Neodymium yttrium aluminum garnet (YAG) lasers are alternative photolysis sources for the generation of transient species. Lasing transitions occur between various electronic levels of neodymium ions in a YAG lattice. The output of the Nd-YAG is in the near infrared (1.06µ) but by processes known as frequency doubling and frequency mixing, the fundamental wavelength can be converted to output at 532 nm, 355 nm and 266 nm. Calculate the maximum energies of the bonds that can be broken by each of these photons. Why do you think that the output at 532 nm is rarely used in the generation of radical species?

Photon energy is \( E = h \nu = \frac{hc}{\lambda} \).

\[
E = 6.63 \times 10^{-34} \text{J sec} \times 3 \times 10^8 \text{M/s} / 1062 \times 10^{-9} \text{M} = 1.8729 \times 10^{-19} \text{J/molecule} = 1.1275 \times 10^5 \text{J/mole} = 112 \text{kJ/mole}
\]

If laser is doubled, \( E = 224 \text{kJ/mole} \), tripled = 336, quadrupled 448.

532nm output is very small compared to most chemical bond strengths.

**A.** Calculate the fraction of gas molecules with speeds greater than the average speed.

\[
f(v > v_{ave}) = \int_{v_{ave}}^{\infty} f(v)dv
\]

\[
= A \int \frac{v^2 e^{-\beta v^2}}{2\beta^{3/2}} \int_{v_0}^{\infty} y^{1/2} e^{-y} dy
\]

\[
= \frac{A}{2\beta^{3/2}} \left[ y_0^{1/2} e^{-y_0} + \frac{\sqrt{\pi}}{2} \left( \text{erf}(\infty) - \text{erf}(y_0^{1/2}) \right) \right]
\]

\[
y_0 = \beta < v^2 > = \frac{m (8kT)}{2kT \left( \frac{\pi m}{\pi} \right)} = \frac{4}{\pi}
\]

\[
f(v > v_{ave}) = \frac{2}{\sqrt{\pi}} \left( 2 \sqrt{\pi} e^{-4/\pi} \right) + 1 - \text{erf}(\sqrt{4/\pi})
\]

\[
= \frac{4}{\pi} \times 0.2799 + 1 - 0.8895
\]

\[
= 0.356 + 1 - 0.8895 = 0.466
\]