22.103 Microscopic Theory of Transport

(Fall 2003)

Problem Set No. 4 **Due: October 24, 2003**

Problem 1

(1) Derive the streaming term in the Boltzmann equation using the control volume approach where you take into account the difference between the number of particles flowing in and flowing out of the control volume.

(2) Derive the collisional terms in the Boltzmann equation, and by combining with your result for part (1) obtain the Boltzmann equation. Define all the quantities in this equation and briefly give physical meaning to each whenever possible.

(3) What are the basic limitations of the Boltzmann equation as a general description of transport phenomena in matter?

Problem 2

Consider a two-body collision where the interaction is a central force potential.

(1) Show that the two-body problem can be reduced to an effective one-body problem involving a particle with an effective mass and moving with the relative velocity by transforming the Newton's equations of motion for the two particles into an equation for the center-of-mass and an equation for the relative position between the two particles.

(2) Derive the relation between the angular differential cross section for the scattering and the impact parameter and the angle of scattering.

Problem 3

Discuss the meaning of collisional (or summational) invariants in the context of kinetic theory of gases. Derive the collisional invariants for the collision operator in the Botlzmann equation and discuss their significance.