Problem set #2 (Modern Physics)

04/02/2018 Provided by *Masahito Oh-e*

Solve the problems below. Describe the ways of thinking in English: only final solutions are not accepted. Make clear how you reach each solution.

Problem 1.
Calculate photon energies of the edges of the visible range spectrum at λ=380 nm, and λ=770 nm, respectively, with the units of J and eV.

Problem 2.
Show that the Planck spectral distribution formula leads to the experimentally observed Stefan law for the total radiation emitted by a blackbody at all wavelengths. Stefan law: $E_{\text{total}} = aT^4$ $\text{W}\cdot m^{-2}\cdot K^{-4}$, where T is the temperature and a is the constant. Use the relation $\int_0^\infty \frac{x^3}{(e^x-1)}dx = \frac{\pi^4}{15}$.

Problem 3.
Suppose that light of total intensity 1.0 μW/cm^2 falls on a clean iron sample 1.0 /cm^2 in area. Assume that the iron sample reflects 96% of the light and that only 3.0% of the absorbed energy lies in the violet region of the spectrum above the threshold frequency.
(a) What intensity is actually available for the photoelectric effect?
(b) Assuming that all the photons in the violet region have an effective wavelength of 250 nm, how many electrons will be emitted per second?
(c) Calculate the current in the photo-tube in amperes.
(d) If the cutoff frequency is f_0 = 1.1 ×10^{15} Hz, find the work function, ϕ, for iron.
(e) Find the stopping voltage for iron if photo-electrons are produced by light with λ=250 nm.

Problem 4.
X-rays of wavelength $\boldsymbol{\lambda}$**=**0.200 nm are aimed at a block of carbon. The scattered x-rays are observed at an angle of 45.0˚ to the incident beam. Calculate the increased wavelength of the scattered x-rays at this angle.

Problem 5.
An electron of charge q and mass m is accelerated from rest through a small potential difference V=50 V. Calculate de Broglie wavelength $\boldsymbol{\lambda}$**,** assuming that the particle is nonrelativistic.

Problem 6.
Consider a 2 μg mass traveling with a speed of 10 cm/s. If the particle's speed is uncertain by 1.5%, what is its uncertainty in position? Use the uncertainty relation: $\Delta x \Delta p_x \geq h$.