Chapter 11: The Ten Core Survival Skills

Survival Skill #1: Study Effectively like Smart Students

I have talked to and observed hundreds of smart students over the years, and discovered that almost all of them have patterns of successful studying. They tend to follow consistent ways of learning.

Do you want to be just like them?

The easiest way is to find out what they do and clone their actions.

The Secrets of Smart Students

Here is the summary of the study patterns found in successful students:

Study Systematically

Follow a simple system day in and day out and keep it up. Chemistry is a subject with rules and patterns. You can maximize your learning in a minimal time by following a system specifically designed for chemistry. Not all general study tips apply to science learning, and some may lead to failure. Adapt and adjust. Stick with it consistently.

Make it a Habit

Learn how to study effectively and make it your habit. Always prepare for class, show up in lectures, read the assigned text and complete the homework. Missing any of these parts would be like misusing your credit card, it will come back to haunt you. Keep up your good study habits. Once they become part of you, academic success will follow. This is often reflected by success later in life.

Impress Your Instructor

Try to make a good impression with positive study activities. Maintain perfect attendance in class and never be late. Visit the professor’s office during scheduled hours and be prepared. Participate in classroom discussions. Do your work neatly and show your effort. Never complain. You might get graded leniently if your instructor associates your name with a good impression.

Find Yourself a Mentor

Academically, an educator would be the best candidate to be your mentor. Find a professor you like and you can connect with. Go to the office hours often and establish a good relationship. If the professor seems receptive, ask for advice on other aspects of your education.

Find Your Own Study Zone

Set up a place to study so you can focus and not be interrupted. Use it consistently. The moment you enter your study zone, your study mind is ready for action. Your own room may not be an ideal place since your neighbors and phone may be too enticing. A quiet cube at the library is a better zone if you really need to study.

Set your Routine Study Time

Schedule your prime time for chemistry. Try to study at the same time every day. Your brain will follow this pattern and function at its best. If you are unsure when your peak efficiency hours occur, keep a record of your mental alertness for a week. You will learn your prime study time.

Keep your Concentration

Keep up the pace and study intensely to focus your full attention on the subject materials. Pull yourself back when your mind starts drifting away.

How do you do this when you are tired of studying? Sound familiar?

Here are a few ways to restore your mental acuity and regain alertness:

- ✓ Physical exercises – a few minutes of jogging with music on or walking a dog will wake you up.
- ✓ Household chores – brief housework such as doing the dishes or laundry will alter your mind and rest your brain.
- ✓ Fun-Fun-Fun – a round of games or a chat with a friend will help relax you.
- ✓ Short nap – If you still can’t ward off your mental fatigue, take a nap – a short one.

My favorite is leisure reading or mingling with my iPod. Whatever it is, find a way to get your concentration back quickly so you can continue your core study.

Break Up Your Study – The 50-10 Method

Long hours of study without breaks is ineffective. The thought of sitting down to regurgitate organic chemistry for three long hours is enough to kill just about anyone’s spirit and stop you from even getting started.

I often use what it’s called the **50-10 Method**. Partition your study into one-hour blocks – 50 minutes study and 10 minutes break. To top it off, reward yourself with a small treat after an hour of intensive study and indulge yourself even more after a long period of study.

Form a Study Group

Take advantage of the talents of your fellow students. Be selective with whom you study. Avoid the social club syndrome and only discuss chemistry. Have a plan for each group study session. Take turns chairing the sessions. In any group, the real learning occurs through participation.

Study Alone

While you might want to engage productive group study once a week or so, you definitely want to stay alone when doing your core study. Otherwise, with the distraction of bonding activities, your three hours in the library might end up with only 30 minutes of study.

When you are alone, you can stick with your study plan better (1 hour per session) and don't have to accommodate your buddy's schedule. Besides, by spending your time effectively, you'll have more time to socialize later.

Sleep (not study) in Bed

We all like to do things in comfort. Reading in bed simply sends you to sleep quicker. You can do your non-essential reading there, but avoid doing your core study in bed.

Study Chemistry First

If chemistry is your most difficult subject, study it before all other subjects, when you are most alert and fresh. Make problem solving a part of every study session.

Keep Up Your Class Attendance

Make it a rule to attend all lectures and be an active listener. Don't fall behind by missing any class. With lecture materials such as PowerPoint or MP3 available online (such as on WebCT), it is very easy to talk yourself into skipping. Don't! Stick with the rule.

Take Advantage of the Chemistry Lab

Make the lab a learning opportunity rather than a chore. In additional to having hands-on experience with chemicals and equipment, you can reinforce the concepts learned from lectures and actually see the chemistry in action.

Make the Periodic Table your Best Buddy

Make it your friend and learn how to use it. Use it as often as possible. Memorize the 1st 20 elements so you can derive their periodic trends easily. This will help you understand and correlate properties of elements.

Survival Skill #2: Top 10 Things You Should Know About Chemistry

Keep these with you all the time. They are the must-know facts of chemistry.

Fact #1: 8 is a Happy Number

Eight represents the Octet Rule: Molecules are happy with eight electrons on their central atoms. However, be aware of the exceptions to the rule – they are frequent test questions.

Fact #2: Remember the First 20

The Periodic Table of Elements is the most important part of chemistry. You should memorize at least the first 20 elements in the table. Knowing what they are and their positions will help you predict many chemical and physical properties and answer test questions right away, without looking through your text.

Fact #3: Mr. Kelvin is No. 273

In Chemistry, the temperature unit is Kelvin (K) – a must-know fact. The absolute temperature is zero Kelvin. The conversion to Celsius is: K = °C + 273.14, another essential conversion factor to remember.

