12.) a.) wave 1 has a longer wavelength than wave 2  
b.) wave 1 has a lower frequency than wave 2.

13.) a.) 0.05 m, this is the microwave region of spectrum  
b.) $4 \times 10^{-7}$ m, this is the violet light of the visible region of the spectrum  
c.) $5 \times 10^{-5}$ m, this is in the infrared region of the spectrum  
d.) 0.15 m, this is in the uhf/microwave region of the spectrum.

16.) order of increasing energy per photon:  
radiowaves < infrared < visible < gamma rays

17.) $c = 3 \times 10^8$ m/s

32.) Of these choices radiowaves have the lowest energy and therefore the least potential for damage to biological systems.

44.) a.) The concentration of ozone drops in the first 10km of the troposphere. There is a region of increasing ozone concentration until 20 km, followed by dropping concentrations to about 30 km. The maximum concentration of ozone is between 10-30 km; this is what its meant by the ozone layer. At higher altitudes the concentration drops even more sharply.

b.) The concentrations of interest are those in the troposphere and stratosphere. Those range from $10^{16}$ to $10^{19}$ molecules per cubic meter. Zero concentration is not relevant and would extend the x-axis and therefore compress the area of interest.

45.) The term ozone while in use, brings an incorrect image of a physically thick blanket like layer to mind. In fact, even in the stratosphere region of highest concentration, ozone’s concentration is typically less than 1 ppm and is not even the most abundant species in that region. The ozone does not completely block all UV radiation, such as a blanket might block all visible light. The ozone that is present, however, serves the
essential function of helping to screen out UV-B and UV-C radiation, reducing these components of sunlight before they reach the earth, making the screen analogy more nearly useful.