[Answer in Finnish, Swedish or English]

1. Explain **briefly**:

   A) Plasma frequency
   B) Surface plasmon polariton
   C) Homogeneous and inhomogeneous line broadening
   D) Rayleigh scattering

2. Two stars are separated by an angle of $1 \cdot 10^{-6}$ rad. The light from both stars includes wavelengths of $\lambda_1 = 577$ nm and $\lambda_2 = 579$ nm.

   a) How large a telescope lens is needed to spatially resolve the two stars?

   b) What kind of a grating is needed to spectrally separate the wavelengths λ_1 and λ_2 from each other?

3. In the atomic oscillator model, the forced oscillations of an electron in an atom caused by the electric field of a light wave are described by the equation of motion for the electron

$$\frac{d^2x}{dt^2} + \gamma \frac{dx}{dt} + \omega_0^2 x = -eE/m ,$$

   where γ is the damping factor, ω_0 is the resonance frequency of the oscillator, e and m are the electron charge and mass, respectively, and $E = E(t) = E_0 e^{-i\omega t}$ is the optical field.

   a) Solve this equation by using a proper trial for $x(t)$.

   b) Calculate the polarization induced in the material.

   c) Calculate the phase difference between the polarization of the material and the optical field at very high and very small frequencies ω, and at the resonant frequency $\omega = \omega_0$.

4. a) What is the difference between Fraunhofer and Fresnel diffractions?

   b) Draw the Fraunhofer diffraction pattern from a single slit (width a) and from a double slit (widths a, separation d) observed on a screen. Point out the distinguishing features of each pattern.

5. a) Why is it impossible to achieve population inversion in a two-level system under stationary conditions?

   b) Explain what is meant by longitudinal and transversal mode structure in a laser.