Fact #4: Less is Better for Formal Charge

Formal charge is the way of counting electrons involved in bonding. The formal charge is the number of valence electrons of the atom minus the number of unbonded electrons minus half the total number of electrons participating in bonds. When determining the correct Lewis structure, the structure is chosen such that the formal charge on each of the atoms is minimized.

Fact #5: Numbers are “Significant” in Chemistry

Keep in mind that all quantities in chemistry come with uncertainty, which is represented by significant figures. When you see a number in chemistry, think significant figures!

Fact #6: Energy is Conserved

Energy can’t be created or destroyed; it just transforms from one form to another. Keeping track of where the energy goes leads to an understanding of many facts, particularly in biological molecules.

Fact #7: Units are Your Best Friend

Chemistry is a quantitative science with measurable properties everywhere. When presented a number, think about its unit. The wrong unit can make a world of difference on the quantity. Be sure to always pair a unit with your number.

Fact #8: Electronic Structure is the Key to Unlock Chemistry

An electronic structure governs the physical and chemical properties of a molecule. Ask yourself the question: “Where are the electrons?” The answer is: The most electrons are likely located at the electronegative atoms such as F, Cl, O and N.

Fact #9: Chemists Communicate in an 2D World

As important as thinking of molecules in 3D, chemists love to draw structures in 2D, the preferred language of communication. When chemists get together for discussion, one thing we sure do is to draw the 2D chemical structures on a board, notepad, or napkin. This custom is reflected in lectures, textbooks and other printed materials. You should always be aware that molecules are in a 3D world.

Fact #10: Chemistry is an Experimental Science

The chemical facts are derived from experiments. Experimental chemistry is usually called wet chemistry. However, on the theory side, models are not facts;: they are created to explain facts as hypothesis – theories requiring investigation via experimentation. Unlike physics or math, chemistry is not known to rely on a few basic principles to generalize every chemical fact. Instead, there are many little models to explain small observations here and there, with limited validity. This really makes chemistry hard to learn. As you advance in chemistry, you will have to unlearn some of the models explaining more ideal situations and adapt models that are more complex with more correct terms, e.g. ideal gas laws, Bohr’s model, and Lewis structure.

Survival Skill #3: Basic Math for Chemistry

Chemistry is a quantitative science. Your quantitative skills may be a life support system for your chemistry survival. It is essential that you have the basic math needed for chemistry. The good news is that for most chemistry courses the math required is rather basic, just simple algebra, exponent, logarithm, etc. In this section, we will do a quick review of math and get you comfortable with math for the rest of the course.

About the Calculator

In science numbers matter. Hand held calculators are still widely used in chemistry – a quantitative science. Most of you know how to key in numbers and get results. There are a few things to keep in mind while using a calculator:

Significant Figures in the Calculator: By far, the No. 1 mistake students make in using the calculator is to ignore significant figures and record all the digits as displayed. You could be penalized for a wrong answer. Chemists deal with measurement data, and all data comes with a certain level of precision. Do consider all numbers that are significant. Do not record the calculator results as is.

Calculator for Exams: Typically, you are not permitted to bring in just any calculator, since some can store text, which might provide a way to cheat on exams. Check with the professor ahead of time as to whether you are allowed to bring a calculator to the exams and which model calculator is acceptable. Also, be sure to use a brand new battery for your exam calculator.

Computer Calculator: Your computer (windows) has a built-in scientific calculator. Just go to Start > All Programs > Accessories > Calculator to open it and click View > Scientific to switch from standard to scientific mode. Mac OS has a scientific calculator, too. Most PDAs have built-in calculators too, but usually not for scientific calculations.

How to Work with Chemical Units

A unit is an essential part of a numeric answer for any chemistry problem and any physical property of matter. Whenever you see a number, always ask yourself about the unit associated with it.

Standard SI Units (Chemistry related)

SI is a worldwide measurement system based on the older metric system. There are minor differences between the SI and metric system, but a few conversions (next topic) will make them interchangeable.

There are really only five pure SI units used in chemistry (meter, kilogram, second, Kelvin and mole). Chemists use a few more SI derived units. Here is a short list of SI units and SI derived units related to chemistry. The list of units here is not as massive as in physics. Chemists use fewer units.

Table 11-1. The SI and SI-Derived Units

Symbol	Name	Quantity
m	Meter	Length
kg	Kilogram	Mass
K	Kelvin	Temperature
mol	Mole	Amount of substance
J	Joule	Energy, work, heat
s	Second	Time
L	Liter	Volume

There are also a few non-SI units being used in chemistry. The conversion factors are something you should remember.

Table 11-2. Non-SI Units in Chemistry

Symbol	Name	Quantity
Å	Angstrom	10^{-8} cm
ATM	Atmosphere	Pressure
Cal	Calorie	4.184 J

Common Physical Constants and Unit Conversion

Most instructors do not require you to memorize the physical constants, but you might want to know some basic conversions (i.e. Kelvin to Celsius or kJ to kCal).

Table 11-3. Common Physical Constants in Chemistry

Name	Symbol	Value/Unit
Avogadro Number	N_A	6.02×10^{23}

		molecules
Speed of Light	c	3.00×10^{8} m/s
Planck's Constant	h	6.63×10^{-34} J·s 1.58×10^{-37} kcal·s
Charge of Electron	e	1.60×10^{-19} C
Gas Constant	R	0.0821 L·atm/mol·K 1.98 cal/mol·K 8.31 J/mol·K
Atomic Mass Unit	μ	1.66×10^{-24} g
Pressure	P	1 atm = 101.3 kPa = 760 mmHg = 760 torr
Heat	ΔH	1 kcal = 4.18 kJ
Nernst Constant at 25°C	RT/F	0.02569 V (JC^{-1})
Standard Temperature and Pressure	STP	273.15 K and 1 atm
Molar Volume of Ideal Gas at STP	V_m	22.41 L/mol

Scientific Notation

Chemists use scientific notation for a couple of reasons:

It is very cumbersome and difficult to work with commonly encountered, very small and very large numbers. Expressing them in exponent makes it much easier to write and read.

