1. Calculate the probability of excitation to the 2p state of a hydrogen atom, originally in its ground state, due to a homogeneous electric field with time dependence

$$E = \frac{E_0}{\pi}\frac{\tau}{t^2+\tau^2}.$$

Discuss the limits of large and small value of τ and their significance.

2. **Two level System:** Solve

$$i\hbar\dot{C}_a(t) = V_{aa}C_a(t) + V_{ab}e^{i\omega_{ab}t}C_b(t) \quad (1)$$
$$i\hbar\dot{C}_b(t) = V_{ba}e^{-i\omega_{ab}t}C_a(t) + V_{bb}C_b(t) \quad (2)$$

3. Consider a particle of charge q and mass m, in SHM along x-axis. A homogeneous electric field $E(t) = E_0\exp(-t/\tau)$ directed along x-axis is switched on at $t = 0$. If the particle was in the ground state before $t = 0$, find the probability that it will be found in an excited state as $t \to \infty$.

4. Consider a particle of charge q and mass m, in SHM along x-axis. A homogeneous electric field $E(t) = E_0\exp\left(-(t/\tau)^2\right)$ directed along x-axis is applied. If the particle was in the ground state at $t = -\infty$, find the probability that it will be found in an excited state as $t \to \infty$.

5. Show that the number of modes per unit volume per unit frequency range for electromagnetic radiation confined to a cubical box is given by ω^2/π^2c^3.

6. Calculate how may photons per second are radiated from a monochromatic source, 1 watt in power, for the following wavelengths (a) 10 m (radio wave) (b) 10 cm (microwave) (c) 5890 A (optical waves) (d) 1 A (x-rays). At a distance of 10 m from the source, calculate the number of photons passing through unit area, normal to the direction of propagation, per unit time and the density of photons, in each case.

7. Show that, with the gauge condition $\nabla \cdot \mathbf{A} = 0$, $\mathbf{p}$ commutes with $\mathbf{A}$ and hence $\mathbf{p}\cdot\mathbf{A}+\mathbf{A}\cdot\mathbf{p} = 2\mathbf{A}\cdot\mathbf{p}$.

8. Generalise Einstein's results in case the two levels E_a and E_b are degenerate with degeneracies g_a and g_b respectively.

9. State and prove the Thomas-Reiche-Kuhn sum rule for oscillator strengths.

10. Calculate the Einstein's coefficient A for the 2p - 1s transition in a hydrogenic atom, and find the half life of the 2p level.