

Assignment – 01 - PHYS 514
Due Monday 19 January – 12:00 mid night
(Late submission will not be accepted)

Submit Question # 3, 4, 6, and 7 ONLY

Please submit your solution via BB or email. Ensure that your **full name and student ID** are included on your submission

Q.1 Plasma Frequency

Following expression is to find to find the ‘plasma frequency - ω_p ’

$$\omega_p^2 = \frac{ne^2}{m\epsilon_0}$$

Where ‘m’ is the effective mass of electron (you use rest mass of electron) and ‘n’ electron density.

- (a) Find the plasma frequency in a metal (of your choice)
- (b) Find the temperature corresponding to your calculated value of ω_p .

(Remember $E = hf = h \frac{2\pi}{\omega}$ and $E = K_B T$)

Q.2

Briefly explain the concept of ‘skin depth’, in reference to electromagnetic radiations

Q.3 Commutation Relation

Using the commutation relation between \hat{x} and \hat{p} show that

$$[a, a^\dagger] = 1$$

Q.4 Eigen State of Oscillator Hamiltonian

If

$$\hat{H}|n\rangle = E_n|n\rangle$$

Where $|n\rangle$ are the Fock states of LC oscillator, using commutation relation between a and a^\dagger show that

$$\hat{H}\hat{a}|n\rangle = (E_n - \hbar\omega)\hat{a}|n\rangle$$

Q.5 Hamiltonian and ladder operator

Using commutation relation of the ladder operator, show that

$$\hat{H} = \frac{\hbar\Omega}{2} [a^\dagger a + a a^\dagger]$$

can be expressed as

$$\hat{H} = \hbar\Omega [a^\dagger a + 1/2]$$

Q.6 Ladder Operator

(a) Show that

$$[\hat{n}, \hat{a}^\dagger] = \hat{a}^\dagger$$

$$[\hat{n}, \hat{a}] = -\hat{a}$$

(b) Find the normalization constant C_1 and C_2

$$\hat{a}|n\rangle = C_1|n-1\rangle$$

$$\hat{a}^\dagger|n\rangle = C_2|n+1\rangle$$

Q.7 Number Operator

Consider a cavity that contains superposition of two Fock states described by

$$|\psi\rangle = \sqrt{0.99}|0\rangle + \sqrt{0.01}|100\rangle$$

- What is the average number of photons in the cavity?
- If you annihilate a photon by acting annihilation operator \hat{a} on this state, then how many photons remain in the cavity? Interpret the result.