Chemists must deal with significant figures. Express 3400000 as 3.40×10^{6} and you can tell right away there are 3 significant digits.

Exponential Notation expresses any number as a product of two numbers, a decimal and a power of 10, e.g. 11×10^{3}. This notation is often used to express very large or small numbers.

Scientific Notation is a more systematic form of exponential notation that is used widely by chemists. The number is expressed with one (and only one) non-zero digit to the left of the decimal point and an integer exponent or power of ten, e.g. $6.023 x 10^{23}$. The same number above ($11 x 10^3$) in exponential notation would have to be rewritten $1.1 x 10^4$ for scientific notation.

Logarithms

A logarithm is an exponent to which 10 (common or e) must be raised to give a specified number.

LogX = Y and $X = 10^y$

A few things to keep in mind:

There are two types of logarithms; common logarithm (base of 10), and natural logarithm (base of e, where e=2.718). Both are used in chemistry.

You can’t take the logarithm of a negative number or zero. In LogX = Y, X must be greater than zero. Use that as your answer checker.

Multiplication: 10^x x 10^y = 10^{x+y} and logX x logY = log (X+Y).
Similarly for Division: $10^x \div 10^y$ = 10^{x-y} and logX ÷ logY = log (X-Y).

Logarithms are used in many scientific calculations. Many scientific laws must be expressed in either exponential or logarithmic form. Consequently, calculations involving these laws must also use exponents and logarithms. Chemists use logarithms extensively. Here are some examples.

Example 1: In chemical kinetics, rate constants for most reactions closely follow an equation, called Arrhenius rate law or Arrhenius equation:

$k = A\, e^{-Ea/RT}$

e is the base of natural logarithms, 2.718. Often it is useful to recast Arrhenius equation in logarithm form. Taking the natural logarithm of both sides of the equation gives

ln k = lnA - Ea/RT

or, expressed in terms of base-10 logarithm,

Log k = logA - Ea/2.303RT

Example 2: Another use of logarithm in chemistry is acidity (pH) and basicity (pOH), where:

pH = - log [H^+] and pOH = -log [OH^-].

The reason for using this form is because in most cases, the concentration of H+ or OH- ions is a very small number. Logarithm expression makes these values easy to use.

Significant Figures

Observations and measurements are the key to chemistry data. Measurements are never exact, but chemists try to record a result with the least amount of uncertainty. Significant figures are the number of digits written after the decimal point to measure a quantity. Almost all measured numbers in chemistry are used to calculate other quantities. You need to report the proper number of significant figures in the computed results. It is essential to know the rules about significant figures – a very common mistake students make.

The following rules are used to determine the significant figures in any quantity:

Rule #1: All nonzero digits are significant.

2.15 ml ➔ 3 (significant figures)

Rule #2: Zeros between nonzero digits are significant.

3.05 ml ➔ 3 (significant figures)

Rule #3: All zeros written to the left of all the nonzero digits are not significant.

0.05 ml ➔ 1 (significant figure)

Rule #4: Zeros to the right of all nonzero digits are only significant if a decimal is actually shown.

3.20 ml ➔ 3 (significant figures)

Rule #5: With logarithms, the result is reported with the same number of digits to the right of the decimal as the number of significant figures in the original number.

pH = $-\log[3.5 \times 10^{-3}] = 2.46$ ➔ 3 (significant figures)

Rule #6: When multiplying or dividing numbers, the result should be written with the least significant figures.

$3.62 \times 2.2 = 8.0$ ➔ 2 (significant figures)

Rule #7: When adding or subtracting numbers, the result should have the least decimal places.

$32.61 - 6.2 = 28.4$ ➔ 3 (significant figures)

Survival Skill #4: Problem Solving Made Easy

Chemistry is all about problem solving, learning the knowns, and applying to the unknowns. If you are pre-med you should know that medical schools are moving an information-heavy curriculum to a concept-centric curriculum – shifting focus toward problem solving and holistic thinking.

If you survive chemistry, you will learn the techniques of problem solving, which is far more important than your ability to recite all the materials known to man. Your survival in chemistry will make your life much easier in future courses and in the real world.

Five Step General Problem Solving Process

I earlier introduced my **KUDOS** method specifically for chemistry word problems. Similarly, the same process below can be applied to generic chemistry problems – calculations, concepts, mechanism, etc.

Step 1: Identify What is Given

Separate the problem into the facts, conditions and assumptions. List them symbolically as familiar chemical terms and formulas.

Step 2: Clarify What is Being Asked

Understand what is asked and if unclear, try to rephrase the question in terms that you know.

Step 3: Select a Strategy

Choose an appropriate method to solve the problem. These strategies include trial-and-error search, deduction, working backward and the knowledge-based method. The goal is to establish a path to get to what is being asked from what is given.

Step 4: Solve

Apply the skills and mathematical expressions needed to carry out the strategy chosen.

Step 5: Review

Examine the reasonableness of the solution, and correctness of the units, significant figures and order of magnitude. Fix the possible errors and re-evaluate the approach.

Survival Skill #5: Top 10 Answer Checkers in Chemistry

1. Estimating a Numerical Answer

Learn to estimate a reasonable answer. For many quantities to be solved, you can approximate the answer by using your basic knowledge and visual inspection. Check if your answer is the correct order of magnitude, decimal point, or the power of 10. If the quantity is familiar to you, judge if the result makes sense or not. For example, 120% of percentage composition would not make sense at all, and is an obvious wrong answer.

