# I$^{st}$ ASSIGNMENT
## Subject: Physics-II (Quantum Mechanics)

**Date:** **Roll No.** **Name**

1. If Planck's constant were smaller than it is. Would quantum phenomena be more or less conspicuous than they are now?
2. Express the Planck radiation formula in terms of wavelength.
3. Is it correct to say that the maximum photoelectron energy $KE_{max}$ is proportional to the frequency ν of the incident light? If not, then, what would a correct statement of the relationship between $KE_{max}$ and ν be?
4. Compare the properties of the particles with those of waves. Why do you think the wave aspect of light was discovered earlier than its particle aspect?
5. Find the energy of a 700 nm photon.
6. Find the wavelength and frequency of a 100 MeV photon.
7. A 1.00 kW radio transmitter operates at a frequency of 880 kHz. How many photons per second does it emit?
8. Under favorable circumstances the human eye can detect $1.0 \times 10^{-18}$ of electromagnetic energy. How many 600 nm photons does this represent?
9. Light from the sun arrives at the earth, an average of $1.5 \times 10^{-11}$ m away, at the rate of $1.4 \times 10^{3}$ W/m$^2$ of area perpendicular to the direction of the light. Assume that sunlight is monochromatic with a frequency of $5.0 \times 10^{14}$ Hz. (a) how many photons fall per second on each square meter of the earth's surface directly facing the sun? (b) What is the power output of the sun, and how many photons per second does it emit? (c) How many photons per cubic meter are there near the earth?
10. A detached retina is being "welded" back in place using 20 ms pulses from a 0.50 W laser operating at a wavelength of 632 nm. How many photons are in each pulse?
11. The maximum wavelength for photoelectron emission in tungsten is 230 nm. What wavelength of light must be used in order for electrons with a maximum energy of 1.5 eV to be ejected?
12. The minimum frequency for photoelectric emission in copper is $1.1 \times 10^{15}$ Hz. Find the maximum energy of the photoelectrons (in electron volts) when light of frequency $1.5 \times 10^{15}$ Hz is directed on a copper surface.
13. What is the maximum wavelength of light that will cause photoelectrons to be emitted from sodium? What will the maximum kinetic energy of the photoelectrons be if 200 nm light falls on a sodium surface?
14. A silver ball is suspended by a string in a vacuum chamber and ultraviolet light of wavelength 200 nm is directed at it. What electric potential will the ball acquire as a result? (Given that work function of Silver is 4.7eV )
15. 1.5 mW of 400 nm light is directed at a photoelectric cell. If 0.10 percent of the incident photons produce photoelectrons find the current in the cell.
16. A metal surface illuminated by $8.5 \times 10^{14}$ Hz light emits electrons whose maximum energy is 0.52 eV. The same surface illuminated by $12.0 \times 10^{14}$ Hz light emits electrons whose maximum energy is 1.97 eV. From these data find Planck's constant and the work function of the surface?

17. The work function of the tungsten surface is 5.4 eV. When the surface is illuminated by the light of wavelength 175 nm, the maximum photoelectron energy is 1.7 eV. Find Planck's constant from these data.
18. Show that it is possible for photon to give up all its energy and momentum to a free electron. This is the reason why photoelectric effect can take place only when photons strike bound electrons.
19. What is the frequency of an X-ray photon whose momentum is $1.1 \times 10^{-23}$ kg.m/s?
20. How much energy must a photon have if it is to have the momentum of a 10 MeV proton?
21. A monochromatic x-ray beam whose wavelength is 55.8 pm is scattered through 46˚. Find the wavelength of the scattered beam.
22. A beam of x-ray scattered by a target. At 45˚ from the beam direction the scattered x-rays have a wavelength of 2.2 pm. What is the wavelength of the x-rays in the direct beam?
23. An energy photon whose initial frequency was $1.5 \times 10^{19}$ Hz emerges from a collision with an electron with a frequency of $1.2 \times 10^{19}$ Hz. How much kinetic energy was imparted to the electron?
24. An x-ray photon of initial frequency was $3.0 \times 10^{19}$ Hz collides with an electron and is scattered through 90˚. Find its new frequency.
25. Find the energy of an x-ray photon which can impart a maximum energy of 50 keV to an electron.
26. At what scattering angle will incident 100 keV x-rays leave a target with energy of 90 keV?
27. (a) Find the change in wavelength of 80 pm x-rays that are scattered 120˚ 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.
28. A photon of frequency ν is scattered by an electron initially at rest. Verify that the maximum kinetic energy of the recoil electron is $KE_{max} = (2h^2 \nu^2/mc^2)/(1+2h\nu/mc^2)$.
29. In a Compton Effect experiment in which the incident x-rays have a wavelength of 10.0 pm, scattered x-rays at a certain angle have a wavelength of 10.5 pm. Find the momentum (magnitude and direction) of the corresponding recoil electrons.
30. A photon whose energy equals the rest energy of the electron undergoes a Compton collision with an electron. If the electron moves off at an angle of 40˚ with the original photon direction, what is the energy of the scattered photon?
31. A photon of energy E is scattered by a particle of rest energy $E_0$. Find the maximum kinetic energy of the recoiling particle in terms of E and $E_0$.
32. The smallest angle of Bragg scattering in potassium chloride (KCl) is 28.4˚ for 0.30 nm x-rays. Find the distance between atomic planes in potassium chloride.
33. The distance between adjacent atomic planes in calcite ($CaCO_3$) is 0.300 nm. Find the smallest angle of Bragg scattering for 0.030 nm x-rays.