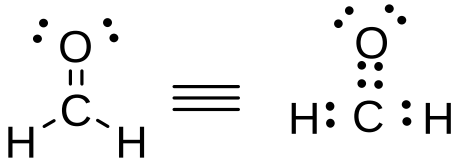
In the end, organic chemistry is centered on synthesis and mechanisms. To understand both of them, just follow the trail of electrons.

Core Concepts Pave the Way to Understanding

Some of the differences between organic chemistry and other chemistry courses have already been discussed. However, organic chemistry shares many of the same basic concepts and ideas with other types of chemistry. To obtain a well-built understanding of organic chemistry, you must start with a broad, strong foundation. The core concepts below will help you do that. Many of these concepts will seem familiar to you as they are usually covered in general chemistry courses.

Core Concept #1: Lewis Structures

You will find organic chemistry is abstract and hard to understand if you do not have a way to visualize the structures. Lewis structures, or electron dot structures, are diagrams that show the bonding between atoms in a molecule and any lone pair of electrons that may exist. A Lewis structure can be drawn for any covalently-bonded molecule.



Lewis Structures of Formaldehyde

Core Concept #2: Polarity

As you will eventually learn in the course, most organic reactions involve nucleophiles (donates electrons to form a bond) attacking electrophiles (accepts electrons to form a bond). Understanding where the electrons are in starting materials provides an excellent way to predict the outcome of reactions. The electron distribution determines the polarity of a molecule (or a bond). Since chemists use electronegativities to predict the polarity of a bond or molecule, it is a good idea to familiarize yourself with the electronegativities of atoms typically used in organic chemistry.

Core Concept #3: Lone Pairs of Electrons

Lone pairs are crucial to understanding organic reactions. Include them in your Lewis structures drawings whether asked to or not. This practice ensures you will not overlook them while trying to solve problems. Always know where the lone pairs are before and after a reaction.

Core Concept #4: Formal Charge

Formal charge is an accounting device that allows chemists to determine the location of charge in a molecule as well as assist chemists in the comparison and assessment of likely Lewis structures.

Knowing the location of the formal charges in a molecule can tell you where a nucleophile might attack it. If you understand Lewis structures, VSEPR theory and the periodic table, you can easily figure out the formal charge of any given element within a compound.

The equation used to determine formal charge appears below:

Formal charge = (# valence electrons in atom) – (# nonbonding electrons) - (1/2)(# bonding electrons)

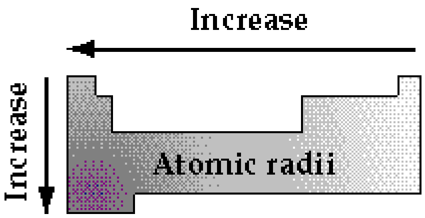
Core Concept #5: Resonance

Resonance is an electronic property that lends a great deal of stabilization energy to a structure. It occurs when a compound has alternating single and double bonds; lone pairs of electrons can also be a part of the resonance of a compound.

Resonance can be used to predict the outcome of a reaction. Where more than one possible product can be produced, the one with resonance is the more likely product.

Core Concept #6: Atomic Radii

The size of atoms is an important consideration in reactions. Spatial interactions (or steric interactions) due to atoms trying to occupy the same space can prevent certain stabilizing forces from occurring (*i.e.* solvation, planarity for resonance delocalization, approach of a nucleophile towards an electrophile, etc.). The graphic below illustrates the trend of atomic radii on the periodic table.



Core Concept #7: Intermolecular Forces

How do you predict the property trends of a given set of organic compounds? The most frequently asked exam questions include asking the student to rank the vapor pressure, boiling/melting points, or solubility of a class of compounds. The answers to such questions rely on the intermolecular interactions between the molecules.

You can learn to rank the strength of intermolecular forces by looking at the compounds' Lewis structures, formal charges, and polarity. You will find these core concepts are interconnected in many ways.

