Spectrum

The electromagnetic spectrum can be defined by wavelength, frequency, or energy, since all of these are related. For the purpose of relating atomic transitions to the energy of photons absorbed or emitted, it helps to know the energies of the various regions of the electromagnetic spectrum.

The following definitions of the regions of the electromagnetic spectrum were taken from *HyperPhysics* by Carl R. Nave at Georgia State University.

Region	Wavelength	Frequency	Energy
Gamma Rays	< 0.001 nm	$> 10^{20}$ Hz	> 1 MeV
X-rays	10 nm − 0.001 nm	$3 \times 10^{16} - 1 \times 10^{20}$ Hz	124 eV − 1 MeV
Ultraviolet	400 nm − 10 nm	$7.5 \times 10^{14} - 3 \times 10^{16}$	3.1–124 eV
Visible	750 nm − 400 nm	$4 \times 10^{14} - 7.5 \times 10^{14}$ Hz	$1.65 - 3.1$ eV
Infared	1 mm − 750 nm	$0.003 \times 10^{14} - 4 \times 10^{14}$	$0.0012 - 1.65$ eV
Millimeter Waves, Telemetry	10 mm − 1 mm	30 − 300 GHz	$1.2 \times 10^{-4} - 1.2 \times 10^{-3}$ eV
Microwaves, Radar	187 mm − 10 mm	1.6 − 30 GHz	$6.6 \times 10^{-6} - 1.2 \times 10^{-3}$ eV
TV and FM Radio	5.55 m − 0.187 m	54 − 1600 MHz	$2.2 \times 10^{-7} - 6.6 \times 10^{-5}$ eV
Short Wave	187 m − 5.55 m	1.605 − 54 MHz	$6.6 \times 10^{-9} - 2.2 \times 10^{-7}$ eV
AM Radio	600 m − 200 m	500 − 1500 kHz	$2 \times 10^{-9} - 6.6 \times 10^{-9}$ eV

Table 1: Electromagnetic Spectrum

Visible Spectrum

Defining where one color ends and another begins requires completely artificial definitions. But at least the middle of these ranges are well defined. The following designation is from *University Physics* by Young and Freedman.

Region	Wavelength	Frequency	Energy
Violet	440 nm − 400 nm	$6.8 \times 10^{14} - 7.5 \times 10^{14}$ Hz	2.8 − 3.1 eV
Blue	480 nm − 440 nm	$6.3 \times 10^{14} - 6.8 \times 10^{14}$ Hz	2.6 − 2.8 eV
Green	560 nm − 480 nm	$5.4 \times 10^{14} - 6.3 \times 10^{14}$ Hz	2.2 − 2.6 eV
Yellow	590 nm − 560 nm	$5.1 \times 10^{14} - 5.4 \times 10^{14}$ Hz	2.1 − 2.2 eV
Orange	630 nm − 590 nm	$4.8 \times 10^{14} - 5.1 \times 10^{14}$ Hz	2.0 − 2.1 eV
Red	700 nm − 630 nm	$4.3 \times 10^{14} - 4.8 \times 10^{14}$ Hz	1.8 − 2.0 eV

Table 2: Visible Region of the Electromagnetic Spectrum

Application

1. Suppose a hydrogen atom in the 5th energy state (–0.544 eV) makes a transition to the 2nd energy state (–3.4 eV). What color photon is emitted?

2. A hypothetical Titus atom has the following energy levels: -10 eV, -5 eV, -2.5 eV, and -1.25 eV.

   (a) What energy photons can be absorbed or emitted by this gas?

   (b) What regions of the electromagnetic spectrum do these photons correspond to?