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Analytical Dynamics on Physical Chemistry

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Editorial

Physical chemistry is the study of macroscopic and particulate phenomena in chemical systems in terms of the principles, practices, and concepts of physics such as motion, energy, force, time, thermodynamics, quantum chemistry, statistical mechanics, analytical dynamics and chemical equilibrium.

Physical chemistry, in contrast to chemical physics, is predominantly (but not always) a macroscopic or supra-molecular science, as the majority of the principles on which it was founded relate to the bulk rather than the molecular/atomic structure alone (for example, chemical equilibrium and colloids).

Some of the relationships that physical chemistry strives to resolve include the effects of:

- Intermolecular forces that act upon the physical properties of materials (plasticity, tensile strength, surface tension in liquids).
- Reaction kinetics on the rate of a reaction.
- The identity of ions and the electrical conductivity of materials.
- Surface science and electrochemistry of cell membranes.
- Interaction of one body with another in terms of quantities of heat and work called thermodynamics.
- Transfer of heat between a chemical system and its surroundings during change of phase or chemical reaction taking place called thermochemistry
- Study of colligative properties of number of species present in solution.
- Number of phases, number of components and degree of freedom (or variance) can be correlated with one another with help of phase rule.
- Reactions of electrochemical cells.
- Behaviour of microscopic systems using quantum mechanics and macroscopic systems using statistical thermodynamics.
- Quantum chemistry, a subfield of physical chemistry especially concerned with the application of quantum mechanics to chemical problems, provides tools to determine how strong and what shape bonds are, how nuclei move, and how light can be absorbed or emitted by a chemical compound. Spectroscopy is the related sub-discipline of physical chemistry which is specifically concerned with the interaction of electromagnetic radiation with matter.

Another set of important questions in chemistry concerns what kind of reactions can happen spontaneously and which properties are possible for a given chemical mixture. This is studied in chemical thermodynamics, which sets limits on quantities like how far a reaction can proceed, or how much energy can be converted into work in an internal combustion engine, and which provides links between properties like the thermal expansion coefficient and rate of change of entropy with pressure for a gas or a liquid. It can frequently be used to assess whether a reactor or engine design is feasible, or to check the validity of experimental data. To a limited extent, quasi-equilibrium and non-equilibrium thermodynamics can describe irreversible changes. However, classical thermodynamics is mostly concerned with systems in equilibrium and reversible changes and not what actually does happen, or how fast, away from equilibrium.

The term "physical chemistry" was coined by Mikhail Lomonosov in 1752, when he presented a lecture course entitled "A Course in True Physical Chemistry" Petersburg University. In the preamble to these lectures he gives the definition: "Physical chemistry is the science that must explain under provisions of physical experiments the reason for what is happening in complex bodies through chemical operations".

Modern physical chemistry originated in the 1860s to 1880s with work on chemical thermodynamics, electrolytes in solutions, chemical kinetics and other subjects. One milestone was the publication in 1876 by Josiah Willard Gibbs of his paper, On the Equilibrium of Heterogeneous Substances. This paper introduced several of the cornerstones of physical chemistry, such as Gibbs energy, chemical potentials, and Gibbs' phase rule.

Developments in the following decades include the application of statistical mechanics to chemical systems and work on colloids and surface chemistry, where Irving Langmuir made many contributions. Another important step was the development of quantum mechanics into quantum chemistry from the 1930s, where Linus Pauling was one of the leading names. Theoretical developments have gone hand in hand with developments in experimental methods, where the use of different forms of spectroscopy, such as infrared spectroscopy, microwave spectroscopy, electron paramagnetic resonance and nuclear magnetic resonance spectroscopy, is probably the most important 20th century development. Further development in physical chemistry may be attributed to discoveries in nuclear chemistry.

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