Fall 2018

in chemistry

The ACS Student Member Magazine

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SUMMER 2019

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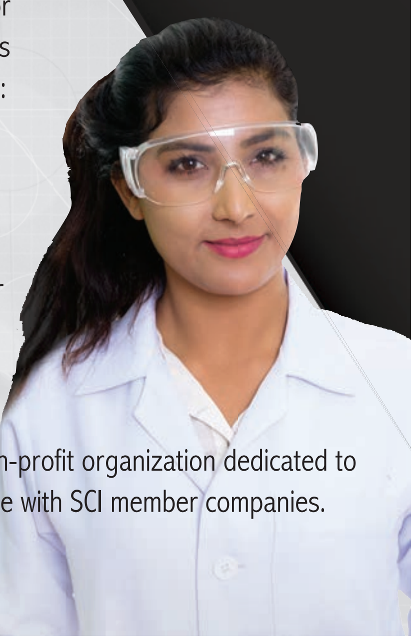

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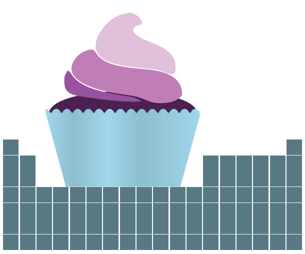
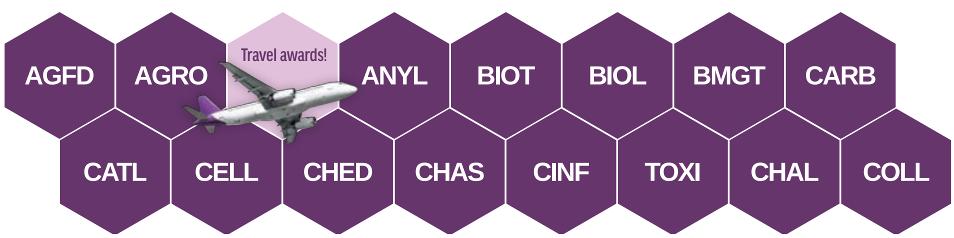
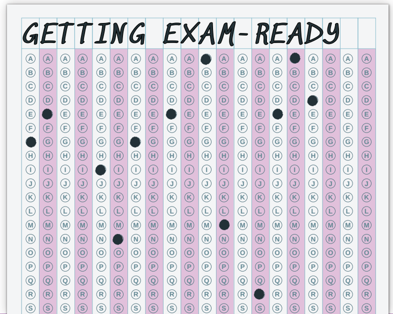
Elements






GETTING EXAM-READY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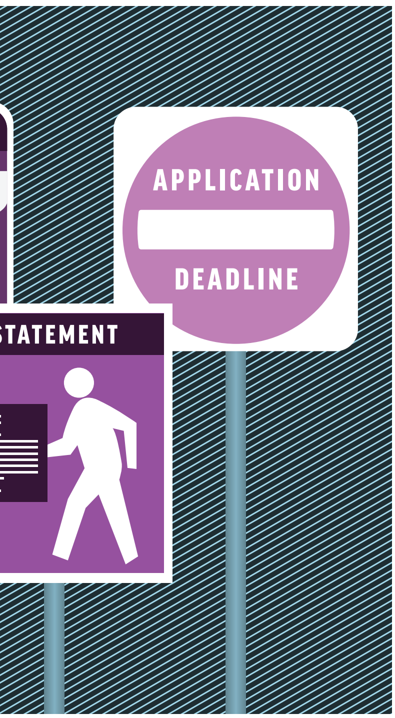
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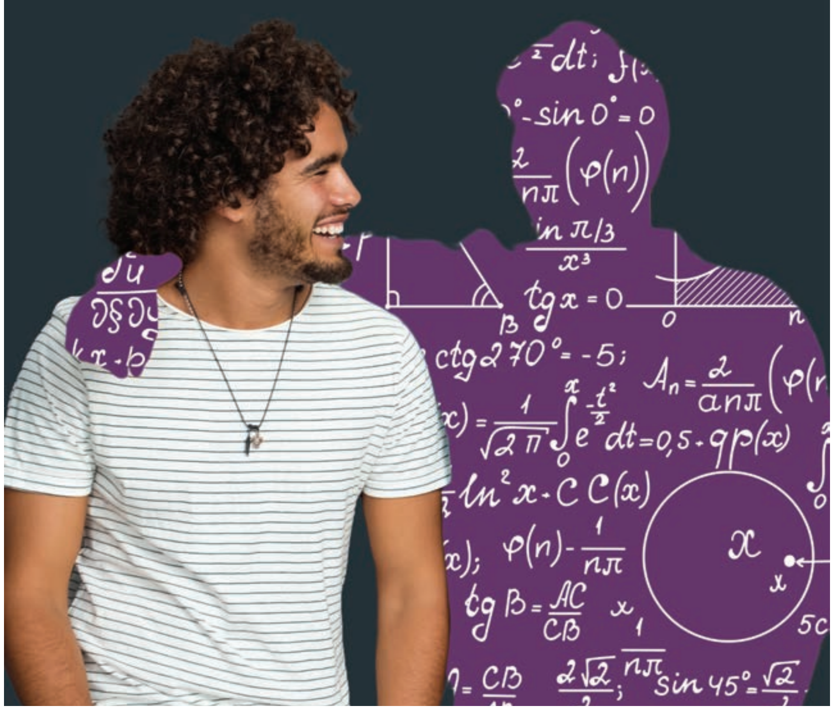


Chapters Cs Demos

Chapters

Launching Out-of-This-World Demos

By Frankie Wood-Black

This year's theme for National Chemistry Week (NCW) is space chemistry. And we've got some ideas for you to bring outer space into the festivities you're planning for peers, students, and the community.

When you hear the word "space", the images that immediately jump to mind are dark regions populated with stars, planets, and galaxies. Or you might think of rockets and space stations. These images can help get your creative juices flowing as you plan activities, and prompt you to ask questions that a lot of people would love to know the answers to: What are stars made of, and how do we know that? If Jupiter is a gaseous planet, how is that different from the solid planet of Mars? If people are going to get to the space station or to Mars, just how are we going to do it? By asking these questions, you can develop some ideas for demonstrations and activities.

Here's an example: let's look more closely at the question, "How do we know the composition of stars?" Well, as chemists, we know that orbiting telescopes and spectroscopic techniques are used to analyze the light that reaches Earth. The concept that the composition of a material can be deduced by the emission of electromagnetic waves or its color allows for some pretty visual demonstrations. And you can even provide audience members with a take-home scientific instrument!

Safety first

You've probably heard more about safety than you care to think about, but it should be first and foremost in your planning. Your audience isn't going to care about science if they are more worried about getting hurt. So, build safety into your plans. When choosing your demonstration, you must consider a variety of factors. Don't just consider flammability; think about toxicity and physical space as well. The Mentos and soda experiment, although nontoxic, is not one that should be performed indoors. Consider, too, what will happen when someone in the audience—without your familiarity with science and safety—decides to repeat your demo at home.

Carefully review the proposed demonstration. You need to know and understand what is happening during the demonstration and what the results are. Will waste be generated that will require special handling? Will there be extreme temperatures, hot or cold? What types of gases may be produced? Will special equipment be required? What types of protective and safety equipment will you need to have on hand? Remember, during any demonstration or hands-on activity, you need to demonstrate proper technique. It is a good idea to check out the Safety Guidelines for NCW and Community Activities and the

Tips for Planning Demos

Step 1 Determine your goals

- > What scientific concepts do you want to cover?
- > Who is the audience (young kids, peers, general public)?
- > Is this demo the most effective and safe way to teach the concept?

Step 2 Get the logistics in order

- > Set a date and secure an appropriate location
- > Check space for exits, emergency equipment, and adequate distance from audience (>10 feet)
- > Order materials
- > Plan safe transportation for people, supplies, and safety equipment
- > Assign tasks and perform a risk assessment

Step 3 Practice the demo

- > Write a detailed procedure the way it will be performed
- > Review Safety Data Sheets, ACS hazard assessment tools, and past incidents to determine what could go wrong
- > Figure out tactics to minimize risk
- > Practice in front of a test audience

Safety Guidelines for Demos
acs.org/safety

Don't forget!

- > Keep 10 feet between demo and observers
- > Encourage audience participation
- > Warn audience of loud noises, potential spills, and other hazards
- > Dispose of waste appropriately
- > Clean demo site completely, wash hands

Flammable Demos Checklist

☑ Before demo, notify hosts, security, administrators, and fire department

☑ Handle flammable liquids safely

- > *Collect only needed amounts from stock bottles before the demo*
- > *Keep bottles capped and stored away*
- > *Never add flammable liquids after ignition to avoid flame jetting*

☑ Appoint a safety officer to follow all fire safety measures *(e.g., personal protective equipment, fire extinguisher, fire blanket, safety shower)*

Chapters Cs Demos

Safety Guidelines for Chemical Demonstrations at acs.org/safety.

Finally, don't assume that a demonstration is safe just because someone says it is or because people have been doing it for a long time. For example, there have been numerous recent news reports of people getting badly hurt by the "rainbow flame" demonstration, which has been around for decades. There is always the potential for something to go wrong with even the "safest" demonstrations. So do your homework before selecting your demonstrations and activities, get creative thinking about what can go wrong, and figure out how to mitigate any risks. You will then have an exciting and educational show that makes an impression for all the right reasons.

