Light absorption

2.70. As a result of the absorption of a light quantum the electron of a hydrogen atom is excited from the L-shell to the N-shell. The energy difference between these shells is 2.55 eV. Give the wavelength of the absorbed light. What kind of light is that?

2.77. What is the transmittance of a solution, if reflectance and scattering are negligible, and its the absorbance is
a) 0;
b) 0.01;
c) 0.1;
d) 0.8;
e) 1;
f) 2;
g) ∞?

2.78. What is the absorbance of a solution, if reflectance and scattering are negligible, and its transmittance is
a) 0;
b) 0.1%;
c) 0.1;
d) 1%;
e) 10%;
f) 0.8;
g) 0.5;
h) 1;
i) 100%?

2.79. The linear attenuation coefficient of water for the light with 540 nm wavelength is 0.08 m^{-1}. A light with that wavelength and 300 W/m^2 intensity enters water. Calculate
a) the half-value layer (or half-value thickness),
b) the mean penetration depth,
c) the light intensity at 100 m depth,
d) the transmittance of 100 m water layer, and
e) the absorbance of 100 m water layer.

2.80. The linear attenuation coefficient of healthy tooth enamel is 3.1 cm^{-1} for the infrared light with 1310 nm wavelength. A light with that wavelength and 300 W/m^2 intensity is used to illuminate an enamel layer of 2 mm thickness. Reflectance can be neglected. Calculate
a) the transmitted intensity,
b) the transmittance,
c) the absorbance,
d) the half-value layer, and
e) the mean penetration depth for this wavelength.

2.81. The decadic extinction of Earth's atmospheric ozone layer (which includes both the absorption and the scattering components) for ultraviolet radiation with 300 nm wavelength is 2.5.
a) What percentage of the incident ultraviolet light can pass through the ozone layer?
b) By how many fold does the transmitted radiation intensity increase if the thickness of the ozone layer decreases by 20%? For the sake of simplicity consider the ozone layer a homogeneous layer with uniform ozone concentration.

2.82. The linear attenuation coefficient of water strongly depends on the wavelength; e.g. for the violet light with 400 nm wavelength it is 0.02 m^{-1} while for the red light with 700 nm wavelength it is 0.8 m^{-1}. Let us suppose that the intensity of the two components in the incident ray is equal.
a) What will be the ratio of the violet and red intensities at 4 m depth?
b) At what depth will the ratio of the violet and red intensities be 100:1?

2.149. A solution of 1 cm layer thickness and 0.3% (m/V) concentration absorbs 20% of the incident intensity of the light passing through it. What percentage of the initial intensity of the same light beam passes through
a) 2 cm
b) 3 cm
c) 10 cm
d) 0.5 cm solution layer supposing the same composition and concentration?
e) What layer thickness of the same solution absorbs 90% of the incident intensity?
f) What is the half-value layer,
g) the mean penetration depth,
h) the linear attenuation coefficient of the solution?
i) What is the specific absorption coefficient of the solute for this kind of light?
j) What is the molar absorption coefficient of the solute for this kind of light if its molar mass is 300 g/mol?

2.150. A solution of 1 cm layer thickness and 0.3% (m/V) concentration absorbs 20% of the incident intensity of the light passing through it. What percentage of the initial intensity of the same light beam passes through
a) the 0.6% (m/V),
b) the 0.9% (m/V),
c) the 0.15% (m/V) solution of the same solute if the layer remains 1 cm?

2.151. A sheet of glass transmits 90% of the incident light. How many % is tranmitted by
a) two,
b) three, and
c) ten such sheets?

2.152. The molar extinction coefficient of the aqueous solution of NADH (nicotinamide adenine dinucleotide, molar mass = 663.43 g/mol) for the 340 nm wavelength light is 6220 $M^{-1} \cdot cm^{-1}$.
a) What is the molar concentration of the NADH solution that has an absorbance of 0.12 measured in a cuvette of 9.98 mm thickness?
b) What would be the absorbance of the solution (measured in the same cuvette) that is prepared by dissolving 0.2 mg NADH in 10 mL water?

2.153. We dissolved 0.4733 mg of ATP (adenosine triphosphate, molar mass = 507.18 g/mol) in 12 mL water. The absorbance of the resulting solution was 1.2 when measured in a 10.02 mm cuvette at 259 nm.
a) What is the molar and
b) specific absorption (extinction) coefficient of ATP?
c) How many μM is the concentration of the ATP solution (measured in the same cuvette and at the same wavelength) if its OD is 0.07?
d) How many mg ATP should be dissolved in 10 mL water to produce a solution with an optical density of 0.25 (measured in the same cuvette and at the same wavelength)?
e) The absorption maximum of ATP (in aqueous solution at neutral pH) is at 259 nm. How many eV energy difference belongs to the corresponding electronic transition?

Solutions

2.70. **488 nm, blue light**

2.77. a) **100%**
b) **97.72%**
c) **79.43%**
d) **15.85%**
e) **10%**
f) **1%**
g) **0%**

2.78. a) **∞**
b) **3**
c) **1**
d) **2**
e) **1**
f) **0.0969**
g) **0.301**
h) **0**
i) **0**

2.79. a) **8.664 m**
b) **12.5 m**
c) **0.10064 W/m^2**
d) **0.03355%**
e) **3.474**

2.80. a) **161.38 W/m^2**
b) **53.79%**
c) **0.269**
d) **0.2236 cm**
e) **0.3226 cm**

2.81. a) **0.316%**
b) **to 1%, i.e. it increases by a factor 3.16**

2.82. a) **J_{violet}/J_{red} = 22.646**
b) **5.904 m**

2.149. a) **64%**
b) **51.2%**
c) **10.74%**
d) **89.44%**
e) **10.319 cm**
f) **3.106 cm**
g) **4.481 cm**
h) **0.223 cm^{-1}**
i) **32.3 (cm^3/g) · cm^{-1}**
j) **9.691 M^{-1} · cm^{-1}**

2.150. a) **64%**
b) **51.2%**
c) **89.44%**

2.151. a) **81%**
b) **72.9%**
c) **34.87%**

2.152. a) **19.33 µM**
b) **0.187**

2.153. a) **15270 $M^{-1} \cdot cm^{-1}$**
b) **301.1 $(cm^3/g) \cdot cm^{-1}$**
c) **4.575 µM**
d) **0.08287 mg**
e) **4.8 eV**