Thermodynamic Properties of Gaseous Plasmas in Zero-Kelvin Limit [[1]](#footnote-1)\*)

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1,2Iosilevskiy I.

1Joint Institute for High Temperatures of the Russian Academy of Sciences,  
 [iosilevskiy@gmail.com](mailto:iosilevskiy@gmail.com)  
2Moscow Institute of Physics and Technology (National Research University)

Remarkable limiting structure of gaseous plasma thermodynamic functions is under consideration in the special joint limit of low temperature and low density (*T*→ 0; *n*→ 0; μel = *const*). The prominent low-temperature tendency, which was claimed many years ago [1], is carried to extreme. All thermodynamic quantities, when their special forms being exposed, *vs.* chemical potential, μel, (as a principal ruling parameter), obtain an outstanding extra-simple form in the limit discussed. Two Equations of State: thermal (*PV/RT*) and caloric (*U* − 3/2*PV*) obtain almost identical *stepped* structure (“ionization stairs”). In the same limit the differential thermodynamic quantities (heat capacity, compressibility *etc*.) degenerate into the set of positive or negative δ-like peaks (“thermodynamic spectrum”). It should be stressed that the binding energies of all possible stable complexes (atomic, molecular and ionic) in its *ground state* are the only quantities that manifest itself in meaningful details of this limiting picture: such as the value of each “stair” or the μel-location of each “line”. It should be stressed also, that there is no any detail in the discussed limiting zero-temperature thermodynamic form (no “stairs”, no “lines’) which correspond to the *exited states* of binding complexes.

The discussed limiting structure appears within a fixed negative interval of μel, which is bounded below by the value of major ionization potential (μel ≥ μel\* = −*IZ*=−*Z2*Ry). This “individual energy scale” includes all the ionization potentials, dissociation energies *etc*. The thermodynamically stable branch of this energy scale is completed from above by the condensation point. The corresponding boundary value of electron chemical potential, μel\*\*, is connected with the sublimation energy of substance, Δo*HS* {μel ≤ μel\*\* = − (Δo*HS* + *I*1)/2 in atomic gases}. In its turn the *metastable branch* of energy scale continue from condensation point, μel\*\*, up to the hypothetical edge of metastable range.

The limiting stepped structure of gaseous zero-Kelvin isotherm is generic prototype of well-known “shell oscillations” in EOS of gaseous plasmas at low, but finite temperatures. It seems to be more important that this limiting form of plasma thermodynamics could be (and should be) used as the most adequate basis for rigorous deduction of well-known quasi-chemical approach (“chemical picture”) in frames of systematic asymptotic expansion on the base of “physical picture” (system of bare nuclei + electrons). Principal feature of the approach proposed ought to be emphasized: in contrast to the traditional approach when the activity is the principal (“small”) asymptotic parameter of developed expansion, while the temperature being a secondary fixed parameter only, the presently discussed approach seek proper systematic expansion in the limit *T →*0 on the set of temperature asymptotic functions λ*k*(*Т*) ~ exp{– *Ak*(μ*е*)/*Т*}around the discussed “ionization stairs” as a reference system (zero approximation: *T*= 0). In frames of this expansion the *temperature* is a “small” parameter, while the chemical potential, μ*е*, is a secondary parameter, which could be fixed *equivalently* in any point of all sited above energy scale − from condensation state point on above and up to the fully ionized state from below. .

Problem of existence and features of similar limiting structure of gaseous thermodynamics is considered, discussed and predicted for wide number of classical Coulomb models.

1. \*) [abstracts of this report in Russian](http://www.fpl.gpi.ru/Zvenigorod/XLVIII/Lt/ru/EK-Iosilevskii.docx) [↑](#footnote-ref-1)