Explaining star stuff

Begin your discussion of space by describing the electromagnetic spectrum and waves. Light is a wave, and the colors of the rainbow are made of light with different wavelengths. This can be demonstrated by creating a rainbow on the wall or a screen with a source of white light and a prism. Of course, the electromagnetic spectrum goes far beyond what you can see; you can demonstrate this by modeling an infrared telescope. And you can go right into a quick demonstration of the Doppler effect and changes in wavelength depending on whether planets or stars are moving away from or toward Earth using a balloon.

Explain that scientists find out what stars are made of by studying their emission spectra. Each element on the periodic table emits a specific set of wavelengths of light. Some of these wavelengths are in the visible range, which you can demonstrate using a safer version of the "rainbow flame" demonstration. Show emission spectra by burning samples of metal salts or aqueous metal salt solutions to show the different colors emitted by the metals. Information about the flame test as well as safety considerations and background materials can be found at acs.org. Check out ACS ChemClubs for more colorful experiments at acs.org/chemclub.

Of course, scientists use more than just their eyes—they also use spectrometers. You can build a webcam spectrophotometer to display spectra from a variety of sources on the screen. Again, with a bit of careful planning, you can show both emission spectra and absorption spectra. To show emission spectra, use a diffraction grating; to show absorption spectra, place different solutions in the path, which will block out various wavelengths depending on the solutions.

Even if you don't have access to element-specific light tubes, you can display emission spectra by comparing tungsten filaments, compact fluorescent lights, and sodium vapor lamps. For some hands-on or take-home science, have your audience members build their own spectrometer using an old compact disk (CD) and a cereal box or their smart phones, or leave them with the instructions for measuring the speed of light in their home microwave: wonders.physics.wisc.edu/measure-the-speed-of-light.

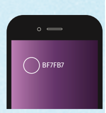
Set "phase-ers" to stun

Astrochemistry is not just about the elements but also about their states of matter and thermodynamics. This makes phase change an excellent topic for space chemistry. The concept of phase transitions can be demonstrated using cedar balls, as shown by Dr. Tadashi Tokieda at Stanford University at vimeo.com/117627467. After an initial explanation of phase changes, there are several demonstrations that

MAKE YOUR OWN SPECTROMETERS USING:

WEBCAM

SMART PHONE



CD + CEREAL BOX

INCHEMISTRY.ACS.ORG
See videos of all the suggested demonstrations in the online version of this article.

can be done using dry ice. When using dry ice, remember to use proper safety techniques to prevent frostbite, and make sure that the area is well ventilated.

If you want to do personalized demonstrations or have something that is hands-on, try boiling water in a syringe to show how pressure affects boiling point. Or you can demonstrate crystallization using Epsom salt paints. To really *wow* the audience, you might want to finish off by making a batch of liquid nitrogen ice cream.

Rocket science 101

Just how does one get into space? And what power sources might be available? Check out a recent ACS Webinar on Rocket Science 101 (acs.org/webinars) to help you prepare for your rocket and rocket fuel demonstrations. Have the audience make their own rockets or race balloons to explore how propulsion and rocket design work together.

You can have discussions about the various types of solid fuels (such as 1,3,5-trinitro-1,3,5-triazinane and 1,3,5,7-tetranitro-1,3,5,7-tetrazocane) and liquid fuels (such as liquid hydrogen, liquid oxygen, and highly refined kerosene). Finish with a flourish by putting a rocketry twist on the traditional "elephant's toothpaste" demonstration using hydrogen peroxide and yeast. This demonstration shows just how much gas you can get from a small amount of liquid.

Finally, solar cells are common on satellites, space probes, and the Mars rovers. Check out the "blackberry solar cell" demonstration outlined in the Green Chemistry Institute's ACS Student Chapter Guide at acs.org. Although this demo requires more preparation time, it will help demonstrate how solar cells work and allows for the discussion of sustainability and renewables.

Last thoughts

The demonstrations and activities highlighted here are supported by ACS resources, making your job just a bit easier. Most of these demonstrations can be performed using readily available materials and have well-documented safety recommendations. But you still have to do some preparation, and you will need to make sure that the demonstrations or activities are appropriate for the audience and location. With preparation and practice, you are sure to provide the "Wow!", getting your audience ready for takeoff to discover some out-of-this-world chemistry.

ACS.ORG

To learn more about safety guidelines for chemical demonstrations and ACS insurance coverage, visit our website.

Frankie Wood-Black *is the Director of Process Technology at Northern Oklahoma College and a science columnist for the* Ponca City News.

Chapters
Cs
IYPT

Are You Ready for the International Year of the Periodic Table?

BY MICHEAL FULTZ

> "With an expected flurry of activities, ACS student chapters have a great opportunity to collaborate with local, regional, and international chapters."

The year 2019 is going to be a big one for chemistry! The United Nations Educational, Scientific, and Cultural Organization (UNESCO) declared 2019 the International Year of the Periodic Table of Chemical Elements (IYPT) in celebration of the 150th anniversary of Dmitri Mendeleev's arrangement of the chemical elements. In addition, according to the UNESCO proclamation of IYPT, "the year 2019 coincides with the anniversaries of a series of important milestones in the history of the periodic table, specifically with the isolation of arsenic and antimony by Jabir ibn Hayyan circa 1200 years ago; the discovery of phosphorus 350 years ago; the publication of a list of 33 chemical elements grouped into gases, metals, nonmetals, and earths by Lavoisier in 1789; the discovery of the Law of Triads in 1829 by Döbereiner; the establishment of the periodic table by Mendeleev 150 years ago; and the discovery of francium by Marguerite Perey in 1939."

With an expected flurry of activities by many groups around the world, ACS student chapters have a great opportunity to plan ahead and to collaborate with local, regional, and international chapters.

01 IYPT Put your networks to work

Great things happen when individuals and organizations come together for a good cause. You can accomplish much more with less work by teaming up with students in other organizations, faculty members, regional scientists, and potential employers.

02 IYPT Choose a theme

Zeroing in on specific topics can help you plan activities more efficiently and thoroughly. Do some brainstorming to think of themes that relate to the periodic table, and outreach activities related to elements and their impact on health, water, food, pollution, or other topics that touch everyday life. These activities can be done at any time of the year as stand-alone events or as complements to pre-scheduled trips to schools or events.

UNESCO suggests in its proclamation that IYPT would be "an occasion to pay tribute to the recent discovery and naming of four super-heavy elements of the Periodic Table of Chemical Elements with atomic numbers 113 (Nihonium), 115 (Moscovium), 117 (Tennessine) and 118 (Oganesson) resulting from close international scientific cooperation." Your chapter could base activities on one or more of these elements.

03 IYPT Brainstorm after NCW

Undoubtedly, you'll soon be gearing up to coordinate activities in celebration of space chemistry, the theme for National Chemistry Week (October 21–27, 2018). An ideal time to start thinking about the theme for 2019 (paper chemistry) would be right after the 2018 celebration. With all the successes and challenges fresh in your mind, you can get a head start in documenting how to make 2019 even more special and aligned with IYPT. Also consider partnering with other ACS student chapters in your region to brainstorm, plan, and compare notes.

Examples of brainstorming questions to get the conversation started:

» *What should we communicate about the history and impact of discoveries of elements related to paper?*

» *What elements were discovered, and how are they important to life today?*

» *What scientists or professors do we know who could help us determine good demonstrations and activities related to paper chemistry?*

After your brainstorming sessions, debrief as a chapter to share how things went, the impact your activities had, and what each of your contributing members learned in the process. Make a list of new skills your members, individually and as a group, may have gained through the event, and help your members recognize how this outreach helped them elevate the level of their résumé as they begin searching for jobs or applying to graduate schools.

04 IYPT Plan Earth Week activities

The 2019 theme for the Chemists Celebrate Earth Week (April 21-27) is paper chemistry. You can discuss the importance of cellulose, how chemistry is used to create paper, and how chemists protect the environment with recycling methods.

05 IYPT Maximize summer

While being mindful of the time that volunteers have available, you might consider adding a periodic table booth to summer 2019 events organized by others (career fairs, carnivals, or other community events). The summer season is a great time for chapter members to do volunteer work, because most students aren't in classes.

06 IYPT Organize a scavenger hunt

Organize a scavenger hunt or treasure hunt to encourage students to learn more about the periodic table. These can be as simple as finding commercial uses of different elements, preparing book reports or literature reviews about individual elements, or—if groups are really ambitious—finding real samples of pure elements.

07 IYPT Raise money

Organize a periodic-table-themed fundraiser. For a bake sale, you could sell element-themed cupcakes that come with a short description or history of an element. This can teach the general public about the periodic table while raising money for the group. Go the extra mile for your community by using those proceeds to buy periodic table posters, games, or sets and donate them to area schools.

08 IYPT Host a speaker, or go on a field trip

In the past 40 years, 12 elements were observed for the first time. Some of the people who were involved in the discovery of these elements would be fantastic and unique speakers to give a perspective on the discovery of an element. You could also make a trip to a science museum or a research or national laboratory to talk to scientists or learn a little history.