In addition, a calculator provides an exact answer almost as quickly as you can arrive at an estimate. Cross-checking these two often can avoid gross errors. Calculator error is one of the most common mistakes, yet the easiest one to avoid. Run through the numbers a second time to double-check the answers.

2. A Number and Its Unit Go Hand-in-Hand

In math, you use numbers, but in chemistry you use quantity. Every chemical quantity is described by the number AND its unit. Units are essential in chemistry problems. Plug in units and their values into the formula or equation being used. Try to form the proper-labeled ratios (equalities). The resulting unit must match the unknown to be solved. Mastering this technique will give you incredible leverage in every chemical calculation.

The two basic, simple rules:

Rule 1: Always write the unit and the number associated with the unit.

Rule 2: Always plug the number and its unit into any mathematical operation. Cancel units until you end up with the unit you want in the final answer. In addition, if this involves multiple steps, be sure that in every step you have the correct interim units.

As a rule of thumb, always set up a problem as follows, in its extremely simple form:

$$\text{Starting Units x } \frac{\text{Desired Units}}{\text{Starting Units}} = \text{ Desired Units}$$

3. Exactly 100%

The percentage composition of all elements in a compound has to add up to exactly 100%. The mole fraction must be a number between 0 and 1. If not, your calculation must be wrong. Go re-check your math.

4. The pH Value - 0 to 14

A $pH<7$ is acidic; $pH=7$ is neutral; and $pH>7$ is basic. The pH range is usually from 0-14 (with rare exception), so that the hydrogen ion concentration $[H^+]$ should be $0 - 10^{-14}$ range. Check your answer against this range. Again, the pH value could go beyond this range but it would be unusual. If so, double-check your calculation.

5. Mass Conservation

The total mass of the reactants equals the total mass of the products. This is the law of conservation of mass, which applies to all chemical reactions.

Moreover, stoichiometry calculations are based on the fact that atoms are conserved. They cannot be destroyed or created. Numbers and kinds of atoms before and after reactions are always the same. This is a basic law of nature. Quantitatively, the mass of a product is rarely more than 5x or less than 1/5 the mass of the reactant. If your answer goes beyond that range, double-check it.

Finally, typical ionic reactions (inorganic-type) involve the change of oxidation number – the number of electrons lost always equals to the number of electrons gained. This is the foundation of electrochemistry.

6. Carbon - Always 4

What is so important about carbon that the entire field of organic chemistry is devoted to it? First, the chemistry of carbon is the foundation of life on earth (plants, animals, and humans). Carbon is also the main element of enormously important materials created by humans (plastics, medicines, polymers, fuels, dyes, etc). Carbon compounds are versatile because of the electronic structure of carbon.

Carbon always forms four covalent bonds. That sounds simple, but many exam mistakes come from forgetting this rule. Organic chemistry is the chemistry of carbon. Due to its versatility in forming covalent bonds, there is a tremendous number of carbon compounds. The four covalent bonds may be present as four single bonds, two single bonds with one double bond, or one single bond with one triple bond. Check every structure you write and be certain each carbon has four bonds. Missing a bond could cost you an arm and a leg on your final grade.

7. Work the Problem Backward

To verify your answer to a problem is correct, work out the same problem in reverse to prove you can match the known information.

8. Find Alternative Solutions

Play with the possibilities. In chemistry, there is usually more than one way to solve a problem and answer a question. Several approaches may work, although one might be more efficient than another. You can check your answer by using an alternate method, if time permits.

9. Know the Range of Commonly Tested Quantities

Building a quantitative sense of a chemistry term is part of learning chemistry. Take notes on commonly used properties from lectures, textbook, homework assignments, and end-of-chapter problem sets. List their normal value ranges and orders of magnitude.

For example, in gases the vapor pressure of a mixture must be between the vapor pressures of the two pure substances in the mixture.

In organic chemistry, the characteristic chemical shifts or IR frequencies would be handy to remember.

In concentration calculation, if you arrive at a molarity of 10,000M as the answer, there has to be a mistake somewhere since you can't possibly fit 10,000 moles of anything into a liter.

The atomic mass should be in a range of 1-200, or so (forget about those super rare elements); you can tell if the answer is reasonable with this checker in mind.

The ionization potential (IP) of any atom is always greater than zero. Moreover, the second or third ionization potentials are always greater than the first. Pause to think about this and it will make sense, since ionization potential is the energy required to remove the outmost electron from a neutral gaseous atom.

Bond energies are always positive, and range from +10kJ/mol to +942 kJ/mol. The bond length can go from the shortest H-H bond (0.74Å) to the longest I-I (2.67Å). A simple correlation between bond length and bond energy is that shorter bonds are stronger bonds and vice versa. Chemistry is all about bond forming and breaking, so understanding the bond energy is important.

10. Solve Problems Qualitatively

The last answer checker is the most important one. You should attempt to solve the problem qualitatively before you write down all the quantitative data. For example, when asking the pH of a mixture of strong acid HCl (2.0 moles) and strong base NaCl (1.5 moles), you know mentally with excessive HCl (0.5 moles extra) that the solution will be acidic ($pH < 7$).

Survival Skill #6: The Four Step Panic Plan – How to Cram Systematically

"Help! I am half way into the course and still have no clue." Rest assured that we've got you covered in this situation. It is never too late to start a simple and effective way to study, even if you are closing in on the final. We do not encourage cramming at the last minute. The easier formula to success is to keep up - not catch up.

Granted, this happens! What do you do if you are down to the wire and have no choice but to try to stuff a lot of material into your head in a very short time? You have to cram, of course. Cramming is not a study strategy but rather a Band-Aid to save you from disaster. After it is all over, you will have to relearn the same material.

