Indicate if each of the following statements is either true (T) or false (F). A correct response is awarded +1, an incorrect response is awarded −1/2, and no response is awarded 0 points. Ambiguous marks are counted as incorrect responses.

1. integral $\Delta[Q]$ in the form

$$\Delta[Q] = \frac{1}{2} \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} n^2 (Q^* + Q_{i}^* - Q_{i}) f f_{i} c c d\sigma d\Omega d\Omega_{cc} d\epsilon_{1}.$$ 

The physical meaning of this form is that $\Delta[Q]$ represents the change in quantity $Q$ as a result of collisions of class $(c,c_{i}) \rightarrow (c^{*},c_{i}^{*})$. 

2. Conservation of mass, momentum, and energy, requires that for $Q = m, me, \sqrt{2} mc^2$, then

$$Q^* + Q_{i}^* - Q_{i} = 0 \rightarrow \Delta[Q] = 0.$$ 

This implies that the collisional invariants $Q = m, me, \sqrt{2} mc^2$, or some linear combination of the collisional invariants, e.g., $Q = \frac{1}{2} mc^2 + B \cdot me + C$, are the only summational invariants.

3. The result of the Boltzmann $H$-theorem is that a stationary state for $H = \ln (nf)$ is also a stationary state for $f$. This corresponds to an equilibrium state where the probable number of molecules in any element of velocity space is constant with time.

For an isolated system, a statement of the second law of thermodynamics is for the entropy $S$ is $dS \geq 0$, and $dS / dt = 0$ corresponds to the condition $f^* f_{i}^{*} = f f_{i}$. An expansion of $\ln f$ in terms of the linear combination of collisional invariants results in the Maxwellian distribution

$$f_0 = \left( \frac{m}{2\pi kT} \right)^{1/2} \exp \left( -\frac{mc^2}{2kT} \right).$$

This implies that the entropy of an isolated system must continually increase until at equilibrium it reaches a maximum and the distribution function is Maxwellian.

4. The Chapman-Enskog method provides a solution of the Boltzmann equation for a restricted set of problems in which the distribution function $f$ is perturbed by some small amount from the equilibrium Maxwellian form, e.g.,

$$f = f^{(0)} + \varepsilon_0 f^{(1)} + \varepsilon_0^2 f^{(2)} + \cdots \quad \text{or} \quad f = f_0 (1 + \Phi_1 + \Phi_2 + \cdots),$$

where $\varepsilon_0$ or $\Phi$ is a “perturbation parameter.” The resulting solution is called a normal solution of the Boltzmann equation because it is valid across a normal shock wave or other discontinuities.
5. ___ The first approximation for the viscosity coefficient $\mu$ for a monatomic gas is

$$\mu = \frac{(5/8)(\pi m k T)^{1/2}}{\left(\frac{m}{4 k T}\right)^4 \int_0^\infty \frac{c_r^7 \sigma \exp\left(-\frac{mc_r^2}{4 k T}\right)}{d c_r}}$$

This shows the explicit dependence of the viscosity coefficient on the viscosity collision cross section

$$\sigma = 2\pi \int_0^{4\pi} \sin^2 \chi \sigma d\Omega.$$ 

6. ___ An empirical measure of a successful molecular model for rarefied gas flow studies is that it should reproduce the viscosity coefficient of the real gas, particularly the temperature dependence.

Bird state that the Navier-Stokes equations are obtained from the Chapman-Enskog method when the viscous-stress tensor and heat-flux vector are specified as

$$\tau_{ij} = \mu \left(\frac{\partial u_i}{\partial x_j} + \frac{\partial u_j}{\partial x_i} - \frac{2}{3} \delta_{ij} \frac{\partial u_k}{\partial x_k}\right) \quad \text{and} \quad q_i = -K \frac{\partial T}{\partial x_i}.$$

Why is this statement not exactly correct?