1. How to measure the temperature of an object by using the principles of blackbody radiation phenomenon? (7%)

2. In the photoelectric effect experiment, how would the photocurrent be changed if one changes the (a) light intensity (b) light frequency? why? (7%)

3. On the basis of Bohr's atomic model, explain why some emission lines are missing in the absorption spectrum. (7%)

4. Explain why it is necessary to use electrons with higher energy in order to resolve smaller dimensions in the electron diffraction experiments. (7%)

5. Illustrate the position-momentum uncertainty principle with the single slit diffraction experiment. (7%)

6. Consider an electron moving in an infinite square well, with well width = L.

a) Solve the corresponding Schrodinger equation for the ground state and the 1st excited state wave functions, $\psi_0(x,t)$ and $\psi_1(x,t)$, respectively. Here x = position, t = time. Note that the wave functions must be normalized. (10%)

b) Suppose the electron is in the state $\psi(x,t) = [\psi_0(x,t) + \psi_1(x,t)]/2^{1/2}$. Calculate the expectation value of *electric dipole*, which is defined as $(-e)x$ in classical mechanics, with (-e) the electronic charge. (10%)

c) The above dipole is a periodic function of time and it can radiate light. What is *the wavelength* of the light? (5%)

7. Consider a potential barrier V(x), with

$$V(x) = V_0,\ 0 < x < W,$$
$$= 0 \quad \text{otherwise.}$$

If a particle with a kinetic energy E, where $E < V_0$, is incident upon the barrier. What is the *approximate probability* for the particle to tunnel through the barrier? (The probability is an exponential function of W. You are only required to obtain this exponential function as the answer.) (10%)

8. **Angular momentum (15%)**

The angular momentum operators L_x, L_y, L_z, L^2 are defined as follows:

$$L_x = yP_z - zP_y\ , L_y = zP_x - xP_z\ , L_z = xP_y - yP_x\ , L^2 = L_xL_x + L_yL_y + L_zL_z\ ,$$

where p_x, p_y, p_z are the x-, y-, and z-component of the linear momentum.

The commutator of two operator A and B is defined by [A, B]= AB-BA.
Evaluate the following commutator:

(A) $[L_x, L_y]$ (B) $[L_x, L^2]$ (C) $[L_x, x]$ (D) $[L_x, y]$ (E) $[L_x, x^2+y^2+z^2]$

9. **central potential problem (15%)**

A particle with mass μ moves in the following three-dimensional central potential:

$$V(r,\theta,\phi) = \begin{cases} 0 & \text{when } r < R \\ V_0 & \text{when } r > R \end{cases}$$

(a) Write down the form of the (unnormalized) wave function $\Phi(r,\theta,\phi)$ for $r < R$ and $r > R$ if the particle has an energy $E < V_0$.

(b) Write down the equation for the radial part of $\Phi(r,\theta,\phi)$ and the conditions that must be satisfied.

(c) Derive an algebraic equation from which the ground-state energy may be solved.