Nobels: Physics and chemistry

Left to right: Bloembergen, Siegbahn and Schawlow: Quantum optics and quantum electronics yield methods for materials studies.

Quantum mechanics and what it can tell us about the structure and dynamics of matter is featured in both the physics and chemistry Nobel prizes for 1981. The physics prize this time was given for techniques and applications. The chemistry prize went to theorists.

Development of two kinds of spectroscopic techniques won the physics prize. Electron spectroscopy won half the total $180,000 for Kai Siegbahn of Uppsala University in Sweden. Nicolaas Bloembergen of Harvard University and Arthur L. Schawlow of Stanford University share the other half of the prize for their contributions to laser spectroscopy.

Son of a previous Nobel winner, Manne Siegbahn, Kai Siegbahn has been a professor at Uppsala since 1954. Bloembergen has been at Harvard almost continuously since 1946. Schawlow has been at Stanford since 1961.

Electron spectroscopy is a technique in which X-rays or ultraviolet are used to dislodge electrons from a sample under study. From the energies of the dislodged electrons much can be learned about the atomic and molecular structure and dynamics inside the sample. Siegbahn is credited with a development that made electron spectroscopy reliable: The electrons coming out of the sample tended to lose unknown amounts of energy on the way out, making analysis of the data extremely difficult. Siegbahn's technique of double focusing eliminated the problem.

Laser spectroscopy is also used to study atomic and molecular properties by illuminating with laser light. The frequencies the sample absorbs and the amounts of each absorbed can be used to determine atomic and molecular energy levels, chemical bonds, chemical changes, etc. Both Bloembergen and Schawlow have been involved in many aspects of laser spectroscopy since the beginning of lasers. Both kinds of spectroscopy can be used in fact in studying the theories propounded by the chemistry prize winners.

Those winners are Kenichi Fukui of Japan's Kyoto University and Roald Hoffmann of Cornell University. Fukui and Hoffmann share the prize for their "independently developed theories on the course of chemical reactions."

Chemical reactions play the dominant role in a variety of research endeavors, ranging from combatting disease to preparing food and drink. Effective use of chemical reactions, though, depends on a solid theoretical foundation. Fukui and Hoffmann helped construct such a foundation with their independent work on predicting the outcome of chemical reactions.

Their research is based on quantum mechanics — complex mathematics that involves the concept that the smallest building blocks of matter may be regarded as both particles and waves. Fukui, the first Japanese to win the Nobel chemistry prize, used quantum mechanics to show that certain properties of the orbits of the most loosely bound electrons and of the most easily accessible unoccupied electronic orbits could be used to predict the reactivity of molecules. Hoffmann—a 1955 Westinghouse Science Talent Search winner (SN: 3/12/55, p. 166)—worked with the late Robert B. Woodward to show that orbital symmetry (a mathematical not a physical symmetry) predicts the "forbidden" and "allowed" products of one-step chemical reactions (SN: 5/9/81, p. 294). ☐

Photos: Wide World

Kenichi Fukui (left) and Roald Hoffmann (right) both predicted the outcome of chemical reactions.

Mt. St. Helens victims: Death by suffocation

Just before the volcanic eruption of Mt. Pelee, in 1902, a woman about to die wrote a friend: "Will death be by fire or asphyxia? It will be what God wills."

Now, 80 years, hundreds of eruptions, and thousands of deaths later, scientists are gaining greater insight into how volcanos kill. Autopsies of 25 victims of the explosion of Mount St. Helens — their bodies so saturated by ash that inch-deep incisions dulled scalpel blades — represent "a step into the unknown," report researchers from the Universities of Washington and Oregon in the Oct. 15 New England Journal of Medicine. The findings, the first of their type in medical literature, contradict previous descriptions of death.

Hands were mummified, muscles appeared dried and frayed, and internal organs had shrunk and hardened. Decompositional changes, although present, were less than expected, the researchers say.

The most common cause of death was suffocation by inhalation of volcanic ash. The gritty ash mixed with mucus and plugged the larynx, trachea, and upper airways. Thermal burns were prevalent in persons nearest the blast zone, who were trapped when superheated water and pyroclastic fluids rolled down the mountain. The remainder of the deaths were caused by physical trauma, such as a blow from falling trees or rocks. Every victim — regardless of the exact cause of death — suffered either tracheo-bronchitis or throat irritation.

In general, volcanic eruptions are so geographically remote or so cataclysmic that careful examination of bodies is impossible. Old historical descriptions of death possess drama but little medical documentation, and were not substantiated by this new research. For instance, observers of the 1911 explosion in the Philippines described victims as unclothed and poisoned by gas. Victims of Mount St. Helens were fully clothed; fumes, although present, were not lethal.

Mount St. Helens was relatively unexpected, and death, for those who died of suffocation, took place within minutes. Those who were burned survived long enough to walk several miles for help. In no case was a victim frozen in place, as reported in historical literature — there was time to escape. Film from a camera of one of the victims shows the ash cloud growing larger and larger, photographed from the rear window of a truck.

The use of gas masks and respirators could have helped prevent suffocation, and adequate shelter would have averted injury from falling objects. But in spite of precautions, thermal burns would still be devastating. "For those who were at the base of the volcano, one cannot imagine protective measures," say researchers. ☐