KING SAUD UNIVERSITY. DEPARTMENT OF PHYSICS AND ASTRONOMY

MODERN PHYSICS (351 PHYS)
PROBLEM SET 3

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PROBLEM (1)

The temperature of your skin is approximately $35^{o}C$. What is the wavelength at which the peak occurs in the radiation emitted from your skin?

PROBLEM (2)

Calculate the energy of a photon whose frequency is (a) 5 1014 Hz, (b) 10 GHz, (c) 30 MHz. Express your answers in electron volts.

PROBLEM (3)

Calculate the momentum and frequency of an $x-ray$ photon whose wavelength $\lambda = 0.1nm$.

PROBLEM (4)

An FM radio transmitter has a power output of 100 kW and operates at a frequency of 94 MHz. How many photons per second does the transmitter emit?

PROBLEM (5)

The photocurrent of a photocell is cut off by a retarding potential of 2.92 V for radiation of wavelength 250 nm. Find the work function for the material.

PROBLEM (6)

The work function for potassium is $2.24eV$. If potassium metal is illuminated with light of wavelength $350nm$, find (a) the maximum kinetic energy of the photoelectrons and (b) the critical/threshold wavelength.

PROBLEM (7)

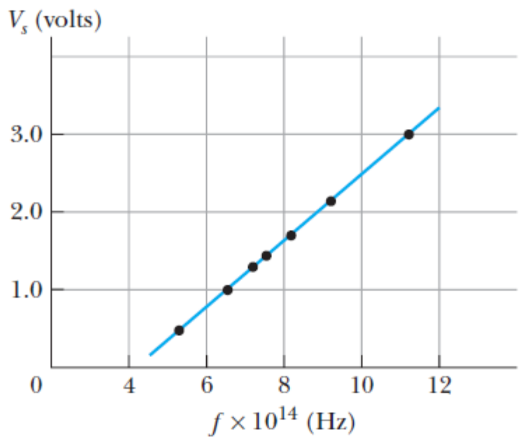
Molybdenum has a work function of $4.2eV$. (a) Find the critical wavelength and threshold frequency for the photoelectric effect. (b) Calculate the stopping potential if the incident light has a wavelength of $200nm$.

PROBLEM (8)

X-rays with an energy of $300keV$ undergo Compton scattering from a target. If the scattered rays are detected at 30^o relative to the incident rays, find (a) the Compton shift at this angle, (b) the energy of the scattered x-ray, and (c) the energy of the recoiling electron.

BONUS PROBLEMS

1. The figure below shows the stopping potential versus incident photon frequency for the photoelectric effect for sodium. Use these data points to find (a) the work function, (b) the ratio h/e, and (c) the critical wavelength. (d) Find the percent difference between your answer to and the accepted value. (*These data are obtained from Milikan's exeriment to determine Plank's constant -R. A. Millikan Phys. Rev. 7, 355 (1916)*)



2. Show that a photon cannot transfer all of its energy to a free electron. (*Hint*: Note that energy and momentum must be conserved.)

3. Gamma rays (high-energy photons) of energy $1.02MeV$ are scattered from electrons that are initially at rest. If the scattering is symmetric, that is, if $\phi = \theta$ find (a) the scattering angle ϕ and (b) the energy of the scattered photons.

4. *Planck's fundamental constant*, h. Planck ultimately realized the great and fundamental importance of h, which, much more than a curve-fitting parameter, is actually the measure of all quantum phenomena. In fact, Planck suggested using the universal constants h, c (the velocity of light), and G (NewtonâĂŹs gravitational constant) to construct 'natural' or universal units of length, time, and mass. He reasoned that the current units of length, time, and mass were based on the accidental size, motion, and mass of our particular planet, but that truly universal units should be based on the quantum theory, the speed of light in a vacuum, and the law of gravitationâĂŤall of which hold anywhere in the universe and at all times.
   Show that the expressions

$$\ell_p = \sqrt{\frac{hG}{c^3}} \ , t_p = \sqrt{\frac{hG}{c^5}} \ , m_p = \sqrt{\frac{hc}{G}}$$

   have dimensions of length, time, and mass and find their numerical values. These quantities are called, respectively, the Planck length, the Planck time, and the Planck mass.