If you do fall behind but are willing to put in extra effort to make it up, just follow the simple steps below and you will do fine for the rest of the course. The goal of cramming is to create a set of super concentrated study sheets and focus most of your time reciting them.

How to Cram Step-by-Step:

For those crammers, you may want to put out extra effort in the last 2-3 days prior to the exam, but avoid at all cost cramming the final night. All your efforts may be wasted if you feel tired or mentally exhausted during the exam, which will block off your knowledge retrieval process. This is particularly true for crammers since cramming only puts information into your short-term memory.

Here are the steps:

Step 1: Get the Lecture Notes: If you have not attended all the lectures, get a decent set of lecture notes from your pal, or buy them from the note-taker if you have to.

Step 2: Rewrite the Lecture Notes: If you still have time, rewrite the notes into yours using the ChemMastery Lecture Notes. If you are cramming for the midterms or finals and running out of time, skip this step.

Step 3: Create the Cheat Sheets: Print a few blank copies of the ChemMastery Cheat Sheets (one copy per chapter). Go to your study zone and lay out the notes and the text side-by-side. One chapter at a time, write down all the key concepts, facts, formulas and equations onto a single cheat sheet. Be selective in what you record and limit your coverage. As needed, use your text to further your understanding by quickly reading the explanation and walking through the examples.

Step 4: Over Study the Cheat Sheets: After going through all the testing chapters, you should have a set of cheat sheets created from step 3. Study-study-study these cheat sheets. Say them out loud if you have to. Carry them with you so you can make the most of every spare minute you have.

If you have completed these four steps in the limited time you have, you should still be able to walk in and take the exam with confidence.

Rules of Cramming

I hope that you won't get yourself into the position that you must cram to survive. However, if you are running out of time to prepare for the upcoming exam, follow these simple rules:

Be Realistic and Practical: Cramming is not the best way to study so you need to set your expectations on how much you can accomplish. The key is to study enough to survive the exam and store what you know long enough to retrieve during the exam.

Study in Depth not Breadth: The most effective way to cram is to find out what topics are important and put all your efforts into them. Producing a concise study sheet will serve this purpose well.

Maximize Your Short-Term Memory: Deploy every memory method to cram the key terms into your short-term memory. Be sure to understand their concepts and applications.

Cramming is to make use of the short-term memory (STM), also known as working memory. It has a capacity limited to 5-9 items in a set, lasting 1-2 days. To be effective in storing information short-term, one method is called "chunking", where you arrange pieces of information into sets of meaningful clusters, which increases your capacity to remember.

To cram, focus on the essential – your cheat sheet.

Survival Skill #7: Fighting the Computer Distraction

Most traditional study guides and test-prep books ignore this issue. With increasing use of software applications and web resources for study purposes, this turns out to be one of the biggest time management issues for today's students – spending too much time on the computer, specifically on the web.

Activities such as reading e-mail, checking the news, surfing endlessly over the web, or simply fiddling with mp3 music files, can prove to be significant impediments to productivity for many students. It always interrupts your "cognitive flow" – a state of strong focus on a particular task. Your core study hours should be computer-less.

Don't Sit in Front of Your Computer to Study!

If your do, you are going to waste your valuable study hours for sure.

Your teachers will recommend you use the web at the fullest to maximize your learning – Google this and ASK that. Web search is a great tool for research and learning. However, there is just way too much chemistry information scattered over the web in an unstructured manner. You would need to sort it out before you could find something useful. It is often a time consuming process. The information over the web is not always accurate and objective. Many chemistry sites were created as class projects by high school students. Verify with your textbook and instructor if in doubt.

Don't Always Rely on Google for the Answers to Your Problems

Google is one of the best research tools available and I use this friendly search engine everyday – it's the best research tool I know. However, there are downsides if you are using it for homework.

First, this tool is so readily available it might deprive you from thinking of problems actively. This is much like checking your answer key before attempting to solve the problem yourself.

Secondly, it often takes too much time to sort out what you are actually looking for from the irrelevant content, or the answer that might not be there in the first place. Meanwhile, you spend your core study hours surfing the net, which is not a productive study activity.

Your goal for survival in the class is to become intimately familiar with your textbook and lecture notes. Always begin your learning or searching for answers with these first because they are the most relevant content, and this process will further your understanding of the core content.

Don't Be a "Computer Potato"

Do not spend too much time on the computer for non-course related activities.

Computers can be addictive and too much of them can be destructive to your academic success. We are at an age where students seemingly can't survive without a computer. Use it as a tool. Remember, your success depends on what you do in the core hours (Stage 1-5). Anything else is icing on the cake.

Don't Turn On Your Computer First Thing

Many of us, myself included, spend too much time emailing which takes away from our daily productivity. My suggestion: Don't check your email first thing when you wake up in the morning. Do your preview and get ready for your lecture first. Be sure to keep up your lecture notes, reading and homework. Try to finish these core study activities before diving into the web for your email, surfing, blogging, IM, or chatrooms. Keep these a low priority and do them only after you have completed the day of study. Resist the temptation when near the computer.

Survival Skill #8: Focus On What You Need To Learn

"To go beyond is as wrong as to fall short."

-- Confucius

"Don't give all of your attention to the trees or you may get lost in the forest." Many students like to spend more time on the subject areas that really interest them. It is natural and captivating. However, it is the wrong way! You should balance your effort on all required areas, and focus more on materials that you are uncomfortable with, yet are important. This is one survival skill you must master in order to survive chemistry. The materials are important because the teachers happen to think that way, not because you happen to like it. The core study materials should be guided by the lecture notes you take.

