Environmental Science, Solutions to Problems Chapter 2

2.1.1

The speed of light in vacuum is $c = 299792548$ m/s. The refractive index n is defined as $n = c/u$, why we get

$$u = \frac{c}{n} = \frac{2.99792458 \cdot 10^8}{1.52} \approx 1.97 \cdot 10^8 \text{m/s}.$$

Even though the speed of light is given by 9 digits, the refractive index is given by 3 digits, why the answer is given by 3 digits.
Answer: $\mathbf{1.97 \cdot 10^8}$ m/s

2.1.2

The wavelength in the medium can be calculated with

$$\lambda_{medium} = \frac{\lambda}{n} = \frac{555}{1.35} \text{ nm} \approx 411 \text{ nm}.$$

Answer: 411 nm

2.1.3

The energy of the photon is given by

$$E = hf = h\frac{c}{\lambda} = 6.33 \cdot 10^{-34} \cdot \frac{3.00 \cdot 10^8}{633 \cdot 10^{-9}} \cdot \frac{1}{1.602 \cdot 10^{-19}} \text{ eV} \approx 1.96 \text{ eV}.$$

Answer: 1.96 eV

2.2.1

Wien's law

$$\lambda_{max} = \frac{2.898 \cdot 10^{-3}}{T}$$

gives the temperature

$$T = \frac{2.898 \cdot 10^{-3}}{730 \cdot 10^{-9}} \text{ K} \approx 3970 \text{ K}.$$

Answer: 3970 K

2.4.1

Using the following expression for the velocity

$$u = \sqrt{\frac{3kT}{m}},$$

we get

$$u = \sqrt{\frac{3 \cdot 1.38 \cdot 10^{-23} \cdot 293}{(12+16) \cdot 1.67 \cdot 10^{-27}}} \text{ m/s} \approx 509 \text{ m/s}.$$

Answer: 509 m/s

2.4.2

Using the following expression for the velocity

$$u = \sqrt{\frac{3kT}{m}},$$

we get

$$u = \sqrt{\frac{3 \cdot 1.38 \cdot 10^{-23} \cdot 298}{(3 \cdot 16) \cdot 1.67 \cdot 10^{-27}}} \text{ m/s} \approx 392 \text{ m/s}.$$

Answer: 392 m/s

2.4.3

The concentration could follow a linear expression $y = kx + m$. The concentration would then be

$$329 - 0.070 \cdot 10^{-2} \cdot (2006 - 1978) \text{ DU} = 329 - 0.020 \text{ DU}.$$

Answer: -0.020 DU

2.7.1

Applying Wien's law we get the wavelength maximum at

$$\lambda_{max} = \frac{2.898 \cdot 10^{-3}}{T} \text{ m} = \frac{2.898 \cdot 10^{-3}}{273 + 20} \text{ m} \approx 9.9 \ \mu\text{m}$$

Answer: 9.9 μm

2.7.2

Applying the Stefan-Boltzmann formula we get the intensity

$$e = \sigma T^4 = 5.671 \cdot 10^{-8} \cdot 293^4 \text{ W/m}^2 = 418 \text{ W/m}^2 \approx 420 \text{ W/m}^2$$

Answer: 420 W/m^2