09 IYPT Look at the discoverers

All too often we as chemists look at the elements or compounds and may not learn about the person who discovered them. Take some time with your chapter to learn about the scientists responsible for the discoveries. These were great people who came from diverse backgrounds. You can make it fun by throwing a costume party or playing games like charades where the answers are the names of the scientists who accomplished the things we rely on in current research.

10 IYPT Host a seminar

Student groups and ACS local sections can do a lot to help others appreciate the incredible science that was done to first isolate or create and observe elements. Consider developing a seminar that can be presented at a school, for an extracurricular group, or at a local section meeting. These seminars can be on the history of the periodic table, the accomplishments of isolating the elements, or how elements benefit society.

Share your results

11 IYPT

Tell others of your successes. Use opportunities like a regional or national meeting to tell others about what you did. When you share your best practices, others can repeat your success across the country or around the world.

Show appreciation

12 IYPT

Show appreciation for members by giving them awards, or give away prizes for competitions. The prizes or awards don't have to be big or expensive. They could be small and related to the periodic table, maybe from the ACS Store (store.acs.org). Some ideas are periodic table T-shirts, mugs, and pencils.

These are just a few ways in which you can incorporate IYPT into your 2019 activities. As future leaders, you know your colleagues and the needs of your community. Don't limit yourself. Be creative and have fun. Collaborate, teach, and encourage people to learn. You never know the life that is changed through the inspiration you create.

***Micheal Fultz** is an associate professor of chemistry at West Virginia State University, an ACS student chapter faculty advisor, and a member of the ACS Committee on Public Relations and Communications (CPRC).*

CHEMISTRY IS OUT OF THIS WORLD

OCTOBER 21-27, 2018

acs.org/ncw

Plan

Get free resources to plan exciting activities and events for your friends and community.

Participate

Help your ACS local section with the Illustrated Poem Contest for K-12 students.

Get Involved

Join forces with other organizations to coordinate and run outreach events.

NATIONAL CHEMISTRY WEEK

College Life
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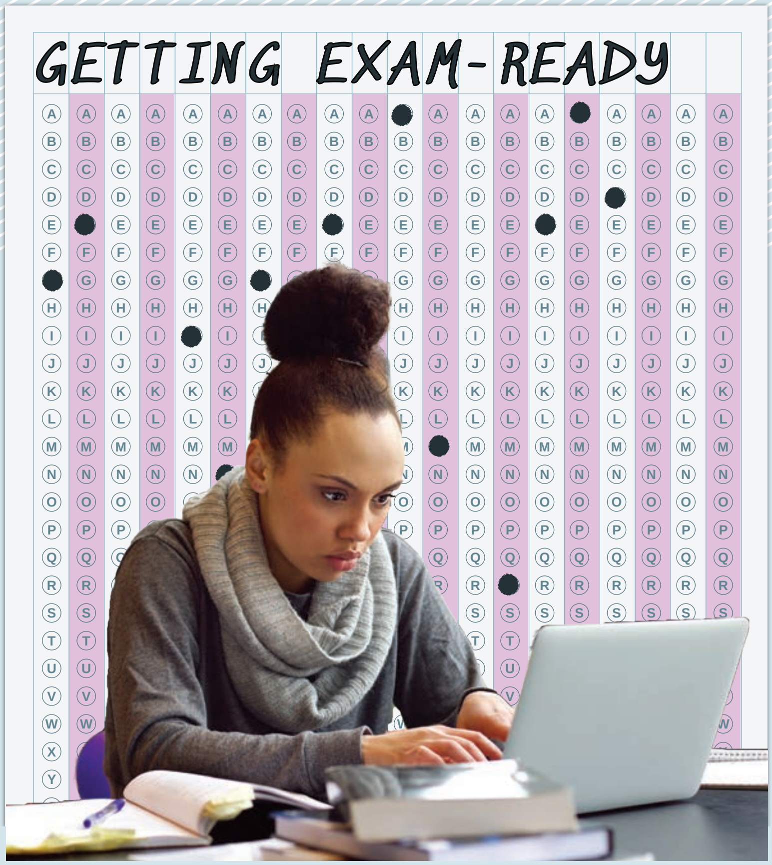
Exam-Ready

College Life



By Amanda J. Carroll

It's the beginning of a new semester, and probably the last thing you want to think about is exams. But actually, the moment you get your syllabi and begin your day-to-day assignments is the moment you should make a plan of action to score high on your exams.

Every lesson you learn in a chemistry course builds on the previous one, so "killing" a final exam doesn't happen because of a cram session; it comes by way of how you study from the very beginning.

Here are five study strategies to get you exam-ready.

#1: Schedule a comprehensive study plan

To plan now for what's coming down the pike, get out the syllabi for all your courses and post all the dates for assignments, projects, and exams onto one calendar. Include preparation time (e.g., studying, writing outlines, drafting papers). To avoid crunches, figure out overlapping due dates and allot time for preparation and study accordingly. For example, if you have a paper due on the same date as a lab report, make sure you have a rough draft of the paper before the lab.

Be sure to include post-exam reviews in your plan. Review your tests, quizzes, and other graded assignments as you get them back, to understand what concepts and knowledge you need to work on. The topics covered in these earlier assessments lay the groundwork for your final, so making sure you understand them as you go along is the most effective way to ensure you're ready for each new stage.

Of course, it's easy for plans to get derailed. You might have to make an emergency trip home, take longer on an assignment than you planned, or simply spontaneously blow off everything one night. *Don't panic!* Simply look at the rest of your plan and revise your calendar. If you are able to space out most of your work, blowing off one or two nights won't tank your semester.

#2: Learn actively

Science has shown repeatedly that simply rereading your notes is just about the single worst way to study. Make better use of your study time by using more active tactics:

» *Complete study problems.*
» *Teach the topic to a friend.*

- *Practice with flash cards.*
- *Draw "thought maps" of the concepts you are learning.*

Study guides and practice tests are also great ways to prepare for exams. If you are taking an ACS exam, you can purchase practice exams and study guides. Check with your professor or with other students who have already taken the course for old tests and problem sets for you to work on as you go.

Tutoring is another way to review old material. Nothing helps you process (and retain!) information like finding new ways to explain it to someone who is struggling.

For cumulative exams, a good tactic is to prioritize studying things you already have a partial grasp of, and try to strengthen your skills and understanding. Keep in mind that each chapter covered on a cumulative final has three to six important concepts. Figure out what these are and make sure you review each one.

#3: Stay on top of the topics

Almost everyone hits a topic in chemistry that is extremely challenging compared with other topics. Remember that chemistry is cumulative—it builds on itself. So, if you are struggling with a topic, it will be that much harder to pick up the next topic in the course.

Work as hard as you can to work through the concept yourself, because this is the best way to retain information. But if a topic is getting the better of you, get help. Seek a tutor, ask a buddy, or join a study group. And take advantage of your professor's office hours.

Incorporating a review of old material when you're studying new material is also helpful. If you are in the second semester of a two-semester course, review one chapter of your previous course each week to make sure you are still on top of the material.

#4: Collect intelligence

Early in the semester, find out as much about the final as possible. You want to know the format (multiple choice, free response) and who wrote it (the professor, the department, the ACS Exams Institute). If someone other than your professor is writing the final, you can expect the questions to look different and to read differently. In this case, you'll want to make sure you study from a variety of sources (alternative textbooks, online problem sets, study guides, old problem sets from different professors).

You'll also need to know what information will be provided (periodic table, key equations, constants, etc.). In general, the more information that is provided on the exam, the more the professor is testing your understanding of the material, rather than your memorization of basic facts—an important clue about where to focus your studying efforts.

#5: Stay active

Be sure to schedule breaks and some personal time in your plans. Even if you have eight hours straight to sit and work, neither your body nor your brain is designed to work that way. Make sure to stop every hour or so for a break—get up, walk around, have a snack, or do something else for about 10–15 minutes to give your brain a rest and reduce your stress level.

Don't underestimate the importance of getting out. It may be a few minutes chatting with a friend, an hour in an exercise class or at the gym, or an afternoon doing outreach with your ACS student chapter. Hanging out with friends (and commiserating over homework) will give you an emotional boost when you are ready to hit the books again. Getting away from your desk will help you refresh and recharge. Sharing your love of chemistry will help you remember why you are still majoring in it.

Midterms and finals may be months away, but now is the time to start getting ready for them. With a good plan and some self-discipline, you will be all set to succeed.

***Amanda J. Carroll** is a lecturer and an ACS student chapter faculty advisor at Tennessee Technological University.*

College Life
Li
Balance

Blood, Sweat, and Beakers: Balancing Chemistry and Sports

By Luis Mauricio Ortiz-Gálvez

Chemistry majors get scholarships all the time, but very few of us have sports scholarships. It took a lot of courage for me to apply for a volleyball scholarship, but it turned out to be the best decision and has made my college journey exciting, enlightening, and challenging. Here's my story.

If at first you don't succeed …

When I applied for a sports scholarship to play volleyball at the Universidad de las Américas Puebla in Cholula, Mexico, I hit a roadblock. I submitted my résumé that documented my academic and athletic skills and then eagerly awaited a phone call from the coaches to attend tryouts. But the call never came.

It turned out that they didn't need anyone for the position that I played. I ended up attending the university on an academic scholarship instead and took solace in playing for fun.