Your required textbook is also your core study material. Many students like to check out a stack of chemistry books at the beginning of the class, as evidenced by the empty shelves in the library. Having so many books, you end up shuffling page after page among these books. This can be counterproductive. Using the wrong textbook is like getting on a wrong train – it might move forward but it will never get you to the destination.

One more tip on the textbook; consider your text as the "Bible". That's not to say there are no errors in it (there are plenty). As long as you use the information in the text faithfully, (even if there is an error in the information you use) you can argue with your instructor to the end of the world to get credit for your work. Guess what? Your instructor will honor your work and make corrections if you were graded unfairly.

The Order of Your Core Study

Here is the priority of your study for the exam, in order. Nail the first one before spending any time on the second one.

1. ChemMastery™ Cheat Sheets and Mock Exam Sheets
2. ChemMastery™ Reading and Lecture Notes
3. Your Required Textbook (mostly Problem Practice)
4. Additional Books or Resources (optional)

Anything else is optional. Do what you need in order to master the core terms and problem solving skills. Spend your core hours on 1-3, in that order, with all your focus.

Survival Skill #9: Learn to Predict Exam Questions

This is an interesting topic. There are patterns to how professors write their exams. Learning a few of them can help boost your grade by guiding you to a more targeted study.

Integrated Problems - One likely area includes the questions that require integration of more than one concept, idea, or equation. Learning how to relate is a skill that chemists like to test on.

Multi-Chapter Concepts – Main concepts that are being discussed across several chapters are also exam favorites. Anything in the lecture or text that has been repeated often is worth paying attention to.

Fundamental Principles – There are a few chemical principles being used widely in many areas of chemistry. These are important ones tested. See the following chapter on "Fundamental Principles in Chemistry" for a list of these general principles.

Exceptions to the Rules – Chemists make up lots of rules to explain and predict chemistry. What makes it hard is the fact that there are also a lot of exceptions to the rules. Try to remember the important ones. They are good candidates for exam questions.

Reviewed – Another likely target is the material that is being discussed in the review session for the upcoming exam.

Homework – Instructors often make up exams from assigned homework problems by modifying them slightly, to reward students who work hard and understand the homework problems.

He Says So – Many instructors are not shy about telling you directly that a term being discussed will be on the exam. No brainer! Mark those down. Also, watch indirect indications on potential test targets. Read more about this in the section *How to Read Your Professor's Mind* (Chapter 12).

Lecture Only – If information is presented in a lecture but not covered in your text, your instructor obviously feels that such material is of special significance for whatever reason. Mark it down. However, consult with your instructor if material is not being discussed in the lecture but assigned as reading assignment.

Handouts – If your instructor has invested the time to provide you a handout about a special topic, he or she must feel strongly the information is important and relevant. Most instructors also like to reward students who pay attention and appreciate the value of the extra materials provided.

Lengthy Lecture – If your instructor allocates an unusually long time to discuss just one concept, you should mark it with triple stars (***).

Pay attention to these hints; you will become skillful in predicting exams in no time.

Survival Skill #10: Organic Chemistry for the Organically Challenged

Note: Skip this one if you are not taking organic chemistry courses.

Many students find organic chemistry particularly difficult. There is a big misconception that it is just like biology, which requires a lot of memorization. Students who adapt this type of approach typically have trouble with the course. The best way to learn this subject is to master the most basic concepts and minimum set of fundamental reactions, along with understanding their mechanism, and to apply this to its maximum extent for organic problem solving. Using the 5-stage ChemMastery™ system outlined in this guide is your best bet to survive an organic chemistry course.

Organic chemistry should be renamed carbon chemistry – it is essentially the chemistry of one element and to a large extent the basis of life. Carbon is the element that makes up 95% of known chemicals. There are over 2 millions organic compounds.

Organic chemistry is to study the reactions, learn the mechanisms, and apply them to synthesize new chemicals. Therefore, there are three things you should learn:

- ✓ Know the types of organic reactions
- ✓ Write reaction mechanisms
- ✓ Use the above to synthesize new compounds

Super Condensed Version of Organic Chemistry

To simplify the overwhelming content of organic chemistry, below is a condensed description. Regardless of the text, the logic flow of introductory organic chemistry stays the same.

The course always begins with the electronic properties of the carbon atom, the reason there are so many diverse compounds.

Next, adding hydrogen to the carbons, an orderly system of naming puts the myriad of compounds into an organized and manageable family called hydrocarbons. This is a very important stage of the course. Its understanding paves the way to a comfortable experience for the entire organic chemistry course.

Adding additional elements into the mix introduces new types of compounds. For example, adding just one oxygen creates families of alcohols, ethers, aldehydes, and ketones. Adding a second oxygen creates carboxylic acids and esters. Adding nitrogen creates amines and a whole family of nitrogen containing compounds.

As the course unfolds through the addition of elements, the molecular structures, nomenclature, and properties of these compounds must be learned, along with their preparation and reactions.

Organic chemistry is centered on synthesis and mechanism. To understand both of them, just follow the trail of the electrons.

The Seven Golden Rules of Organic Chemistry

Many students think of organic chemistry as a subject that requires a lot of memorization. To some extent this is true. 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 down your memorization load by 50% and help you to understand the course work easier in less time.

Are you ready? Let's go!

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

If you look at any synthetic or mechanistic questions in organic chemistry, you can always trace back the root of the cause by following the electrons.

Here is a general answer to this question: Electrons like to be around more electronegative atoms – that is F, Cl, O, N, S. This leads to the next golden rule.

O-Chem Golden Rule #2: Electronegativity is Your Best Buddy

In the landfill, to predict where the rainwater will go, you just have to see where the lowest spots are. In organic chemistry, the electrons go where the higher electronegative atoms are. Similarly, a structure always tends to settle to the lowest energy state.