Try to fully understand the core concepts before going on in your course work. You will be thankful to have a strong foundation upon which to build.

General Rules of Organic Chemistry

To some extent, organic chemistry does involve some memorization. All the information that you must know can be overwhelming at times. The memorization becomes much easier with generalization and understanding. The good news is that there are a few general rules in organic chemistry, which will trim your memorization load by 50% and help you understand the course work in less time.

O-Chem Rule #1: The Most Important Question: "Where are the electrons?"

If you look at any synthetic or mechanistic question in organic chemistry, you can always figure out what is occurring by following the electrons.

So here is a general answer to this question: Electrons like to be around more electronegative atoms like F, Cl, O, N, and S.

O-Chem Rule #2: Electronegativity is your Best Friend

Electronegativity is a measure of the attraction of an atom for the electrons in a chemical bond. The higher the electronegativity of an atom is, the greater its attraction for bonding electrons. You should memorize the electronegativity values of the more common elements in organic chemistry. These values can be found in the introductory chapters of an organic textbook.

Remember this: electrons will go where the higher electronegative atoms are.

O-Chem Rule #3: Atoms Prefer Filled Valence Shells

Valence shells, or the outer shells of electrons on an atom, are where all the chemistry takes place on an atom so you can forget about the filled inner shells for now. Atoms in a molecule prefer to fill their valence shells by making new bonds. Why do the atoms do this? You may recall from your general chemistry course that filled valence shells are extremely stable (*e.g.* noble gas elements). The Valence Bond theory explains this observation.

O-Chem Rule #4: Unpaired Electrons are not Welcome

Molecules like to have all their electrons paired up as this is a very stable configuration. Molecules with unpaired electrons (*i.e.* radicals) are often seen reactive intermediates and transition state structures where their energies tend to be higher. They are then stabilized by pairing up electrons or spreading out the electron density to other atoms to form the products.

O-Chem Rule #5: Nature Dislikes Localized Charges

A molecular charge does not want to be isolated on just one atom. If possible, the charge distributes itself over as many atoms as possible via hyperconjugation or resonance. In addition, it is better to have a full or partial positive charge on a less electronegative atom (*e.g.* C or H) and a full or partial negative charge on a more electronegative atom (*e.g.* O, N, F, Cl). Once again, knowing the electronegativity of atoms is very helpful in this instance.

O-Chem Rule #6: Atoms Like More Space

Steric hindrance is an important consideration for reactions. Its effect often can be used to predict whether a reaction will occur and what the preferred products will be. Atoms do not want to bump into each other, and steric hindrance can actually prevent a reaction from occurring. Space-filling models may help to visualize the steric interactions in a molecule. Get to know the relative size of atoms and become accustomed to thinking in 3D. The steric effect will then be easier to understand.

O-Chem Rule #7: Pi Electrons Love to be Delocalized

The delocalization of electrons in a molecule is always a stabilizing influence. The π electrons and lone electron pairs of a molecule prefer to be dispersed over as many adjacent sp^2 hybridized atoms as possible via the resonance effect. Aromaticity is the most stable form of π electron delocalization. The Hückel theory deals with π-bonding in planar molecules like aromatic compounds.

Learn these basic rules of organic chemistry and then apply them in your studying. You will be amazed at how much easier your study load becomes.

Tackling the Challenges of Organic Chemistry Problems

There are several concepts specific to organic chemistry that traditionally give students trouble. We as teachers can rattle off topics that we know will be problematic before we even step into the classroom. Some of these topics are below:

- ✓ Functional groups
- ✓ Nomenclature
- ✓ Stereochemistry
- ✓ Reactions
- ✓ Developing multi-step syntheses
- ✓ Reaction mechanisms (also called “electron pushing”)
- ✓ Biological molecules

The following tips and suggestions should help you avoid some of the common pitfalls inherent in these troublesome topics.