One day the coaches and the players saw me play. They suggested I try applying again and invited me to practice with them. It wasn't until the third semester (with some encouragement from family and friends) that I accepted their offer. I practiced with the team and played in competitions until my position opened up. Finally, I got the long-awaited call to deliver the documentation needed to secure a sports scholarship.

I thought the hard part of becoming a college athlete was over, but it was just the beginning.

Dealing with setbacks

Even though I was able to pursue my two biggest passions—chemistry and volleyball—the commitment was overwhelming. I often felt nervous about not being good enough. I had to keep up with coursework, labs, reports, homework, and exams. I had to train, practice, and compete in games. There was so much to juggle.

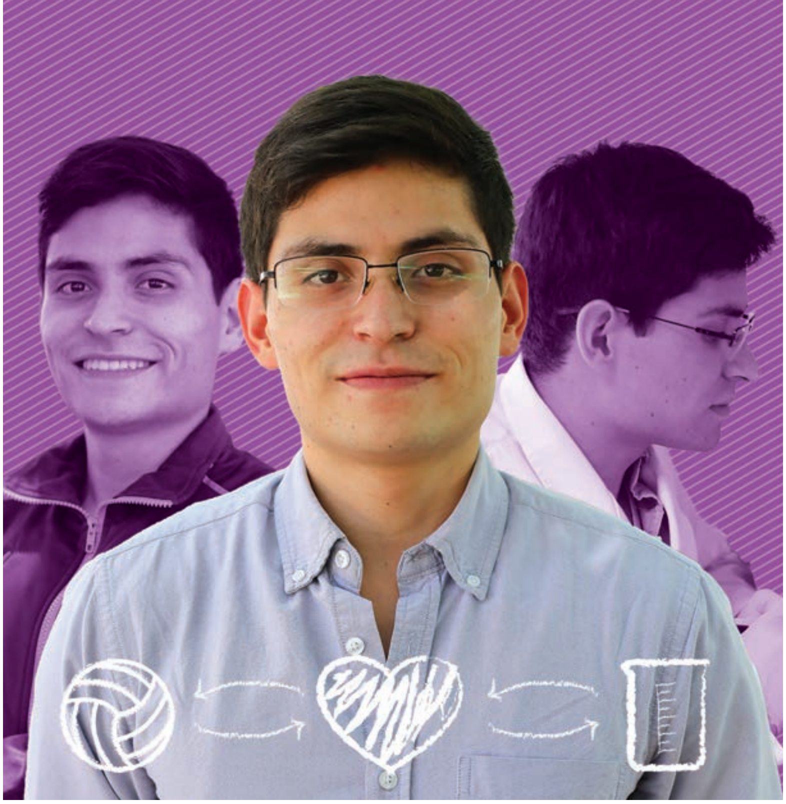
I firmly believe that my successes and failures depend on me and my willpower to stay focused. I remember when I was about 13 years old, my family decided to visit the Pan American Volleyball Complex in Jalisco, Mexico, when the Pan American Games were approaching. The director gave us a tour of the premises and asked me if I wanted to train with them. I didn't know what to say, so my family made the decision for me and said "yes". It was the first time I was training outside of my home town. The training was exhausting, and people kept saying I was too short and not good enough. The negative feedback made me work harder than ever before. I started playing as libero, where my height wouldn't be an issue, and I developed my skills. Even though I'm still a short guy, I've been in some National Olympiads and my college team won the championship two years in a row.

Whether I am preparing for a test or a tournament, I always find something positive in every hurdle on my path. And whenever anxiety starts to creep in, I just take a deep breath, relax, and let my body take control of the situation.

My role models also give me a sense of confidence. Cameron McEvoy, an Australian physicist and Olympic swimmer, is a great example of how you can balance two challenging disciplines. Jenia Grebennikov, a French volleyball player who was voted the best libero in the European Volleyball Champions League, reminds me to keep my head high and keep moving forward.

Keeping the balance

I have learned that being organized is the key to balancing academics and sports. The first thing I did when I started playing on the volleyball team was define my goals. I wrote out the big things that I wanted to achieve, like becoming a



professional chemist or becoming a stronger volleyball player. Then I defined my objectives by outlining the individual steps I needed to follow to reach my goals.

From there, I established priorities. I wrote down all my duties, responsibilities, and activities. Next, I asked myself which was the most important one at that time, and which would help me with my goals and objectives the most. I rearranged my list in order of importance.

The list became my work plan. I added in all my activities, including eating and resting, and assigned each activity a time in order of importance. I also keep a notebook that works double duty as a diary and a planner. I make sure I jot down my activities and events so that I don't have to worry about forgetting them.

Staying organized helps me manage my workload.

My study routine

I usually practice and go to the gym in the afternoon, do my homework at night, and study on the weekends. When I have to travel to another university to play, I study on the way to the school, during free time, or in the evenings before going to sleep. When I have exams, I shift my priorities even further to my courses and cut back on gym time so I can devote more hours to studying.

And, of course, sometimes I have to sacrifice things like going out to parties or hanging out with my friends, to stay on top of everything. Sometimes away games mean I have to miss classes. But I ask my friends for help, and they always come through. Not only do they give me class notes; they also give me the motivation to work hard.

Managing my health

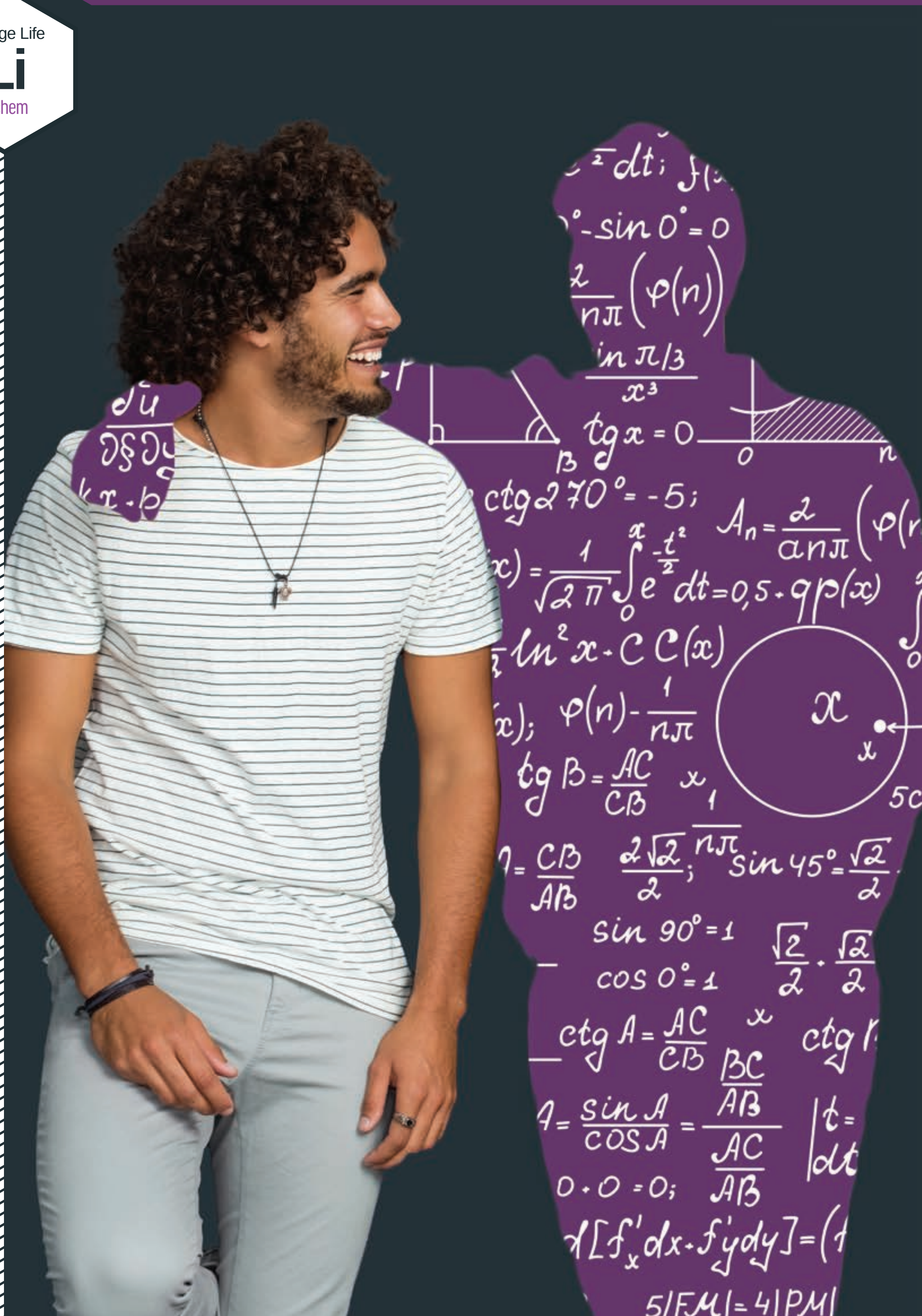
I am lucky to have family members who have taught me to take care of myself. If I'm not healthy, I can't keep moving forward. So, if I am sick or have injuries or pain, I make sure I rest after practice. I also make sure I go to the doctor and do whatever they say I need to do to heal.

Last semester, I had an injury to the anterior cruciate ligament of my left knee and I had to have a surgery. I was sad and it was difficult to accept, but I had to take care of myself.

