9-58 (Carbon monoxide Spectrum)

- Rotational transitions are permitted within a particular vibrational state for molecules w/ a permanent electric dipole moment.

a) What is moment of inertia for CO

$I = \mu r_0^2$

$\mu = \frac{m_1 m_2}{m_1 + m_2}$

$m_{carbon} = 12.011u$

$m_{oxygen} = 15.999u$

$r_0 = 0.113nm$

So $\mu \approx \frac{12 \cdot 16}{12+16} = \frac{48}{7}u$

~~$I = 1.287 \times 10^{-36}$~~

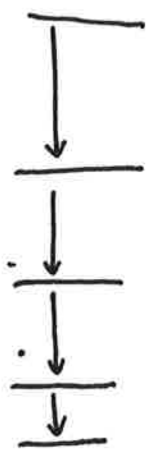
And $\boxed{I = 1.45 \times 10^{-46} kgm^2}$

So the characteristic rotational energy is

$E_{or} = \frac{\hbar^2}{2I} = 2.394e{-4}eV$

$\boxed{E_{or} = 0.239 meV}$

b) energy level diagram. Lets take $E = \frac{1}{2}hf + \ell(\ell+1)E_{or}$



$\ell=4$, $E_4 = 20E_{or}$

$\ell=3$, $E_3 = 12E_{or}$

$\ell=2$, $E_2 = 6E_{or} = 1.436\,meV$

$\ell=1$, $E_1 = 2E_{or} = 0.479\,meV$

$\ell=0$, $E_0 = 0eV = 0\,meV$

{ $hf = ?$ Lets just focus on the dependence on ℓ ....

$\Uparrow$ increasing ℓ increasing E

c) The downward arrows $\downarrow$ indicate transitions with $\Delta\ell = -1$

The photon energies are

$\frac{E_4 - E_3}{h} = \frac{8E_{or}}{h} = 462\,GHz$

$\frac{E_3 - E_2}{h} = \frac{6E_{or}}{h} =$ ~~462 GHz~~ $347\,GHz$

$\frac{E_2 - E_1}{h} = \frac{4E_{or}}{h} = 231\,GHz$

$\frac{E_1 - E_0}{h} = \frac{2E_{or}}{h} = 116\,GHz$

} Microwaves