Identifying and Naming Compounds

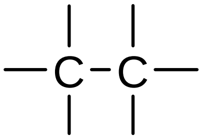
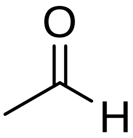
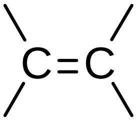
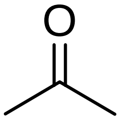
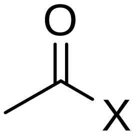
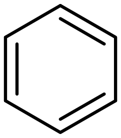
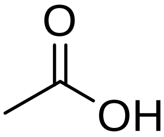
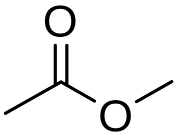
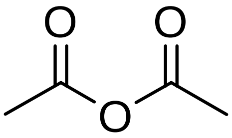
Unlike other chemistry courses you have previously taken, organic chemistry has well defined groups of atoms responsible for the vast majority of the reactivity that you will be studying. One of the first challenges you will face in organic chemistry is learning how to spot the common functional groups and name the compounds that contain them.

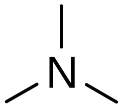
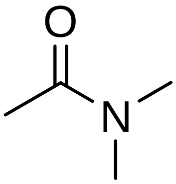
Some professors introduce the functional groups and their nomenclature rules all together while others take a slower approach. However the material is presented in lecture, there are some things you can do to help to ease your way through this first obstacle.

Hunting for Familiar Patterns

It was mentioned earlier that functional groups are specific groups of atoms that impart characteristic reactivity to the molecules that contain them. Some common examples of organic functional groups are in the table below.

Table 13-1: Common Functional Groups

Functional Group	Structure	Functional Group	Structure
Alkane		Aldehyde	
Alkene		Ketone	
Alkyne	—C≡C—	Acid Halide	
Aromatic		Carboxylic Acid	
Alkyl Halide	R−X	Ester	
Alcohol	R−OH	Anhydride	

Ether	R−O−R	Amine	
Thiol	R−SH	Amide	
Sulfide	R−S−R	Nitrile	—C≡N

There are three ways professors typically test your knowledge on these functional groups:

- ✓ The name of the functional group is given and then you must provide the corresponding structure.
- ✓ The structure is given and then you must provide the corresponding name.
- ✓ A molecule is given and then you are asked to indicate the location of any functional groups present and give their names.

Every time you are introduced to a new functional group, you should put it in your notes, your cheat sheets and flashcards. Learn their names; spelling counts here as several groups have similar names, *e.g.* amine versus amide. Practice recognizing the individual groups alone or in a molecule.

It is also important that you practice drawing out each structure. Many students think just studying the structures is adequate, however, drawing them out by hand helps put the details of the structures in your long term memory. Develop the habit of including any lone pairs of electrons in the structures. This "electron bookkeeping" will be particularly helpful to you later as you learn about reactions and their mechanisms. (You should note that many books leave lone pairs of electrons off structures due to the assumption that students will realize they are there.)

"What's in a Name? That which We Call a Rose by any Other Name would Smell as Sweet."

With all due respect to Shakespeare, this approach does not work well in the scientific world. In organic chemistry, calling a compound by a dozen different names can lead to confusion and problems in the laboratory. That is why nomenclature systems were developed. Such systems allow scientists from around the world to communicate without confusion.

In a general sense, nomenclature is a system of rules that describe the process of determining a compound's name. In organic chemistry, the most commonly used nomenclature system is one established by the International Union of Pure and Applied Chemistry (IUPAC). Rules exist for naming every conceivable kind of compound.

The first time students usually learn of the IUPAC rules is after the introduction of hydrocarbons, the simplest of all functional groups. The nomenclature rules for subsequent functional groups build onto the hydrocarbon nomenclature rules so it is imperative that students obtain a firm grasp on the rules from the outset.

Every time a new functional group is introduced (which is almost every chapter), you can expect the IUPAC rules for naming compounds containing that functional group will be included in the text. As a result, almost every exam will have problems on nomenclature. Knowing now that these rules build on previous ones, you can see how failing to learn them will come back to haunt you on every single exam.

