Planck to Bohr
Planck to Bohr
Planck to Bohr

Problem Set SP1

1. Calculate the photon energy for light of wavelengths 400 nm (violet) and 700 nm (red).

These are approximately the extreme wavelengths in the visible spectrum. (answer 3.1 eV and 1.77 eV)

2. The intensity of sunlight at the Earth’s surface is approximately 1,400 W/m^2.

Assuming the average photon energy is 2 eV (corresponding to a wavelength of about 600 nm), calculate the number of photons that strike an area of 1 cm^2 in one second.

(answer 4.37 \times 10^{17} \text{ photons}).

3. The threshold wavelength for potassium is 564 nm.

(a) What is the work function for potassium?

(b) What is the stopping potential when light of wavelength 400 nm is incident on potassium?

answer (a) 2.20 eV    b) 0.9V

4. Calculate the percentage change in wavelength observed in the Compton scattering of 20 keV photons at theta = 60 °.

(answer 1.97%)
5. At what scattering angle would a photon experience its greatest change in wavelength for a Compton scattering? Show how you acquired your answer.

6. Find the energy and wavelength of the longest wavelength in the Lyman series.
   (answer 10.2 eV, 121.6 nm)

7. Find the deBroglie wavelength of a particle of mass $10^{-6}$ g moving with a speed of $10^{-6}$ m/s. 
   (answer $6.63 \times 10^{-19}$ m)

8. Find the wavelength of an electron whose kinetic energy is 10 eV.
   (answer 0.388 nm).

9. The kinetic energy of the electron in the ground (lowest energy) state of the hydrogen atom is 13.6 eV. Find the deBroglie wavelength for this electron.
   (answer 0.332 nm which is the circumference of the first Bohr orbit in the hydrogen atom!)

10. The work function for Tungsten is 4.58 eV.

   a) find the threshold frequency and wavelength for the photoelectric effect

   Find the stopping potential if the wavelength of the incident light is

   b) 200 nm
   c) 250 nm

   answer a) $1.11 \times 10^5$ Hz, 271 nm, b) 1.63 V, c) 0.39 V

11. The threshold wavelength for the photoelectric effect in silver is 262 nm.

   a) Find the work function for silver
   b) Find the stopping potential if the incident electromagnetic radiation has a wavelength of 175 nm

   answer a) 4.74 eV, b) 2.36 V

12. A light beam of wavelength 400 nm has an intensity of 100 W/m$^2$.

   a) What is the energy of each photon in the beam?
b) How much energy strikes an area of 1 cm$^2$ perpendicular to the beam in 1 second?

c) How many photons strike this area in 1 second?

(answer a) 4.97 x 10$^9$ J, b) 0.01 J, c) 2.01 x 10$^{16}$ photons/s

13. Find the shift in wavelength of photons scattered at theta = 60 ° via Compton scattering.

(answer 1.215 pm)

14. Find the momentum of a photon in eV/c and in kg m/s if the wavelength is

a) 400 nm

b) 2 nm

c) 0.1 nm

d) 3 cm

(answer a) 1.66 x 10$^{-27}$ kg m/s, 3.11 eV/c,

b) 3.32 x 10$^{-25}$ kg m/s, 621 eV/c, c) 6.63 x10$^{-26}$ kg m/s, 12.4 keV/c, d) 2.21 x 10$^{-32}$ kg m/s, 4.14 x 10$^{-5}$ eV/c.

15. Compton used photons of wavelength 0.071 1 nm.

a) What is the energy of these photons?

b) What is the wavelength of a photon scattered at 180 °?

c) What is the energy of a photon scattered at this angle?

d) Find the momentum of the incident photon and the scattered photon. From this

use momentum conservation to find the momentum of the recoil electron in this experiment.

(answer a) 17.5 KeV, b) 76 pm, 16.3 keV

16. Find the photon energy for the three longest wavelengths in the Balmer series and calculate the wavelengths .

(answer E 3-2 = 1.89 eV, 656 nm, E 4-2 = 2.55 eV, 486 nm, E 5-2 = 2.86 eV, 434 nm )

17. Calculate the deBroglie wavelength for an electron of kinetic energy:

a) 2.5eV

b) 250eV

c) 2.5keV
d) 25 keV

Energy is such that non relativistic equations can be used.

(answer a) 0.775 nm b) 0.0775 nm c) 0.0245 nm d) 0.00775 nm)

18. An electron has a wavelength of 200 nm find

a) its momentum

b) its kinetic energy

(answer a) 3.313 x 10^{-27} kg m/s b) 6.024 x 10^{-24} J)

19. An x ray undergoes Compton scattering and emerges with a wavelength of 0.20 nm at

a scattering angle of 100°. What was the initial energy of the x-ray photon?

6.31 keV

20. Suppose that a 100 W light source radiates light of wavelength 600 nm uniformly in all directions and that the eye can detect this light if only 20 photons per second enter a dark adapted eye having a 7 mm diameter pupil. How far from the source can the light be detected under these rather extreme conditions?

6.8 x 10^6 m (4225 miles)

21. An x ray photon of wavelength 6 pm makes a head on collision with an electron so that

it scatters at 180°

a) what is the change in wavelength of the photon

b) what is the energy lost by the photon

c) what is the kinetic energy of the scattered electron?

(answer a) 4.86 pm b) 92.7 keV c) 92.7 keV)