Volleyball has been a tremendous force in my life. It has taught me to identify my strengths and work on my weaknesses every day. And it has taught me teamwork, something that is essential in the laboratory and on the court. The patience, tolerance, and respect I developed with my teammates has helped me to work with my classmates and strengthen our lab work. I have learned to seek out information and support when I need it, and I've developed the tenacity and dedication to pursue a chemistry career.

Even though my future will probably focus on chemistry rather than sports, pursuing a sports scholarship allowed me to attend one of the best universities in Mexico and set me up for a great career in chemistry. Taking a chance on pursuing two passions was the best decision I ever made.

__Luis Mauricio Ortiz-Gálvez__ is an undergraduate student in the Nanotechnology and Molecular Engineering Program at Universidad de las Américas Puebla in Mexico. He is part of the university's volleyball team and is also a member of Catalyst, the university's ACS international student chapter.



DON'T FEAR THE MATH. P-CHEM WILL ELEVATE YOUR UNDERSTANDING OF MOLECULAR BEHAVIOR TO HELP YOU SEE THE BIGGER PICTURE.

BY **MICHELLE BOUCHER** AND **ALYSSA THOMAS**

Making Peace with P-chem

Aah, P-chem. If you're a chemistry major, the perpetually dreaded physical chemistry course is probably a requirement in your junior or senior year. You've heard all the rumors: it's confusing; it's all advanced calculus and you'll never understand it. We're here to tell you: don't believe all the (negative) hype! OK, yes, P-chem *is* challenging for many people, although the same is true for many chemistry courses. But if you can make friends with this fascinating area of chemistry, you will come away with a rich, fundamental understanding of the chemical phenomena you've already learned about.

What's P-chem all about?

In physical chemistry, you use physics and math to understand and describe atoms and molecules, getting to the theoretical basis for thermodynamics, kinetics, electron configurations, and even the phases of matter. You'll see how the quantum numbers used to describe electrons are not arbitrarily assigned, but rather determined by solving equations that describe atomic behavior. The energy diagrams that show reaction mechanisms suddenly become clear when you have an understanding of how to derive those energy values.

Physical chemistry is the place where you finally get to dive into some of the topics that other courses brushed over. What you learned about heats of combustion in organic chemistry will help you gut-check answers in P-chem. The molecular worldview of kinetics that you picked up in general chemistry is a great foundation for kinetic problems in P-chem. And spectroscopy is just a practical application of what you will learn about energy levels in quantum mechanics.

Give it a chance, and everything may make more sense through a set of P-chem-colored goggles.

Practice, practice, practice

The first lesson you'll learn in the thermodynamics section is to define the system and the surroundings. This general philosophy is actually useful for everything you'll encounter in the course: What are you trying to figure out? What is being asked? What information do you have, and what are you looking for?

You will need to imagine what is going on with the system and picture what the molecules are doing. The best way to get good at picturing the system accurately is to practice, practice, practice. Oh, and also to practice. Everything in a P-chem course is about how you go about solving the problem. It isn't about drilling the same type of problem over and over again, because there is always a new way to ask the same question. You will learn how to decode problems and decide what approach to take.

The good news is that decoding is actually easier than memorizing. You can start developing your decoding skills by taking the following approach to each new topic:

- *Identify the basic definitions for the topic.*
- *Work to understand the equations by translating them into words.*
- *Define or write down your symbols (and what units they should have) so that they feel real to you.*

This approach will help you treat the math like what it is—a tool to describe molecules and molecular behavior—and it will help you really think about what each variable and each equation are telling you. This is your first step in decoding P-chem problems.

Then, when you are given a problem, continue the decoding process:

- *Write down each piece of information you are given, using both words and symbols.*
- *Identify where you need to end up.*
- *Select the equations you need, the information to plug into them, and the order of your calculations to get to where you need to go.*

If you get into the habit of approaching problems in this way, it will help you tackle even the most difficult ones.

Make note of trigger words — words that point to specific areas of chemistry or types of problems. For example, words such as "isothermal" (vs "adiabatic") and "irreversible" work (vs "reversible" or "maximum") will point you in the direction of the equations that would be useful. There are subtle, but important, differences between "ideal" gases and "perfect" gases in heat capacities and intermolecular interactions.

State functions are also triggers for the right equations. For example, when trying to find changes in internal energy (ΔU) for an adiabatic expansion or compression of a perfect gas, first allow for the volume change under constant temperature, and then allow for the temperature change under constant volume. These changes of state can then be added together to describe a process that actually happens in one step (see sidebar).

Practice Tips

The more problems you do, the stronger you will get in this course.

- Ask your professor for more practice problems
- Check out your textbook's companion website
- Consult with your professor about the approach that they take before searching the Web for resources (e.g. YouTube)

Don't fear the math

Yes, statistics and calculus are involved in learning physical chemistry, but they are only tools. P-chem is so much more than just math. The concepts you will be studying are the same concepts you've been studying all along to learn about molecules and molecular behavior; however, now you are finally going to be fully equipped with the rationale to really understand and describe what is going on.

Before P-chem, you may have memorized and used a number of equations to solve problems. In this course, you'll learn how to use math to derive answers, and how the variables affect one another, and all of this work will help you see the bigger picture. For example, a lot about thermodynamics can be described with a few equations that you can rearrange as needed. Once you've mastered P-chem, you won't have to memorize these equations; you will be able to rearrange a few basic ones. Think about reaction rate laws: all they are is a description of the change in concentration of reactants. In calculus, this is known as a derivative (hence, differential rate laws). Inversely, an integrated rate law directly links concentrations with time via integration.

Also, remember that not all the math is going to be advanced math. Knowing how to manipulate equations, solve simple two-variable systems, or even just isolate one variable is as important as remembering

Authors

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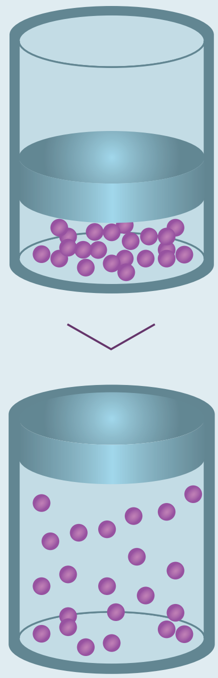
Alyssa Thomas is an associate professor of chemistry at Utica College, an ACS Councilor, and a member of the ACS Committee of Minority Affairs.

A TALE OF TWO APPROACHES

Most P-chem problems have one right answer but multiple ways to reach it. The following has a **mathematical approach** and a **theoretical approach**. See which works best for you.



The problem

A piston filled with 0.0400 moles of a perfect gas expands reversibly from 50.0 mL to 375 mL at a constant temperature of 37.0 °C. As it does so, it absorbs 208 J of heat from the surroundings. Calculate q, w, ΔH, and ΔU for this process.

Define trigger words and phrases

- **Perfect gas:** The equation of state is $PV = nRT$.
- **Reversibly:** Infinitesimally small changes, meaning you may need to use calculus.
- **Constant temperature:** $\Delta T = 0$, which is important because it relates to the change in internal energy, ΔU.
- **Absorbs 208 J of heat:** Heat (q) for this process is a positive value.

What you know:

- $n = 0.0400$ moles of gas
- $V_i = 50.0$ mL
- $V_f = 375$ mL
- $T = 37.0$ °C $= 310$ K

What you need to find:

- q (heat)
- w (work)
- ΔH (change in enthalpy)
- ΔU (change in internal energy)

Theoretical approach

- You are given the value of q and know that $\Delta T = 0$.
- No change in temperature leads you to determine that $\Delta U = 0$, because for perfect gases, the internal energy U is only concerned with kinetic energy. (If the average kinetic energy of the system—the temperature—remains constant, so will U.)
- Because $\Delta U = q + w$, and you already know that $\Delta U = 0$, w must be equal to $-q$ (simple algebraic rearrangements are all you need so far). From the problem, $q = +208$ J. Thus, $w = -208$ J.
- Solve for ΔH using $\Delta H = \Delta U + \Delta(PV)$. You already know that $\Delta U = 0$. The change in PV would be final minus initial. Using the perfect gas law, $PV = nRT$, you realize that because there was no change either in temperature T or in the number of moles n, $\Delta(PV) = 0$, and thus $\Delta H = 0$.

Mathematical approach

- The problem gives you the value of heat ($q = +208$ J)
- Derive the equation for work (w) for an isothermal reversible expansion of a perfect gas, and calculate w.
- Add together the values for q and w to get ΔU.
- For ΔH, you have ΔU and now need to find $\Delta(PV)$. Use the perfect gas law to find the pressure for the final and initial states in atm.
- Keep as many digits in the calculator as possible when you multiply the pressures and volumes, to ensure that you get the correct value for ΔH (i.e., zero). Rounding too soon introduces errors that will result in an incorrect answer.

Answers (the same for either approach)

$q = +208$ J $\quad w = -208$ J $\quad \Delta H = 0$ J $\quad \Delta U = 0$ J

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how to integrate by parts. So don't assume you need to take partial derivatives when you simply need to divide both sides of an equation by the same quantity to solve the problem.

In fact, you should use the math to your advantage. When you get an answer, do a gut check and think about what kind of answer would make sense. If you are getting a bond length of 200 cm or finding that you need 6.5×10^9 J to heat up 10 g of water by 10 °C, you should know by now that your order of magnitude is off. Time to rethink what you did.

