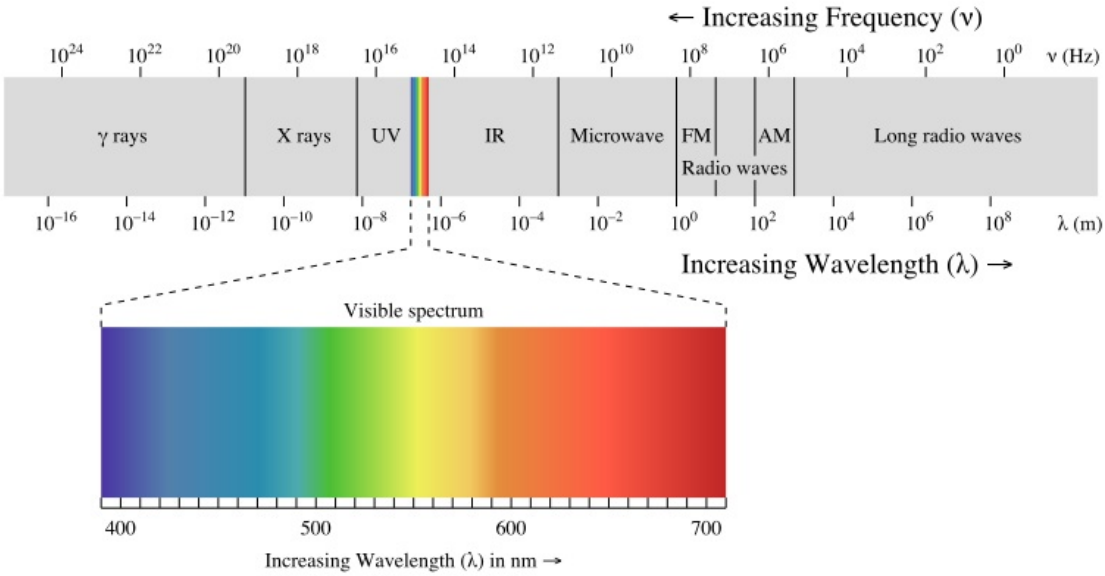
**Condensed Matter Physics I**
**I partial written test**
**academic year 2016/2017**
**November 10, 2016**

(*Time: 2 hours*)

**Exercise 1**: *Plasma frequency*

In silver, the electron density $n$ at room temperature is 5.86 $10^{22}$ cm$^{-3}$. The DC resistivity at room temperature is 2.04 microhm centimeters.

1. Find the relaxation time $\tau$.
2. Find the plasma frequency $\omega_p$ using the Drude model, convert it in Hertz, and using the figure below find in which part of the electromagnetic spectrum does it fall.
3. Considering now that the mass density of silver at room temperature is 10.5 g cm$^{-3}$ and the atomic mass is 107.8682 a.m.u., recalculate the electron density from these data and compare with the value previously given. What can you conclude?




**Exercise 2**: *Free-fermions model*

1. Most of metallic elemental solids crystallise in BCC structure. Write an expression of the valence electron density $n$ as a function of the atomic valence $Z$ and of the lattice parameter $a$.
2. Using a model of independent, non interacting and free electrons, calculate for which value of $Z$ the Fermi surface touches the first Brillouin zone faces.
3. The He$^3$ atom (the light isotope) has spin 1/2. The density of liquid He$^3$ is 0.081 g/cm$^3$ at T approaching 0K. Considering the He$^3$ atoms as independent, non interacting and free fermions, calculate the Fermi energy $E_F$ and the Fermi temperature $T_F$.

**Exercise 3**: *Crystalline structures*

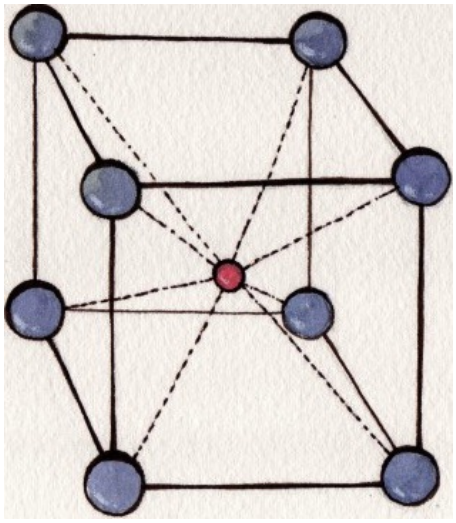
Consider the Cesium Chloride (CsCl) structure. Let $f_{Cl}$ and $f_{Cs}$ the atomic form factors.

1. Specify which is the Bravais lattice and the basis. Write the primitive translation vectors $\mathbf{a}_i$ and the vectors of the basis $\mathbf{d}_j$.

2. Write the expression for a generic vector $\mathbf{K}$ of the reciprocal lattice (parametrized using integer numbers). Write the crystal structure factor for such vectors.

3. If $f_{Cl}$=$f_{Cs}$, for which $\mathbf{K}$ the intensity of the diffraction peaks does not vanish? Which is the lattice described by the subset of those $\mathbf{K}$ vectors? How do you explain the result?

4. If $f_{Cl}$=$-f_{Cs}$, for which $\mathbf{K}$ the intensity of the diffraction peaks does not vanish? Which is the relationship of this subset of $\mathbf{K}$ vectors with the one at the previous point?



**NOTE:**

- Give all the steps necessary to understand in detail the solution procedure. Answers with the final result only or with insufficient details will not be considered valid.

- When required, numerical evaluations should be given exactly with 3 significant figures, if not otherwise indicated.