



Physical Chemists

... Explore the ways things work

When asked to describe physical chemistry, the renowned chemist Gilbert Newton Lewis is purported to have responded: "Physical chemistry is everything that is interesting!" In fact, physical chemists aim to develop a fundamental understanding at the molecular and atomic level of how materials behave and how chemical reactions occur, knowledge that is relevant in nearly every area of chemistry. These scientists study diverse topics, from biochemistry to materials properties to the development of quantum computers.

Physical chemists seek to unravel such varied mysteries as how proteins fold into their active state, how complex nanostructures can be formed and behave, how biomolecular motors work, and how global phenomena such as the stratospheric ozone hole originated. They develop theories about these properties, analyze materials, and discover potential uses for materials.

Physical chemists work extensively with sophisticated instrumentation and equipment as well as state-of-the-art computers. When you walk into a physical chemistry lab, for example, it is bound to be packed with computers and large instruments, including lasers, mass spectrometers, nuclear magnetic resonance (NMR) spectrometers, and a variety of microscopes that can see and follow molecules at atomic resolution.

... Apply physics and math

Physical chemistry applies physics and math to problems that interest chemists, biologists, and engineers. Physical chemists use theoretical constructs and mathematical computations to understand chemical properties and describe the behavior of molecular and condensed matter. Their work involves manipulations of data as well as materials.

The specialty really clicks for some students when they first study the connections between math and chemistry, learning how they can use math as a powerful tool to predict properties of chemicals. A relatively new technology that similarly combines chemistry, math, and physics is the area of molecular simulation. Physical chemists developed molecular simulation tools that are becoming fundamental to research in all areas of chemistry. Scientists who understand how to use such tools are expected to be critical to the growth of this specialty.

... See their work as interdisciplinary

Physical chemistry has traditionally given students broad training and positioned them to work in a variety of scientific careers. A multifaceted, interdisciplinary perspective is central to the field.

Many physical chemists ultimately work as analytical chemists and assume responsibility for the advanced analytical work that moves the field forward. Scientists who work for a company that manufactures beauty care products, for example, may work in physical or analytical chemistry, conducting applied and basic surfactant research for product development applications. Such work involves measuring and understanding the assembly of molecules. Assembling surfactant molecules in crystals and solutions, physical chemists determine how to measure these basic components in terms of arrangements of atoms and molecules, how they grow to form bigger aggregates in solutions as well as in crystals, and how these aggregates of surfactants impart various properties to a product.

Recently, more and more physical chemists have found work in the emerging fields of materials science, molecular modeling, and biosensor development, where their skills in analyzing and predicting the behavior of physical properties have exciting new applications. The development of these areas makes it a good time to study physical chemistry.

Scientists caution students that job opportunities in this discipline require interdisciplinary knowledge. They warn that it is vital for students to combine their knowledge of physical chemistry with other disciplines. The multifaceted nature of physical chemistry gives the work a rich variety that many physical chemists say they find exciting. Physical chemists today perform such diverse activities as conducting chemical engineering research for computers, developing sensors for bio-agent detection or for medical diagnostics, discovering new enzymes with optimal surface interactions for pharmaceuticals, developing films that allow imaging on polyester materials, developing an understanding of pollutant movement in groundwater, and inventing new applications of quantum mechanics in areas such as quantum computing. One of the great strengths of physical chemistry is that it permits the scientist to approach a complex problem whose solution might be based on many measurements and scientific perspectives.



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FACT FILE: Physical Chemists

WORK DESCRIPTION ► Physical chemists work in a variety of different industries, but their common goal is to discover, test, and understand the fundamental physical characteristics of a material—be it solid, liquid, or gas. Precision and attention to detail make their work similar to analytical chemistry, although physical chemists also stress the importance of applying knowledge of math and physics to develop an understanding of the material. They work with both their minds and hands, manipulating complex sets of data and operating sophisticated lab instrumentation.

WORKING CONDITIONS ► A physical chemistry lab is characterized by the large equipment and sophisticated instrumentation these scientists use to test and analyze materials. Many who work in the lab say their time is divided between working at the bench and working at their desks doing calculations and reviewing data. Physical chemists also work with the most up-to-date and powerful computers.

Physical chemists who go into management spend time supervising other scientists, reviewing department needs and goals, and meeting with business managers in their companies.

PLACES OF EMPLOYMENT ► Physical chemists find employment in a wide range of settings, including almost every industry, government agency, research institute, and educational institution. Industries employing physical chemists are as diverse as plastics, ceramics, catalysis, electronics, pharmaceuticals, surfactants and colloids, and personal care products. Physical chemists also work in such areas as environmental and analytical chemistry. Materials science, nanoscale science, and chemical biology are growing fields for physical chemists, and the emerging field of molecular modeling uses all the basic skills of these scientists.

PERSONAL CHARACTERISTICS ► Physical chemists generally describe themselves as having a strong curiosity about how things work at the atomic level. They enjoy working with their hands as well as with instruments and computers. Their varied interests predispose them to undertake the interdisciplinary studies that help them excel in this field. Many describe having been drawn to physical chemistry because of the importance of math and physics to the field, sometimes noting the similarity of the discipline's processes to those of engineering. As physical chemists, they are also often able to combine their knowledge and love of chemistry to make discoveries that have social, economic, and personal value.

EDUCATION AND TRAINING ► In addition to a solid foundation in chemistry, physical chemists say this career requires strong skills in math and physics. Hands-on courses, such as lab, electronics, and optics courses, are particularly helpful. Also, because the field is becoming increasingly interdisciplinary, physical chemists encourage students to take courses outside of their major and develop an understanding of the synergies among the different disciplines. A fundamental understanding of quantum mechanics, kinetics, thermodynamics, and structure is crucial.

JOB OUTLOOK ► A degree in physical chemistry provides ideal training for many high-tech, bioscience, environmental science, and materials science careers. Having obtained a strong understanding of the dominant structural and dynamic merits of real materials, many physical chemists are redirecting their skills into applications research and interdisciplinary fields such as materials science or chemical biology.

SALARY RANGE ► According to 2002 salary data, the median salaries for physical chemists are in the mid \$50,000s for B.S. chemists, in the mid \$60,000s for M.S. chemists, and between \$76,000 and \$106,000 for Ph.D. chemists.

FOR MORE INFORMATION

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WHAT YOU CAN DO NOW ► The most important qualification to pursue a career as a physical chemist is to have a real curiosity about molecules, how they work, and how they can be studied. Lab experience, especially with sophisticated instrumentation, is extremely valuable. An understanding of how computers work and a knowledge of software, graphics, and programming are very helpful. Physical chemists encourage students to pursue interdisciplinary studies at every level. Some physical chemists recommend that students interested in the field work in an industrial lab—for example, through an internship—to gain an appreciation of the many practical applications of physical chemistry.