Use your units to check your work, too. If you expect the answer to be a unit for energy and your answer is in L·atm, something has gone wrong. Always, always, always check your units before, during, and after putting them into an equation. When in doubt, put the units into SI and see if you suddenly have an idea of what to do with a problem (or what to do if an answer is right or wrong). You may have come across these tips in earlier chemistry courses; P-chem is no different!

You can do this

Studying P-chem is your chance to think back to what you've learned about molecules and piece together how the concepts you are studying can enhance and deepen your understanding. So, before you start to panic, remember that physical chemistry is, first and foremost, a chemistry course. You have made it this far by learning about the qualitative aspects of atoms and molecules. Now it's time to dig into the quantitative underpinnings of their behavior.

P-chem is everywhere

Applications of P-chem beyond the classroom

The dispersion of perfume scents in a room relies on Maxwell's distribution of speeds (root-mean-square speed), $PV = nRT$, diffusion, and heat of vaporization. Molecular mass also plays a role: lighter-molecular-weight top notes, medium-molecular-weight middle notes, and heavier base notes.

$PV = nRT$ can tell you why tire manufacturers recommend cold tire inflation pressures and are careful to define what that means (e.g., no more than 5 minutes of driving). With fairly rigid tires (i.e., approximately constant volume), as the temperature goes up, so does the pressure. Overfilling a cold tire can easily result in a blown tire.

Fireworks are all about thermodynamics, because they are designed to be exothermic, but not too exothermic, and to have the largest entropy change possible, so that the reaction is spontaneous.

Chocolate "bloom" is an example of phase separation, which is described in multiple-component phase diagrams. Chocolate doesn't go bad; the white film, or chalky appearance, is thermodynamically driven by the fats separating from the chocolate matrix to form fat blooms on the surface. You can slow down the separation by putting the candy in the freezer. This decreases the kinetic energy of the molecules, and therefore slows down the separation.

Marshmallows are a great demonstration of food polymers and thermoreversible gels. Gelatin melts in your mouth to give the unique mouthfeel and texture of marshmallows because of the thermoreversibility of the hydrogel. The transition temperature between solid and fluid states is close to body temperature; this is why marshmallows (and Jell-O) melt in your mouth.

American Chemical Society Scholars Program

At-A-Glance

The American Chemical Society Scholars Program is an undergraduate scholarship program that offers financial support, mentoring, and networking for students majoring in a chemical science. Eligible majors include chemistry, biochemistry, chemical engineering, chemical technology, and materials science. Students entering pre-med, nursing, dentistry, pharmacy or veterinary medicine programs are not eligible.

The application period is open from November 1 until March 1, annually.
Visit our website, www.acs.org/scholars to find more information and apply.

To be considered a candidate, students should be:

- A U.S. Citizen or permanent resident of the U.S.
- African-American, Hispanic/Latino, or American Indian
- Pursuing an undergraduate degree at a nationally accredited U.S. college, university or community college
- A graduating high school senior, college freshman, sophomore or junior
- A cumulative grade point average (CGPA) of 3.0 or higher on a 4.0 scale
- Able to demonstrate financial need according to the Free Application for Federal Student Aid (FAFSA) form

To obtain additional information, please email us at **scholars@acs.org** or call toll-free at **1-800-227-5558 (ext. 6250).**

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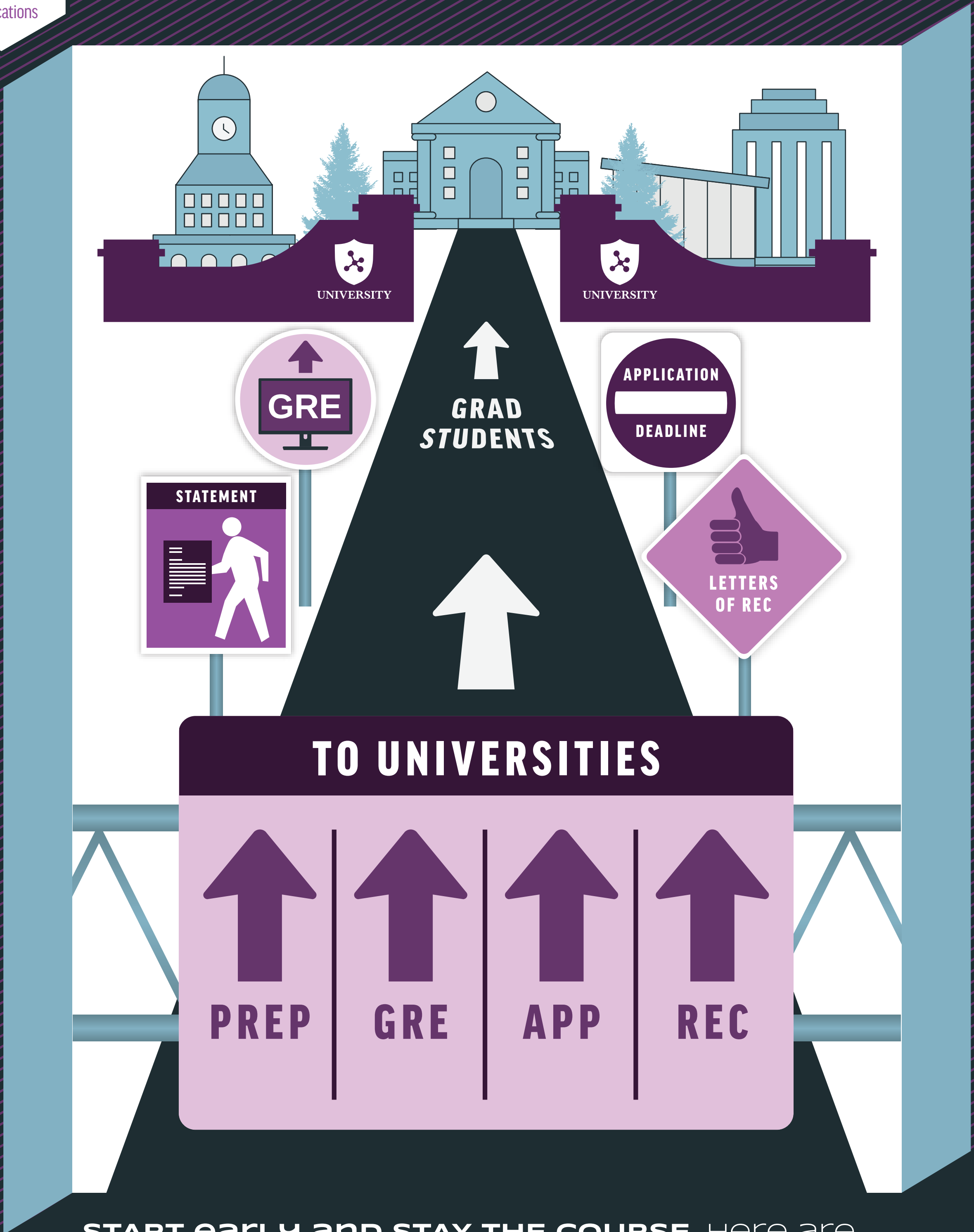

START EARLY AND STAY THE COURSE. HERE ARE SOME TIPS TO HELP YOU MANAGE THE "GETTING IN" PART OF GRADUATE SCHOOL. BY **BLAKE J. ARONSON**

The Road to Grad School

Your guide to the application process

You've made a major decision to go for your master's (M.S.), professional science master's (P.S.M.), or doctorate (Ph.D.) degree. Whether you *should* go is a topic for another article. Now it's time to apply.

On the face of it, the next few steps are simple: select a few programs, take your Graduate Record Examinations (GREs), complete some application forms (including preparing a tailored personal statement), and submit your applications, along with your transcripts and some letters of recommendation.

OK, maybe it's not so simple. Here is what it takes to get through the "getting in" part of graduate school.

Give yourself plenty of time

Ideally, you should start the process about a year before the application deadline. Most deadlines are between December and February, so if you plan to start graduate school in September 2020, the best time to start the process is in the spring of 2019.

Why do you need so much time? There are several reasons. First, you don't want to rush through the application itself, so give yourself time to collect your thoughts. Second, some parts of the application take time to complete. The general-subject GREs are offered almost any day, but you need to reserve your spot in advance. Your references will need at least one month to write recommendation letters. And your registrar will need time to send your transcript out.

Taking time to find the right programs for you is also important. Candice L. Progler-Thomsen, a recruiter for King Abdullah University of Science and Technology in Saudi Arabia, advises students to consider the application process as a journey of reflection and finding the right fit. "If the student isn't confident that they meet the program requirements and that the program is a good match for them, it will be difficult to convince an admissions committee that the student is meant to be in the program," she says.

Look for three to six graduate programs that are right for you. Choose from schools with well-

Grad School
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Applications

Author

Blake J. Aronson is a lead associate in the ACS Student Communities office.

defined programs (whether M.S., P.S.M., or Ph.D.) in your area of interest. Check out professors' webpages and abstracts of their recent articles to find those whose research interests you. Look for programs with industry connections or extra teaching opportunities, depending on what professional skills you want to develop. Also, consider the location—whether it's a new city or a new country for you, you want it to be a place that appeals to you.

