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Übungen zur Vorlesung
Quantenmechanik für Nanostrukturwissenschaftler und Lehrer

Exercise 1

Task 1

a) The maximal energy of the photoelektron from aluminium is 2,3 eV at a radiation with 200 nm and 0,9 eV with 258 nm. With this, calculate the Planck constant h and the work function W_A of aluminium.

b) Electromagnetic radiation of the wavelength $\lambda = 290$ nm hits a metal surface with the work funktion of $W_A = 4{,}05$ eV. Which potential difference (voltage) is necessary to stop the photoelektrons with the most energy?

Task 2

a) How big is the De-Broglie wavelength of an electron with the energy of 6,0 eV?

b) How many optical photons with the wavelenth of $\lambda = 450$ nm does a lightbulb with a power of 20 J/s per second emit?

Task 3

For the Compton effect, the momentum and energy conservation laws are $\mathbf{p} = \mathbf{p}' + \mathbf{P}$ and $h\nu + m_e c^2 = h\nu' + \sqrt{m_e^2 c^4 + P^2 c^2}$. Here, $\mathbf{p}$ and $\mathbf{p}'$ as well as ν and ν' are the momentum as well as the frequency of the photon before and after the impact with an resting electron, which is hit with the momentum $\mathbf{P}$. Show that $\lambda' - \lambda = \dfrac{h}{m_e c}(1 - \cos\theta)$, where θ is the deflection angle between $\mathbf{p}$ and $\mathbf{p}'$. For the photons, use the relations $E = pc = h\nu$ and $\nu = c/\lambda$.

Task 4

A series of spectral lines in the hydrogen atom corresponds with the transition to a final state, which is characterized with the quantum number n. The wavelength of the radiation, which corresponds to the transition $\Delta n = 1$, is 657 nm. Find n.

Useful physical constants:

- Speed of light in vacuum: $c = 3 \cdot 10^8 \ \frac{\mathrm{m}}{\mathrm{s}}$
- Mass of electron : $m_e = 9{,}109 \cdot 10^{-31}$ kg
- Elementary charge : $e = 1{,}602 \cdot 10^{-19}$ C
- Plack constant : $h = 6{,}626 \cdot 10^{-34}$ Js
- Fine-structure constant : $\alpha = 1/137$