Electronegativity is a measure of the attraction of an atom for the electrons in a chemical bond. The higher the electronegativity of an atom, the greater its attraction for bonding electrons. The electronegativity value of the elements is something you should memorize. Fortunately, there are less than 10 elements that really matter in organic chemistry.

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

As I mentioned previously, valence shells are all chemists care to know, so forget about inner shells for now. Atoms in a molecule prefer to fill up the valence shells to make new bonds. This can be explained by the Valence Bond theory (VSEPR model) – the way to predict molecular structures.

O-Chem Golden Rule #4: Unpaired Electrons Are Not Welcome Here

Molecules like to have all their electrons paired up, otherwise molecules are reactive (i.e. free radicals). Molecules with unpaired electrons are often seen in intermediates and transition state structures where their energies tend to be higher, and then stabilized by forming the products by pairing up the electrons or spreading out the electron density to other atoms within the same molecule.

O-Chem Golden Rule #5: Nature Abhors Localized Charges

The 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 and inductive effects. In addition, it is better to have more positive charge (H, C) on a less electronegative atom and more negative charge on a more electronegative atom (O, N, F, Cl). Once again, knowing the electronegativity is crucial.

O-Chem Golden Rule #6: Atoms Like to Have More Space.

Steric hindrance is a very 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 this can prevent reactions from happening. Space-filling models may help to visualize the steric interactions in a molecule. Get to know the size of a few atoms and become accustomed to thinking in 3D. The steric effect will then be easier to understand.

O-Chem Golden Rule #7: Mr. Pi loves to be delocalized.

Just like a good pie is well blended, delocalization is AlWAYS stabilizing. The π electrons prefer to be dispersed over as many adjacent sp2 hybridized atoms and lone pairs as possible via the resonance effect. Aromaticity is the most stable form of π electron delocalization. The Hückel Theory treats π-bonding in planar molecules (e.g. aromatic hydrocarbons and alternating double bonded alkenes).

How to Cut O-Chem Memorization in Half

I have to confess, organic chemistry was miserable for me, at least initially. It was like a totally different animal than other chemistry courses – less structured and more memorization. After an initial struggle, one revelation about organic chemistry finally stuck: **After all, it is organic indeed, but still chemistry**.

What makes the difference? It is the connection between the foundation of organic chemistry and what I have learned so far from general chemistry!

If you can use a few facts that you have already learned and apply them to the understanding of organic chemistry, bingo! Mastering this course becomes much easier and you no longer have to memorize so much because you now actually understand it. After all, that is what learning chemistry is all about.

It might even be an enjoyable experience. Oh well, that might be a stretch, but it certainly cut down the number of facts to remember. For me, organic chemistry eventually became an easy task and I liked it so much that I went on to get a couple more advanced degrees in organic related fields (M.S. in Physical Organic Chemistry and Ph.D in Computational Organic Chemistry), and had some fun along the way also.

Okay, here are core concepts that make a difference in understanding organic chemistry, all of which you have learned from introductory chemistry.

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. The simplest model to use is VSEPR (Lewis Structures) is by deriving its Lewis structure, and how to figure out a lot about any given organic compound.

Core Concept #2: Polarity

As you will eventually figure out, most organic reactions involve nucleophiles (give out electrons) attacking electrophiles (accept electrons). Simply understanding where the electrons are provides the best way to predict the reactions. The electron distribution determines the polarity of a molecule (or a bond).

Once again, one of the golden rules is to familiarize yourself with the electronegativities of typical organic atoms (H=2.1; C=2.5; S=2.5; Br=2.8; N=3.0; Cl=3.0; O=3.5; F=4.0). Chemists use these values to predict the polarity of a bond or overall molecule.

Core Concept #3: Lone Pairs

Lone pairs are very crucial to understanding organic reactions. Include them in your Lewis Structure drawings. Always know where the lone pairs are before and after the reaction.

Core Concept #4: Formal Charge

Polarity leads to charges. The formal charge can tell you where the attack is going to happen in a given molecule. If you understand the Core Concept #1 (VSEPR model and Periodic Table), you can easily figure out the formal charge of any given element within a compound:

Formal Charge = # of Valence Shell Electrons in Element - # Valence Shell Electrons in Compound

The first term is from the periodic table (# of valence electrons in the element). The second term is the sum of lone pairs and bonding electrons.

By now you realize that each concept interrelates with other concepts. This is the nature of chemistry.

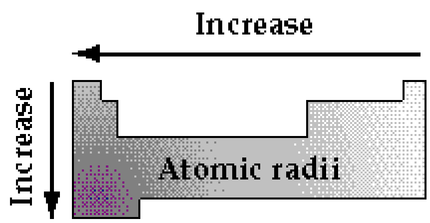
Core Concept #5: Resonance

Resonance is also a very important concept in predicting the outcome of a reaction. Where more than one possible product can be produced, the one with resonance is the more likely candidate.

Resonance is an electronic property that lends a great deal of stabilization energy to the structure. Hence it is used to determine the preferred products. It occurs when a compound has alternating single and double bonds. Lone pairs can also be part of the resonance.

Core Concept #6: Atomic Radii

Spatial interactions due to atoms and groups trying to occupy the same space, i.e. closer than their Van der Waals' radii, can prevent certain stabilizing forces from occurring (i.e., solvation, planarity for resonance delocalization, approach of a nucleophilic site in one reactant molecule to an electrophilic site in another reactant molecule, etc).



Core Concept #7: Intermolecular Forces

How do you predict the property trends of a given set organic compounds? The most frequently asked exam questions are to rank the vapor pressure, boiling/melting points, or solubility of a class of compounds. The answer relies on their intermolecular interactions.