Many programs have rolling admissions or make their funding available on a first-come, first-served basis. Either way, getting your application in early can only work to your advantage.

You are a busy person, and applying to graduate schools is stressful. Spreading out the workload will help alleviate some of the stress.

Tackle the finances

Sure, applying for graduate school can get expensive. The fee to take the GRE General Test is just more than $200, and the GRE Subject Test costs an additional $150. You can also expect to pay for official copies of your transcript. Plus, most graduate programs have application fees. Applying to six or seven programs could easily run you $700.

Fortunately, there is help. The GRE Fee Reduction Program provides 50% off the testing fees in certain circumstances. In addition, some graduate programs will waive their application fee. Check with the graduate admissions office to see if you qualify.

If money is still an issue, many schools can help you secure microloans and other resources to get you over this particular hurdle. Check with your financial aid office.

Even better: remember that financial aid is typical for chemistry graduate students. Most programs provide their students with a tuition waiver and a living stipend. The stipend is usually in exchange for teaching in your first year or two, and research after that.

Securing external funding isn't necessary for graduate school, but it can bolster your application. Leslie Hamachi, a graduate student at Columbia University in New York, recommends applying for the NSF Graduate Research Fellowship Program simultaneously with your graduate school application. "Winning this can help open doors as far as getting off waiting lists for school admissions and the ability to join the lab of your choice when you get to graduate school," Hamachi says.

Meet the criteria

There is no version of the Common Application for graduate programs. Each program has its own process, requirements, and deadlines. Review each of the criteria for each program carefully, and make sure you meet them. You don't want to be rejected from a program on a technicality.

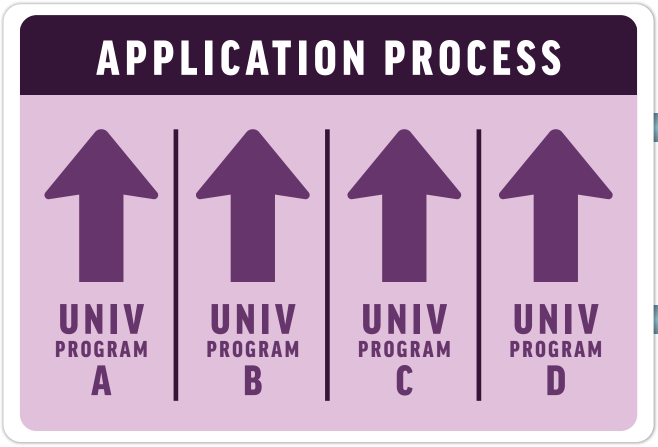
As Melissa King, a graduate student at Wesleyan University in Middleton, CT, says, "Graduate school applications are not generic and should be tailored to each institution to which you are applying."

That said, there are some components that are pretty universal:

Transcripts

In general, programs will require official copies of transcripts from every institution you have attended since high school. That includes the writing course you took at your local two-year college over the summer to fulfill your humanities requirement.

Make sure you order your transcripts well in advance of the application deadline; your application will be considered incomplete without them. And, because things do happen, it can't hurt to check with the programs to ensure that the transcripts have arrived on time.



GREs

GREs are a lot like the SATs or ACTs you took for college admission. The GRE General Test includes verbal reasoning (two sections), quantitative reasoning (two sections), and analytical writing (one section). The complete test takes four to five hours (including breaks).

If you need to take the GRE Subject Test, it takes about one and a half to two hours and covers all four years of your major, including your senior year. Consequently, it is helpful to take the Subject Test later in the academic year. Don't wait too long, though! The scores need to arrive ahead of the application deadline, along with the rest of your application.

If you are aiming to start graduate school in the fall, it is ideal to take your GREs no later than September or October of the year before. Taking them even earlier is better, so that you have the option of retaking them if you don't like your scores. However, in some cases you may find yourself taking them later, especially if scheduling is a challenge. Just do your best and make sure the scores arrive before the application deadline.

As with college entrance exams, preparation helps. ETS, which administers the GREs, has information, testing times, and locations, and—best of all—practice tests at ets.org/gre. You can also find workshops and study guides that will help you prepare.

Personal statement

Graduate school applications require some type of personal statement. This is your chance to show that you are more than a collection of scores and grades. Make the most of it.

Start by knowing what the graduate program is asking for. Some programs simply ask why you are interested in graduate school, while others may have very specific topics to address. Consider what life and school experiences have led you to pursue graduate school and how each specific program will help you on your path. Tell the reader a story of who you are and how you will contribute to science and the world.

"Each program will have its own process, its own requirements, and its own deadlines."

Worried about your GPA?

Graduate programs typically like to see applicants with GPAs of 3.0 or higher and in the 60th percentile or higher for GRE scores. If your digits aren't quite there, make sure your personal statement and recommendation letters clearly demonstrate why you belong in graduate school.

Special notes for international students applying to U.S. programs

TOEFL

Most U.S. programs require the Test of English as a Foreign Language (TOEFL) as part of the application process. Like the GREs, it is administered by ETS. You can learn more at ets.org/toefl. Additional fluency tests may also be required. Letters of recommendation should also mention your proficiency in English.

Visa

You will be responsible for obtaining your own visa to attend graduate school in the United States. Most students use an F-1 or J-1 visa, which you can obtain only after you have been accepted by the graduate program and after you have informed them of your intent to enroll. But you will want to start this process as soon as you can. More information on these visas can be found at www.ice.gov/sevis.

Living arrangements

Finding off-campus housing in a different country can be challenging. Some graduate programs offer on-campus housing for international students to ease the transition. Either way, visit the International Student office and ask about your options as soon as you accept an offer.

Emphasize research, teaching, leadership, and other experiences that will have an impact on your career. Because research is the cornerstone of most chemistry programs, describing your undergraduate research and what you learned from the experience will lend weight to your statement. You should mention specific faculty you are interested in working with, and why. This will help the reader visualize you at the school and demonstrate your interest in the program.

Most importantly, remember to proofread your statement. Spellcheck doesn't no "best" form "beast", so ITS easy to right a sentence that is bade but technically spelled correctly. **Seriously—spellcheck didn't catch any of the errors in that sentence.** So, proofread each version. Better yet, distribute your statements among some friends for proofing.

Letters of recommendation

Graduate programs usually require three letters of recommendation. These should come from people who know you in a way that is relevant to the program. For example, Ph.D. programs are research-based, so a letter from the professor who mentored your undergraduate research is a must. Letters can also come from your advisor, professors who taught courses in which you excelled, or faculty for whom you have tutored or performed as a teaching assistant. "Ask your letter writers if they feel like they could write you a strong recommendation letter," King recommends. "It is very important to have letter writers that know you well enough to speak to your work ethic, character, and skills."

Give your references at least one month's notice and as many specifics as possible—deadlines, submission information, names of the letter's recipients, topics to address, and so on. Providing your personal statements can be very helpful to letter writers. And although you don't need to pester your references, there is no harm in a polite reminder of the approaching deadline.

Hamachi offers one final piece of advice: "Ask current graduate students for drafts of their application materials and to help proofread your personal statement; people will be way more excited to help you than you think."

Graduate program applications are high-stakes, but, as thousands of graduate students can attest, they are manageable. With a little determination, a little planning, and a lot of proofreading, you will soon be one of them!

://
inchemistry.acs.org

Read more about getting an awesome recommendation letter online.

Careers
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Careers

Thinking Outside the Research Box

“Industry or academia?” You’ve probably heard that question a dozen times. And what it really means is, “Are you going to pursue a research career in industry or in academia?” But there are other options. If research or teaching isn’t your thing (yes, it is possible to love chemistry but not love research), the world has plenty of chemistry-related opportunities in a multitude of fields, like cinema, food production, public policy, law, journalism, technology, sales, and human resources.

Here are two scientists who took a detour from research to end up in a place they truly enjoy, with their chemistry knowledge in tow.

Careers
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Maxwell Kushner-Lenhoff

Communications Manager

The Dow Chemical Company

B.S., M.S. (Concurrent), Chemistry, Yale University, New Haven, CT

Speaking of chemistry

Like many chemistry majors, Maxwell Kushner-Lenhoff thought his life's career as a research scientist was set in stone. As an undergraduate at Yale University, he had the opportunity to earn both bachelor's and master's degrees in inorganic chemistry in four years. After a Harvey Mudd College Research Experiences for Undergraduates (REU) program in physical chemistry during the summer after his freshman year, Kushner-Lenhoff received a National Science Foundation (NSF) travel grant to present a poster at his first ACS national meeting. In the second semester of his sophomore year, he started research in an inorganic chemistry lab, focusing on renewable energy catalysis.

Later, as a Society of Chemical Industry (SCI) Scholar and as president of the Yale ACS student chapter, he was awarded travel grants from Nalco and ACS, which he used to present research at two other ACS national meetings.

"I enjoyed the lab work, but I found that that was not my favorite part of what I was doing," Kushner-Lenhoff says. "One of the beautiful things about research is that you can focus on one problem and follow it through, but I like changing things up a bit, winding up with slightly different problems to work on."

A pivotal conversation started Kushner-Lenhoff down a different path. At a national meeting meet-and-greet event for students and chemical professionals, he had the opportunity to speak with former ACS president and Dow employee Katie Hunt (yes, students can talk to ACS presidents!). "We spoke about my interest in trying to find a science-related job outside of R&D, and she encouraged me to consider Dow," Kushner-Lenhoff remembers.

