1. 10% (matter wave) A 0.15kg baseball is flying at a speed of 40m/s, what is the wavelength of this baseball?

2. 20% According to Bohr's model, electrons in a hydrogen atom must be at one of the allowed energy levels. If an electron is at the first energy level, it must have exactly −13.6 eV of energy.

   (a) 10% How much energy would the electron of hydrogen have to gain to move from energy level n = 1 to n = 4? (In the unit of eV)

   (b) 5% When the electron transit in hydrogen between quantized energy levels with different quantum numbers (n) it will yield a photon by emission with quantum energy. What will be the wavelength of the emitted photon when the electron transit from n=4 to n=1? Please present it in the unit of nanometer.

   (c) 5% What is the size of the hydrogen atom? (Hint: estimate it from the smallest allowed radii (n=1) for electron in circular orbits). (In unit of angstrom) (5%)

3. 20% The work function for lithium is 4.6×10^{-19} J.

   (a) 10% Calculate the lowest frequency of light that will cause photoelectric emission.

   (b) 10% What is the maximum energy of the electrons emitted when light of 7.3×10^{14} Hz is used?

4. 20 % In a Michelson interferometer, an incident laser beam is equally split into two by a beam splitter (BS), one transmitted straight through and the other reflected at an angle of 90°. After traveling an equal distance, both the transmitted and reflected beams are normally reflected back to BS and then reflectively reflected and transmitted by BS. This makes them propagate collinearly to interfere with each other.

   (a) 5% Please draw the basic layout of a Michelson interferometer with all the components marked.

   (b) 15% Explain how this interferometer is used to (i) prove or disprove the existence of Luminiferous aether, dubbed aether or ether, (ii) detect cosmic gravitational waves, and (iii) measure sub-wavelength order displacement of objects.

5. 10% Determine whether each of the following statements about x rays is correct or false.

(a) 2% All materials are transparent to x rays to some degree and the transparency decreases with increasing density due to scattering.

(b) 2% The wavelengths of x rays range from 0.01 to 10 nm.

(c) 2% Airport security demands x rays of longer wavelengths than medical computerized tomography.

(d) 2% In a regular physics laboratory (length and width are ~15 m and height is ~2.5 m), we can observe the diffraction-induced x ray beam broadening using the setup for HeNe laser diffraction.

(e) 2% By examining the interference of x rays due to scattering from various parallel planes of atoms, we can analyze the crystals' structures.

6. 8% Briefly answer the following questions in view of quantization of charge, light, energy, etc.

(a) 2% Why does a laser of linear cavity deliver light consisting of components at discrete frequencies?

(b) 2% Quantization of what properties does the Millilan's Oil-drop experiment verify?

(c) 2% Quantization of what properties did Planck employ to explain the blackbody radiation spectrum?

(d) 2% Quantization of what properties does the Compton Effect infer?

7. 12% Determine whether each of the following statements about the wave mechanics is correct or false.

(a) 2% De Broglie's hypothesized that particles have wave properties.

(b) 2% Schrödinger's wave equation is used to predict the behavior of matter waves.

(c) 2% The wave function tells us the probability of finding a particle within a given region.

(d) 2% A particle can penetrate into a classically forbidden region and can tunnel through a potential barrier.

(e) 2% The Heisenberg uncertainty principle illustrates that one cannot measure certain pairs of quantities simultaneously to arbitrary precision.

(f) 2% The Schrödinger wave mechanics cannot tell the uncertainty principle addressed in (e).

*Additional remarks: The Planck constant is $h=6.626\times10^{-34}$ kg×m^2/s$=6.626\times10^{-34}$ J·s; the mass of an electron is $m_e=9.11\times10^{-31}$kg; the fine structure constant is ~1/137.