1. (a) Derive a formula for the charge density profile induced around a point charge $Q$ in a metal. Use the Thomas-Fermi approximation and assume the Thomas-Fermi screening radius $R_{TF}$ is density-independent. What is the problem with this approach at small distances near the point charge? Do the derivation both in SI and CGS.

(b) Same question for a planar sheet of charge of axial density $g$ inside of a bulk metal.

2. Einstein-Stokes relation: A spherical Brownian particle of radius $R$ executes a random motion with the diffusion coefficient $D$ in a liquid at temperature $T$. Find the viscosity $\eta$ of a liquid using the arguments similar to those in the derivation of Einstein's relation for electrical conductivity.

Hints: (1) The force of a viscous friction acting on a particle moving with velocity $V$ is given by a Stokes formula $F = 6\pi R \eta V$.

2. In an ensemble of Brownian particles, the relation between their concentration $N$ and chemical potential $\mu$ is given by the Boltzmann statistics $N = Ne^{\beta \mu}$ ($N$ is some $T$-dependent parameter).

3. Consider the dynamical equilibrium of such an ensemble in a gravity field. Collisions of electrons with impurities and phonons cause a finite lifetime of plasmon excitations in metals and semiconductors. As a result, oscillations of the electron density $\delta n(t)$ tend to decay in time according to the law $\delta n(t) \propto e^{-t/\tau_p} e^{-i\omega_p t}$ + c.c. Derive a formula for $\tau_p, \omega_p$ in terms of the conductivity $\sigma$ and relaxation time $\tau$. Estimate $\tau_p$ and $\omega_p$ for Cu ($\sigma \sim 10^6 \Omega^{-1} cm^{-1}, \tau \sim 10^{-14}s$) and some dirty semiconductor ($\sigma \sim 10^1 \Omega^{-1} cm^{-1}, \tau$ the same).

Hint: $\frac{1}{\tau_p}$ and $\omega_p$ are the imaginary and the real parts of the complex solution $\omega$ of the plasmon defining equation $\varepsilon(\omega) = 0$. 