Atomic Physics – Sample Quiz (2024/2025)

30 December 2024

1. Calculate the temperature of a blackbody if the spectral distribution peaks at (a) gamma rays, $\lambda = 1.50\times10^{-14}\,\mathrm{m}$; (b) x rays, 1.50 nm; (c) red light, 640 nm; (d) broadcast television waves, $\lambda = 1.00\,\mathrm{m}$; and (e) AM radio waves, $\lambda = 204\,\mathrm{m}$.

   http://kfe.fjfi.cvut.cz/ sinor/tmp/edu/f7ambaf/mp/mp3.pdf, Problem 14 (page 37)

   Solution: (a) $T = 2.898\times10^{-3}\ \mathrm{m.K}/\lambda_{max} = 2.898\times10^{-3}\ \mathrm{m.K}/(1.50\times10^{-14}\,\mathrm{m}) = \ldots$

2. What is the maximum wavelength of incident light that can produce photoelectrons from silver ($\phi = 4.64\,\mathrm{eV}$)? What will be the maximum kinetic energy of the photoelectrons if the wavelength is halved?

   http://kfe.fjfi.cvut.cz/ sinor/tmp/edu/f7ambaf/mp/mp3.pdf, Problem 29 (page 38)

   Solution: $E = hc/\lambda_{max} = \phi \;\Rightarrow\; \lambda_{max} = hc/\phi = 1240\ \mathrm{eV.\,nm}/(4.64\ \mathrm{eV}) = 267\,\mathrm{nm}$.

   $E = hc/(\lambda_{max}/2) = \phi + E_{kin} \;\Rightarrow\; E_{kin} = 2\,hc/\lambda_{max} - \phi = \phi$.

3. What is the binding energy of the electron in the ground state of (a) deuterium, (b) He^{+}, and (c) Be^{+++}?

   http://kfe.fjfi.cvut.cz/ sinor/tmp/edu/f7ambaf/mp/mp4.pdf, Problem 25 (page 32)

   Solution: $E_n == -E_0 Z^2/n^2$, $n = 1$, (a) $Z = 1$, (b) $Z = 2$, (c) $Z = 4$.

4. We learned that a particle (ideal gas) in thermal equilibrium with its surroundings has a kinetic energy of 3kT/2. Calculate the de Broglie wavelength for (a) a neutron at room temperature (300 K) and (b) a "cold" neutron at 77 K (liquid nitrogen).

   http://kfe.fjfi.cvut.cz/ sinor/tmp/edu/f7ambaf/mp/mp5.pdf, Example 5.3 (page 14)

5. A person can perceive yellow light with the naked eye when the power being delivered to the retina is 1.8×10^{-18} W. The wavelength of yellow light is about 600 nm. At this power, how many photons fall on the retina each second?

6. X-rays with a wavelength of 0.1 nm are scattered on graphite. The scattered radiation is observed perpendicular to the direction of the incident x-rays.
   a) How large is the Compton shift $\Delta\lambda$?
   b) How large is the kinetic energy of the ejected electron?
   c) What fraction of its original energy does the photon lose?
   d) How large is the corresponding fraction of energy lost by a photon with a wavelength $\lambda = 0.01$ nm if it is deflected through 90° by Compton scattering?

7. Give the electron configuration and the nl value of the electrons in the subshells for the $_{35}$Br.

   Solution: $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,4s^2\,3d^{10}\,4p^5$