Use of Lasers in Chemistry
Spectroscopy
Examining the structure of matter

- IR
- Raman
- Ultrafast (Time Resolved)
- More...

Photochemistry
Study of the dynamics of chemical reactions initiated by the absorption of light
Two laser beams:
1. Pump pulse – Initiates Reaction
2. Probe pulse – Records Changes

\[ \text{ICN}(g) + h\nu \rightarrow \text{I}(g) + \text{CN}(g) \]
Results...

- The intensity increases as the concentration of CN radicals increases.
- No additional CN is formed after \(\sim 600\) fs.
- Solid line has form \(1-\exp(-t/\tau)\); \(\tau\) is the reaction half-life.
- For this reaction, \(t = 205 \pm 30\) fs.
High Resolution Spectroscopy

Lamp based Spectrometer

Why would the laser spectrometer have higher resolution?

Laser based Spectrometer
Types of Photochemical Reactions

a. Photodissociation: $\text{O}_3 + (\lambda = 300 \text{ nm}) \rightarrow \text{O}_2 + \text{O}$

b. Photoisomerization:

\[
\text{H}_2\text{C} = \text{CH}_2 + (\lambda = 250 \text{ nm}) \rightarrow \text{H}_2\text{C} = \text{CH}_2
\]

\((\text{trans-butadiene} + (\lambda = 250 \text{ nm}) \rightarrow \text{cis-butadiene})\)

c. Photodimerization:
Quantum Yield

\[ \Phi = \frac{\text{Number of molecules that undergo reaction}}{\text{Number of photons absorbed}} \]

Upon absorption of 313 nm light, acetone photodissociates according to the chemical equation:

\[(\text{CH}_3\text{CO}_g) + (\lambda = 313 \text{ nm}) \rightarrow \text{C}_2\text{H}_6(g) + \text{CO}_g\]

Exposure of a gaseous sample of acetone to a radiant power of 1.71 \times 10^{-2} \text{ W} (recall: 1W = 1J/s) at 313 nm for a period of 1.15 \times 10^4 \text{ s} results in the photodissociation of 8.68 \times 10^{-5} \text{ mol} of acetone. Determine the quantum yield for this photodissociation (assume 100% absorption of light).

A: 0.17