İzmir Kâtip Çelebi University
Materials Science and Engineering
Mse228 Engineering Quantum Mechanics
Assignment
Due to June 06, 2018
Good Luck!

NAME-SURNAME:

SIGNATURE:

ID:

DEPARTMENT:

◇ **Answer only 10 questions. Write the number of question.**
◇ **Write the solutions explicitly and clearly. Use the physical terminology.**

	Question	Grade	Out of
1			10
2			10
3			10
4			10
5			10
6			10
7			10
8			10
9			10
10			10
TOTAL			100

1. (a) Find the change in wavelength of 80-pm x-rays that are scattered 120^o by a target. (b) Find the angle between the directions of the recoil electron and the incident photon. (c) Find the energy of the recoil electron.

2. Photoelectrons may be emitted from sodium ($\phi = 2.36\ eV$) even for light intensities as low as $10^{-8}\ W/m^2$. Calculate classically how much time the light must shine to produce a photoelectron of kinetic energy 1.00 eV. (Hint: The number of exposed atoms per m^2 is $8.64 \times 10^{18}\ atoms/m^2$)

3. To "observe" small objects, one measures the diffraction of particles whose de Broglie wavelength is approximately equal to the object's size. Find the kinetic energy (in electron volts) required for electrons to resolve (a) a large organic molecule of size 10 nm, (b) atomic features of size 0.10 nm, and (c) a nucleus of size 10 fm. Repeat these calculations using alpha particles in place of electrons.

4. X rays scattered from rock salt (NaCl) are observed to have an intense maximum at an angle of 20^o from the incident direction. Assuming n=1 (from the intensity), what must be the wavelength of the incident radiation? (Hint:Number of atoms in volume is $N_A\rho/M$ where N_A is Avogadro's number, ρ is the density and for NaCl, $\rho = 2.16\ g/cm^3$ and M is the gram-molecular weight and for NaCl, $M = 58.5\ g/mol$)

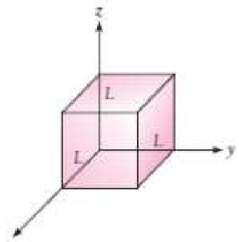
5. In the n = 4 state of hydrogen (for Bohr model), find the electron's radius, velocity, kinetic energy, and potential energy.

6. Draw an energy-level diagram showing the lowest four levels of doubly ionized lithium. Show all possible transitions from the levels and label each transition with its wavelength.

7. Compute the average position <x> and the quantum uncertainty in this value, Δx, for the particle in a box, assuming it is in the ground state. (Hint: $\Delta x = \sqrt{< x^2 > - < x >^2}$)

8. A particle is in a cubic box with infinitely hard walls whose edges are L long (see Figure). The wave functions of the particle are given by

$$\psi = A \sin \frac{n_x \pi x}{L} \sin \frac{n_y \pi y}{L} \sin \frac{n_z \pi z}{L} \qquad \begin{array}{l} n_x = 1, 2, 3, \ldots \\ n_y = 1, 2, 3, \ldots \\ n_z = 1, 2, 3, \ldots \end{array}$$



i Find the value of the normalization constant A.

ii The particle in the box is in its ground state of $n_x = n_y = n_z = 1$. Find the probability that the particle will be found in the volume defined by $0 \leq x \leq L/4$, $0 \leq y \leq L/4$, $0 \leq z \leq L/4$.

9. Show that the ground state energy for a particle trapped in the one-dimensional Coulomb potential energy is $E = -\frac{me^4}{32\pi^2\epsilon_0^2\hbar^2}$.

10. Which of the following transitions for quantum numbers (n, l, m_l, m_s) are allowed for the hydrogen atom, and for those allowed, what is the energy involved?
(a) (2, 0, 0, 1/2) $\rightarrow$ (3, 1, 1, 1/2)
(b) (2, 0, 0, 1/2) $\rightarrow$ (3, 0, 0, 1/2)
(c) (4, 2, -1, -1/2) $\rightarrow$ (2, 1, 0, 1/2).

11. Calculate the average orbital radius of a 1s electron in the hydrogen atom.

12. i List the six possible sets of quantum numbers (n, l, m_l, m_s) of a 2p electron.

ii Suppose we have an atom such as carbon, which has two 2p electrons. Ignoring the Pauli principle, how many different possible combinations of quantum numbers of the two electrons are there?

iii How many of the possible combinations of part (ii) are eliminated by applying the Pauli principle?

iv Suppose carbon is in an excited state with configuration $2p^1 3p^1$. Does the Pauli principle restrict the choice of quantum numbers for the electrons? How many different sets of quantum numbers are possible for the two electrons?