You can expect test questions on nomenclature to take the following forms: You are given a structure and asked to provide the correct IUPAC name or you are given an IUPAC name and asked to provide the corresponding structure.

Yet again, the best preparation for such questions is practice, practice, practice. Place any new rules, prefixes or suffixes on your cheat sheets and flashcards. Many students find keeping a running cheat sheet of just nomenclature rules is helpful. This way all the information is one place for easy review.

Another way to prepare for nomenclature exam questions is to study with your friends and take turns quizzing each other by composing your own nomenclature problems. If you are having trouble doing this or you just want to double check your answers, there are several links to pages on organic nomenclature in chapter 16. These links also include sites that generate IUPAC names from structures and vice versa.

Organic Chemistry in 3D

One of the hardest challenges most students face in organic chemistry is learning how to see molecules in three-dimensions. In most textbooks, at least one chapter is devoted to the three-dimensional arrangement of molecules. The branch of chemistry dedicated to the study of the relative spatial arrangement of atoms within molecules is called stereochemistry. Here are some tips on surviving your first brush with stereochemistry.

Molecular Models

Most professors will require you to buy a molecular models kit for their course to help you learn how to visualize molecules in three-dimensions. Even if these models are not required, you should buy a set. Molecular model kits consist of colored plastic balls that represent the common elements of organic chemistry: carbon, hydrogen, oxygen, nitrogen, and the halogens. Plastic sticks are included to use as bonds. Using models like these, you can quickly understand things like why there is free rotation around a single bond but not a double bond and why some of molecules are more strained than others. Models are like pictures – they are worth a thousand words.

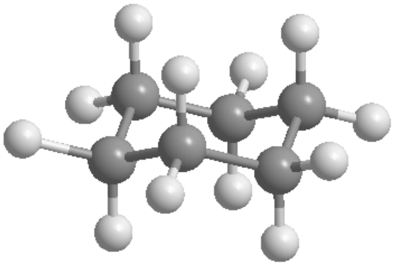
Make sure you buy a quality molecular model kit. We have seen kits as cheap as $10 and as expensive as $70. Price does not guarantee quality. You want a kit that is made of sturdy plastic as you will be constantly putting together and pulling apart the balls and sticks. You want the plastic parts to be a comfortable size in your hand. Many times the balls or sticks are very small and are difficult to work with. Ideally, the kit will come in a compact carrying case that can easily be slipped into a book bag.

Once you settle on a molecular modeling kit, use it!

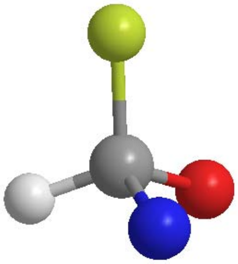
Using Models in Class

Ask your professor on the first day of class if you will be allowed to use the models on exams and if you are required to bring them to lecture. If the answer is yes to either question, make sure the night before class you set the kit with the other materials you will be taking with you in the morning.

On exams and quizzes, many students find it helpful to pre-fabricate any models they might need during the exam. For instance, if your exam will cover cyclohexane conformations, make a cyclohexane ring model like the one pictured below the night prior to the exam and then take it with you in the morning. You will save time by not having to fumble with small plastic parts during the exam.



You can do something similar when you are tested on stereochemistry. Stereochemistry involves concepts like chirality centers (a tetrahedral carbon that is bonded to four different groups) and determining whether those centers have an *R* or *S* configuration (a convention related to nomenclature; establishing a configuration of a center enables scientists to know what the three-dimensional spatial orientation of the center is). Again to save time during the exam, students may find it helpful to construct a ball and stick model of a carbon attached to four different colored balls like below:



During the exam, if you are asked to assign a configuration to a chiral center, you can assign a color ball on the model to each of the four groups on the carbon. That way you do not have to spend time making the entire molecule using your model kit.