The turning point came during an "Oratory and Statecraft" seminar at Yale. Thanks to a recommendation from an alumnus of the course, Kushner-Lenhoff found a position as a Communications Manager at Dow, tackling activities across the communications spectrum, from research and writing to public relations and marketing.

The most rewarding part of his job now is being part of a team that supports the most senior leaders of a company that "is truly making a difference in the world," Kushner-Lenhoff says. "When people hear that I was the coordinator for the environmental advocacy organization at Yale, they are sometimes surprised at the transition.

"The truth is that technological advancements and political buy-in from companies like Dow are absolutely necessary if we are going to find the solutions to the challenges facing our planet. Dow's collaboration with the Nature Conservancy is a case in point."

Karen Tkaczyk

Freelance Translator

McMillan Translation

Master of Chemistry with French (M.Chem.), University of Manchester, United Kingdom; Ph.D., Organic Chemistry, Queens' College, University of Cambridge, United Kingdom

Translating chemistry across borders

What do you do with an undergraduate minor in French and a Ph.D. in organic chemistry? If you're Karen Tkaczyk, you start a translation business that focuses on translating chemistry and related science and technology content from French into English.

As the owner of her business, Tkaczyk is responsible for state licensing, accounting, marketing, and, of course, translating content. She delights in the variety of responsibilities. "I have always loved languages, and I enjoy the broad range of chemistry and related science and technology that I am exposed to as I translate. One of the most unexpected benefits of my career is the breadth of knowledge I have developed .... I thrive on learning about something new with almost every job."

Tkaczyk relied on her working knowledge of French, a one-year internship in a French pharmaceutical research laboratory, and her own bilingual home (her husband is French) to build her business, but certifications in translation are useful for building credibility. In the United States, the American Translators Association's "Certified Translator" is an important credential. "I earned that after I had gained a few years' experience," Tkaczyk says. "For me, a niche specialization like chemistry and common-sense business practices were enough to get into the market and be earning a decent income before I was certified."

Tkaczyk notes that freelancing can be challenging. "The freelance world is often described as one of feast and famine—indeed, initially, more famine than feast. I work about 40 hours most weeks, but I sometimes work 70 if I get a rushed or lucrative project, and I take a lot of time off—six to eight weeks a year. ... The environment is fast-paced. Everyone wants everything now. I do tend to be connected a great deal, so that my clients receive a prompt response."

Tkaczyk describes her secret to success succinctly. "I'm a proactive, self-motivated person. That is the only way anyone will break into a freelance market and thrive once there." She takes advantage of ACS and other resources to increase her "subject matter knowledge and awareness of the industry as a whole." She also relies on ACS Webinars and the ACS Style Guide to inform her work.

Although there is no one path to a successful career, there are plenty of opportunities for people with the right passion. For more ideas on building a career outside of the lab, visit CollegeToCareer (acs.org/CollegeToCareer).

ACS & You
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Divisions

ACS & You

Take Your Career Further with ACS Technical Divisions

By Kevin McCue

If you are a new ACS member—or considering joining—you have the special privilege of being part of a global community of chemistry professionals. Soon you'll be interacting with peers who love chemistry, presenting at professional meetings, and accessing a wealth of resources and opportunities that will propel your career forward.

Becoming a member of the world's largest scientific society sounds like it should be enough all on its own, right? Well, there are special communities within ACS, which you may have overlooked, that allow you to explore your interests *in depth:* ACS's 32 technical divisions. And this year, a new offering gives first-time members a chance to see what divisions are all about. You can join up to *three* technical divisions for free for a year!

What are ACS technical divisions?

Technical divisions are field-specific communities within the ACS umbrella that provide members with a forum for networking, collaboration, and professional development.

One of the first ways you might encounter a technical division is when you submit an abstract for an ACS national meeting. Technical divisions plan and organize the technical programs at these meetings, so you submit your abstract to a specific division. You'll often see them referenced by their four-letter abbreviations. For example, ORGN is the Division of Organic Chemistry, CHED is the Division of Chemical Education, and BIOL is the Division of Biological Chemistry.

Divisions are led and managed primarily by volunteers. They also have a few members who are elected to represent them in ACS governance. Also, as noted, they manage technical programming at ACS national and regional meetings. Divisions vary in size—from a few hundred members to 10,000. The resources they provide are equally varied. In addition to organizing technical programming at national and regional meetings, divisions often maintain websites and social media, organize networking events, publish newsletters, administer grants, and more.

Why join a technical division?

Here are some of the many big advantages to being involved with technical divisions:

Be in the know about awards for travel and research

Many divisions have travel awards for undergraduate students that help pay for travel to an ACS national meeting. For example, the Division of Agrochemicals (AGRO) offers selected undergraduate and graduate students up to $600 to help defray the costs of attendance to give poster and oral presentations. AGRO also has a poster competition where first-, second-, and third-place winners receive an additional cash award. The Division of Fluorine Chemistry (FLUO) offers the Moissan Summer Undergraduate Research Fellowship in Fluorine Chemistry. Opportunities abound, and a good way to stay in the know is to join a division.

Connect with like minds

To the outside world, a chemist is a chemist. As a new chemist, you have probably started to see the amazingly diverse ways to be a chemist, and to see the richness of chemistry subcultures. The experience of being a synthetic organic chemist is very different from being a computational chemist. If you can't understand what some of your peers are working on or don't see yourself doing what they do, you are not alone. Divisions are a way to network regionally,

Learn more at ▶ acs.org/divisions

An undergraduate student shares her research at a Division of Carbohydrate Chemistry (CARB) poster session held at the Spring 2018 ACS National Meeting & Exposition. — JOE ORLANDO INC.

AGFD Agricultural & Food Chemistry

AGRO Agrochemicals

Travel awards!

ANYL Analytical Chemistry

BIOT Biochemical Technology

BIOL Biological Chemistry

BMGT Business Development & Management

CARB Carbohydrate Chemistry

CATL Catalysis Science and Technology

CELL Cellulose and Renewable Materials

CHED Chemical Education

CHAS Chemical Health & Safety

CINF Chemical Information

TOXI Chemical Toxicology

CHAL Chemistry & the Law

COLL Colloid & Surface Chemistry

COMP Computers in Chemistry

ENFL Energy & Fuels

ENVR Environmental Chemistry

FLUO Fluorine Chemistry

GEOC Geochemistry

Connections!

HIST History of Chemistry

I&EC Industrial & Engineering Chemistry

DIC Inorganic Chemistry

MEDI Medicinal Chemistry

NUCL Nuclear Chemistry & Technology

ORGN Organic Chemistry

PHYS Physical Chemistry

POLY Polymer Chemistry

PMSE Polymeric Materials: Science & Engineering

PROF Professional Relations

RUBB Rubber

SCHB Small Chemical Businesses

nationally, and internationally with peers who share your interests.

Explore your interests

With the option of joining up to three different divisions, you don't have to limit yourself to just one area of interest. If your passion is inorganic chemistry but you also have a thing for history, you can join both the Division of Inorganic Chemistry (DIC) and the Division of the History of Chemistry (HIST). If you have an entrepreneurial streak, join the Division of Small Chemical Businesses (SCHB). After your first free year, division memberships are discounted for students. This is your chance to explore what divisions have to offer, not just the division associated with your undergraduate research.

WATCH
Find out what people value about divisions.

Boost your résumé

Showing involvement in specialized areas of chemistry can help your résumé shine. If you are planning to use your chemistry degree in the field of law, you'll be able to highlight your experiences with the Division of Chemistry and the Law (CHAL).

At this stage, you're probably looking to build a résumé that will eventually help you advance in chemistry. Joining a technical division may give you access to experiences that will set you apart from the competition. You'll have access to awards, leadership, and volunteer opportunities, and connections within specific fields of chemistry. You will learn more about the different areas of chemistry and, hopefully, find your niche in the career that's right for you.

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DOUBLE CODING

The following puzzles use two kinds of codes. The first code is a simple substitution of symbols for letters. Answer the chemistry trivia questions to find out which letters correspond to which symbols in the corresponding riddle. The second code is numeric—the numbers in the riddles are atomic numbers. Use the element symbols that correspond to the atomic numbers to complete the riddles.

E	Ar
◊	18
↑ Only one letter per box	↑ One or two letters, depending on the element

Puzzle A

Vitamin C, chemically speaking:

<				>					<			□

It makes you happy, literally:

	◊	>		Δ				

Silver, originally:

<	>	∧	◊				∨

Puzzle A Riddle

74	1	85		□	53	□		Δ	2		90	68	42	∨	◊	52	>

16	<	39		Δ	8		90	◊		6	39	3	60	68	?	39	8	92

∨	<	39		4		∧	88	□	92	85	◊	□	,	5	92	Δ		53

1	<	23	◊		42	75		□	◊	∧	75	99	.

Puzzle B

He put it all on the table:

‡	♥		■	>			♥	●		‡	●	+	●	●	

Famous polymerization catalyst, with Natta:

#		●		+	●	>

Puzzle B Riddle

74	1	39		‡	53	‡		■	2		5	8	♥	5	68

15	53	+	8	■		‡	>	8	15		1	17	?	■	8

10	92	■	88	3	#	●		■	2		●	10	♥	39		56	34	.