The photodissociation wavelength of ozone is 320 nm. This means that ozone efficiently absorbs light below this wavelength and breaks apart according to the following photochemical reaction.

$$O_3 + h\nu \rightarrow O_2 + O$$

Any excess energy above the dissociation energy will be carried away by the kinetic energy of O_2 and O. Assuming that the kinetic energy is shared equally by O_2 and O calculate the velocity of O_2 and O when ozone is photodissociated by a photon with a wavelength of 250 nm.

Solution: The photodissociation of a molecule can be treated conceptually in the same way that one treats an ionization process. The atom has a binding energy in the molecule. If the incident photon has a greater energy then the bond is broken and the atom can leave. Any excess energy is carried away as kinetic energy. The difference in the case of atoms is that the kinetic energy is not simple. For an electron we assume that the all of the kinetic energy is in the electron (because its mass is so small). For atoms and molecules we cannot assume that only one of the species will carry away all of the kinetic energy. This problem simplifies the matter by stating that the kinetic energy will be carried away by both species (O2 and O) equally.

MKS units.

The energy of a 250 nm photon is:

$E = hc/\lambda = (6.626 \times 10^{-34}\ \text{Js})(2.99 \times 10^{8}\ \text{m/s})/(250 \times 10^{-9}\ \text{m}) = 7.92 \times 10^{-19}\ \text{J}$

The energy of the O-O bond in ozone is:

$E = hc/\lambda = (6.626 \times 10^{-34}\ \text{Js})(2.99 \times 10^{8}\ \text{m/s})/(320 \times 10^{-9}\ \text{m}) = 6.19 \times 10^{-19}\ \text{J}$

Therefore the energy of a 250 nm photon is greater than the threshold needed to break a bond by:

$\Delta E = E(\text{250 nm photon}) – E(\text{320 nm threshold energy}) = 1.73 \times 10^{-19}\ \text{J}$

This is the total kinetic energy of the photodissociated ozone molecule.

Both the O_2 molecule and the O atom carry away half of this energy or 8.65×10^{-20} J.

The velocity of the oxygen atom is m = sqrt(2E/m)

$= \text{sqrt}(2*8.65 \times 10^{-20}\ \text{J}/16/1.67 \times 10^{-27}\ \text{kg}) = 2544\ \text{m/s}$

The velocity of the oxygen molecule is m = sqrt(2E/m)

$= \text{sqrt}(2*8.65 \times 10^{-20}\ \text{J}/32/1.67 \times 10^{-27}\ \text{kg}) = 1800\ \text{m/s}$