Once again, you can rank the strengths of their intermolecular forces by looking into their Lewis Structures, Polarity and Formal Charges. The core concepts work tightly together to solve your organic chemistry problems.

Most of these concepts are straightforward. Try to fully understand the core concepts discussed above before going into organic compounds, reactions, and mechanisms. You will find your ah-ha moments.

Chapter 12: Top 12 Confusions in Chemistry

Do you feel confused by many 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 chemistry. Here is the countdown of the Top 12:

1. Chemical Properties and Physical Properties

When asked about chemical or physical properties of a species, you ought to know the difference (common exam questions).

Chemical properties: The properties enable one substance to be converted into another brand new one – they describe how a substance reacts with other substances. Water could turn into H_2 and O_2 – that is its chemical property since new species are formed.

Physical properties: The properties describing the physical characteristics of a substance. Typical properties are the mass, volume, density, color, and phase. Water can be vaporized into steam – that is its physical property since no new substance is formed; only the phase changes (liquid to gas phase).

So to tell the difference, just ask yourself a simple question: Is there a new substance formed?

2. Charge and Oxidation Number

The oxidation number of an atom is defined as the number of valence electrons in the free atom form minus the number of valence electrons controlled by the same atom in a molecule. For an ionic molecule (electron transfer), the oxidation number of an atom equals the resulting charge. For a covalent molecule (shared electrons), the oxidation number does not equal the charge. Here is the rule: *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).

3. 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 – thermodynamics is the study of heat energy.

Heat = (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.

4. Molality and Molarity

Molality (m) is defined in terms of a kilogram – the number of moles of solute per kilogram of solvent in a solution, while molarity (M) is defined in terms of a liter – the number of moles of solute per liter of solution. Another concentration quantity is Normality (N) – the number of equivalents of solute per liter of solution.

Watch what is asked for on the exam and use its definition accordingly. Consciously ask yourself when asked to calculate the concentration: "Which concentration?"

5. Ionic Bond and Covalent Bond

A bond is about the overlapping of electrons between atoms. In one extreme, one atom takes all the electrons and the other one gets nothing – that is 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 **cation**. The atom accepting the electron then becomes negatively charged, and is called **anion**. Ionic bonds are seen mostly in inorganic compounds

However, for 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.

Table 12-1 Comparison of Ionic and Covalent Bonded Compounds

Properties	Ionic	Covalent
Element Type	Metal-metal, nonmetal-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

6. Precision and Accuracy

Since chemistry for the most part deals with quantitative measurement, precision and accuracy are used often to measure the numerical results. Most people use the words "accuracy" and "precision" interchangeably and think that they are the same. Well, they are different.

In plain English, precision is how well you can repeat the measurement values, and accuracy is how close you can get to the right answer. That is, accurate data are always precise, but precise data may not always be accurate.

Precision is the closeness of two sets of measured groups of values. Just think of this as the degree of reproducibility of a set of measurements. This does not necessarily reflect the closeness to the true value.

Accuracy is linked to how close a single measurement is to the true value. High accuracy means getting close to the truth.

7. Empirical Formula and Molecular Formula

Determination of a formula is the most basic and frequent calculation in chemistry. In some cases, the molecular formula and empirical formula of a given molecule are identical. However, in many cases, the molecular formula is different from the empirical formula. For example, CH is the empirical formula and C_6H_6 is the molecular formula. Be aware.

Empirical Formula: The simplest chemical formula that expresses the relative number of moles of elements in a compound using the smallest whole numbers. It can be easily calculated with a simple six-step process: (1) Determine the percent composition of each element; (2) Assume 100 grams of sample, which automatically converts percent from the previous step to grams; (3) Calculate the moles for each element by dividing its weight from previous step by its atomic weight; (4) Set up a formula with the number of moles of each element as subscripts; (5) Normalize the subscripts by dividing through by the smallest number of moles; (6) Round up the fractional to whole numbers.

Molecular Formula: A formula indicating the actual number of atoms of each element making up a molecule. In other words, the molecular formula must accurately state the exact number of atoms of all of the elements in one molecule of the substance. Given the empirical formula is known, its molecular formula can be determined via the four-step process: (1) Determine the molecular mass in grams; (2) Divide the molecular mass of the compound by the molecular mass of the empirical formula; (3) Round the quotient to the closest integer; (4) Multiply the rounded whole number by all the subscripts. The result is the new molecular formula.

8. Atomic Number (Z) and Atomic Mass Number (A)

In the periodic table, a symbol is used to designate an element, and each atom is characterized by a value of A and Z. The atomic number (Z) is at the lower left of the symbol, and atomic mass number (A) is at the upper left.

Atomic Number (Z): Its value is equal to the number of protons in the nucleus.

Atomic Mass Number (A): Its value is equal to the number of protons plus the number of neutrons in the nucleus.

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.

9. 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 valence electrons, particularly the influence of 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 the 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 orbital and antibonding molecular orbital. However, these two are very different concepts (delocalized and molecular in nature) than the pair (localized and atomic in nature) in VSEPR theory.

10. 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 second and third laws of thermodynamics deal with the concept of entropy.

Enthalpy (ΔH): The energy from the reaction 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.

11. 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).

Oxidizing Agent – The species that undergoes reduction (decrease in oxidation number).

Reduction – The process of gaining electrons (decrease in oxidation number).

Reducing Agent – The species that undergoes oxidation (increase in oxidation number).

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.

12. Resonance (↔) and Equilibrium (⇆)

Resonance (A ↔ B): In terms of electrons, when resonance exists two or more equivalent Lewis structures can be drawn. The two-headed arrow shows that an electronic structure of a molecule can be represented by more than one resonance structures.

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.