You can use either CGS units or MKS units to answer the following questions.

Problem 1. (30%)

For an arbitrary shape conductor with an arbitrary shape empty cavity inside the conductor. If we put charge Q into this conductor, please prove **in detail** that the electric field inside the conductor is zero and the electric field inside the cavity is zero, too.

Problem 2. (10%)

i) In the electrostatics $\nabla \times \vec{E} = 0$ is due to what properties of the $\vec{r}$ dependent of the Coulomb's low? (5%)

ii) In the electrostatics $\nabla \bullet \vec{E} = 0$ is due to what properties of the $\vec{r}$ dependent of the Coulomb's low? (5%)

Problem 3. (20%)

Given an infinite surface charge with the surface charge density σ, please find the electric field $\vec{E}(\vec{r})$ by the following two methods.

i) Coulomb's law (15%)

ii) Gauss' law (5%)

Problem 4. (20%)

Please prove the following boundary conditions,

i) Normal component of $\vec{B}$ is continuous.

ii) Tangential component of $\vec{H}$ is continuous. (for the case of $\vec{J} = 0$)

Problem 5. (20%)

In the free space, using the plane wave solutions $\vec{E}$ and $\vec{H}$ as well as the field energy density U, wave vector $\vec{k}$ and the group velocity c to prove that the poynting vector $\vec{S}$ is the energy flux vector.