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Exercises and Complements for the Introduction to Physics II

for Students

of Biology, Pharmacy and Geoscience

Sheet 11 / 13.05.2021 **Solutions**

Exercise 41.

(a) With $f = c/\lambda$ we have:

$$E_{Ph} = hf = \frac{hc}{\lambda} = 2.88 \cdot 10^{-19}\ \text{J}\ (\approx 1.8\ \text{eV})$$

$$m_{Ph} = \frac{E_{Ph}}{c^2} = \frac{hf}{c^2} = 3.2 \cdot 10^{-36}\ \text{kg}$$

$$p_{Ph} = m_{Ph}c = 9.6 \cdot 10^{-28}\ \text{kg m/s}$$

The number of photons emitted per unit time is:

$$\dot{N}_{Ph} = \frac{P}{E_{Ph}} = 1.74 \cdot 10^{19}\ \text{s}^{-1}$$

(b)

$$P = \dot{N}_{Ph,A} E_{Ph} = 1.44 \cdot 10^{-18}\ \text{W}$$

Exercise 42.

(a) The radiant flux density S_s of a black body of absolute temperature T over all wavelengths λ contained in the radiation is

$$S_s = \sigma T^4$$

with $\sigma = 5.67 \cdot 10^{-8}\,\text{W}/(\text{m}^2\text{K}^4)$. We then obtain $T_S = 5800\,\text{K}$ for the total radiant power from the solar surface $A_S = 4\pi R_S^2 = 6.1 \cdot 10^{18}\,\text{m}^2$.

$$P_S = S_S A_S = \sigma A_S T_S^4 = 3.92 \cdot 10^{26}\,\text{W}$$

(b) The surface of an imaginary sphere around the sun with the distance sun-earth r_E as radius has the surface area $A = 4\pi r_E^2 = 2.83 \cdot 10^{23}\,\text{m}^2$. Accordingly, the energy received from the sun per m^2, or the so-called solar constant, is

$$E_S = \frac{P_S}{A} \approx 1385\,\text{J}/(\text{m}^2\text{s})$$

Exercise 43.

It follows from Wien's law

$$\lambda_{\max} T = 2.898 \cdot 10^{-3}\,\mathrm{m} \cdot \mathrm{K}$$

After that, the position of the maximum of the spectral radiance shifts more and more to the short-wavelength part of the spectrum with increasing temperature. We obtain for $\lambda_{\max}$
(a) 966 nm (infrared range)

(b) 500 nm (Range of visible light, green)

(c) $1.07 \cdot 10^{-3}\,\mathrm{m} = 1.07\,\mathrm{mm}$ (Microwave range)

Exercise 44.

For the de Broglie wavelength, we have:

$$\lambda = \frac{h}{p} = \frac{h}{m \cdot v} = \frac{6.626 \cdot 10^{-34}\ \mathrm{Js}}{9.109 \cdot 10^{-31}\ \mathrm{kg} \cdot 0.01 \cdot 2.9979 \cdot 10^{8}\ \mathrm{m/s}} = 2.43\,\text{Å}$$