

# THE UNIVERSITY OF CHICAGO

## DEPARTMENT OF CHEMISTRY

### PHYSICAL CHEMISTRY

PHYSICAL CHEMISTRY 101: THERMODYNAMICS AND STATISTICAL MECHANICS

- 1. The first law of thermodynamics states that the change in internal energy of a system is equal to the heat added to the system minus the work done by the system.
- 2. The second law of thermodynamics states that the entropy of an isolated system never decreases over time.
- 3. The third law of thermodynamics states that the entropy of a perfect crystal is zero at absolute zero temperature.
- 4. The Boltzmann constant,  $k_B$ , relates the average kinetic energy of particles in a gas to the temperature of the gas.
- 5. The partition function,  $Z$ , is a central quantity in statistical mechanics that allows us to calculate thermodynamic properties of a system.
- 6. The Helmholtz free energy,  $A$ , is defined as  $A = U - TS$ , where  $U$  is the internal energy,  $T$  is the temperature, and  $S$  is the entropy.
- 7. The Gibbs free energy,  $G$ , is defined as  $G = H - TS$ , where  $H$  is the enthalpy,  $T$  is the temperature, and  $S$  is the entropy.
- 8. The chemical potential,  $\mu$ , is the partial molar Gibbs free energy of a component in a mixture.
- 9. The van der Waals equation of state is a cubic equation in volume that accounts for intermolecular forces and the finite volume of molecules.
- 10. The Maxwell relations are a set of equations that relate the second derivatives of thermodynamic potentials.

These concepts are fundamental to understanding the behavior of matter at the molecular level and are essential for the study of physical chemistry.

PHYSICAL CHEMISTRY 102: ELECTROCHEMISTRY AND PHOTOCHEMISTRY

- 1. The Nernst equation relates the cell potential to the concentrations of the reactants and products in an electrochemical cell.
- 2. The Faraday constant,  $F$ , is the charge carried by one mole of electrons.
- 3. The standard reduction potential,  $E^\circ$ , is a measure of the tendency of a chemical species to be reduced.
- 4. The photochemical reaction quantum yield,  $\Phi$ , is the number of molecules of a particular product formed per photon absorbed.
- 5. The rate of a photochemical reaction is proportional to the intensity of the incident light and the quantum yield.
- 6. The Arrhenius equation describes the temperature dependence of the rate constant of a chemical reaction.
- 7. The transition state theory provides a framework for understanding the rates of chemical reactions.
- 8. The activation energy,  $E_a$ , is the minimum energy required for a chemical reaction to occur.
- 9. The pre-exponential factor,  $A$ , in the Arrhenius equation is related to the frequency of collisions between molecules.
- 10. The rate-determining step is the slowest step in a reaction mechanism and controls the overall rate of the reaction.

These topics are crucial for understanding the kinetics and thermodynamics of chemical reactions and the behavior of electrochemical systems.

PHYSICAL CHEMISTRY 103: QUANTUM CHEMISTRY AND SPECTROSCOPY

- 1. The Schrödinger equation is a partial differential equation that describes the wavefunction of a quantum system.
- 2. The Heisenberg uncertainty principle states that the position and momentum of a particle cannot both be known with arbitrary precision.
- 3. The Pauli exclusion principle states that no two electrons can occupy the same quantum state simultaneously.
- 4. The Born-Oppenheimer approximation is used to separate the electronic and nuclear degrees of freedom in a molecule.
- 5. The Franck-Condon principle states that the probability of a vibrational transition is highest when the equilibrium internuclear distance changes significantly.
- 6. The Beer-Lambert law relates the absorbance of a solution to its concentration and the path length of the light.
- 7. The molar absorptivity,  $\epsilon$ , is a measure of the ability of a chemical species to absorb light.
- 8. The Stokes shift is the difference in wavelength between the absorption and emission maxima of a fluorescent molecule.
- 9. The fluorescence quantum yield,  $\Phi_f$ , is the ratio of the number of photons emitted to the number of photons absorbed.
- 10. The lifetime of an excited state is the average time that a molecule spends in that state before returning to the ground state.

These topics are essential for understanding the quantum nature of matter and the interaction of light with matter.