Topic list for Physical Chemistry I exam

1. **Perfect and real gases** (The ideal gas law. Changes of state: isothermal, isobaric and isochoric processes. Mixtures of ideal gases, the concept of molar fractions, partial pressure, Dalton's law. Description of real gases (isotherms). The critical state. Compressibility. The van der Waals equation of state. The critical state.)

2. **The 1st law of thermodynamics** (The concept of work, expansion and additional (useful) work. The concept of heat. Definition of internal energy and its molecular interpretation. Different forms of the first law of thermodynamics. The concept of enthalpy. Internal energy of an ideal gas. Joule's experiment. Internal energy and enthalpy of real gases. The Joule–Thomson effect and the Joule–Thomson coefficient.)

3. **Thermochemistry** (Thermochemical equations. Thermodynamic definition of the heat of reaction. Standard state. Standard enthalpy of reaction. Hess's law. Calculation of reaction enthalpies based on enthalpies of formation and combustion enthalpies. Calorimetry. Heat capacity, types of molar heat capacities. Kirchhoff's law. The Born–Haber cycle.)

4. **The 2nd law of thermodynamics** (Different wordings of the second law. Statistical and thermodynamic definition of entropy. Entropy change in a few important processes for the system and for the surroundings. Transformation of heat to work: the Carnot cycle and the Carnot efficiency. Principles behind heat engines, refrigerators and heat pumps.)

5. **The 3rd law of thermodynamics** (Different wordings of the third law. Temperature dependence of entropy. The inaccessibility of absolute zero degree. Absolute and standard values of entropy. Standard reaction entropy.)

6. **Thermodynamic potential functions** (Combination of the first and second laws of thermodynamics. The Helmholtz and Gibbs energies. Thermodynamic potential functions and their use to find the directions of spontaneous processes. The conditions of equilibrium in closed and in opened systems.)

7. **Chemical potential** (The concept of calculation of the chemical potential in one- and multi-component systems. Chemical potential of an ideal gas, real gas, liquid. Chemical potential in multicomponent systems. The Gibbs–Duhem equation. Ideal and real mixtures. The Raoult and Henry laws. Thermodynamic significance of activity. Standard state convention.)

8. **Thermodynamics of one-component systems** (Definition of phase and component. Phase diagrams. Phase diagram of CO_2 and water. Phase stability and phase transitions. The use of chemical potential to describe the equilibria in one-component multiphase systems. The effect of pressure and temperature on phase equilibria. The Clapeyron and Clausius–Clapeyron equation. Trouton's rule. Ehrenfest classification of phase transitions.)

9. **Multicomponent systems: mixtures and solutions** (The definition of mixture. Partial molar quantities. Definition and determination of partial molar volume. Thermodynamics of mixing. Excess functions. Ideal and real mixtures. Thermodynamic description of colligative properties: boiling point elevation, freezing point depression, solubility, partition, osmosis. Practical importance of colligative properties.)

10. **Mixtures of volatile liquids** (Vapor pressure of liquid mixtures. Vapor pressure–composition diagrams. Temperature–composition diagrams. Distillation. Azeotropic mixtures. Vapor pressure above immiscible liquids. Steam distillation. Significance of distillation.)

11. **The phase rule** (Number of components, phases, degrees of freedom. The phase rule and its derivation. Application of the phase rule in one-component, two-component and three-component systems. Phase changes and their detection methods. Reactive systems.)

12. **Chemical equilibrium** (Equilibrium in chemical reactions – concepts and conditions. Equilibrium constant. Other expressions for the equilibrium constant: K_p, K_x, K_a. Determination of the equilibrium constant from other thermodynamic data The concept of reaction Gibbs energy, exergonic and endergonic processes. Standard reaction Gibbs energy and its connection with the chemical potential.)

13. **Influence of external conditions on the chemical equilibrium** (The dynamic nature of equilibrium. Le Chatelier's principle. The influence of pressure change on the equilibrium constant and equilibrium composition. The influence of temperature change on the equilibrium constant and equilibrium composition (van't Hoff equation). The influence of the addition or removal of a reactant or product on the equilibrium composition. Practical applications.)

14. **Homogeneous equilibrium electrochemistry** (Overview of electrochemistry. Thermodynamics of electrolytes. Characterization of electrolytes. Thermodynamic formation functions of ions. Activities of ions in solution. The Debye–Hückel theory.)

15. **Heterogeneous equilibrium electrochemistry** (Galvanic *versus* electrolytic cells. Galvanic cells: chemistry and thermodynamics, parts and usual notations of Galvanic cells, potential of a Galvanic cell, concentration cells, measuring cell potential, Galvanic cells in practice, fuel cells. Electrodes: dependence of the electrode potentials on the composition, measuring electrode potentials, scale of electrode potentials, types of electrodes.)