TL 9-49 (HCl Spectrum)

- Suppose HCl is illuminated with $\lambda = 435.8\ nm$ light.

a) Find 4 absorption lines nearest to this.

- Looking at table 9-8, for $H^{35}Cl$, $E_{or} = \frac{\hbar^2}{2I} = 1.32\ meV$

  and the vibrational frequency is $f_o = 8.97e13\ Hz$

- The incident frequency is $f = \frac{c}{\lambda} = 6.879e14\ Hz$,

  which is <u>much</u> higher than the frequency needed to take the HCl from $E_{n=0} = \frac{1}{2}hf_o$ to $E_{n=1} = \frac{3}{2}hf_o$, $\Delta E = hf_o$

- So to absorb this photon, we need to excite the HCl from, say $n=0$ to $n=$ much higher. How much higher? $n\Delta E = hf$

$$n = \frac{hf}{hf_o} = \frac{f}{f_o} = \frac{6.879e14}{8.97e13}$$

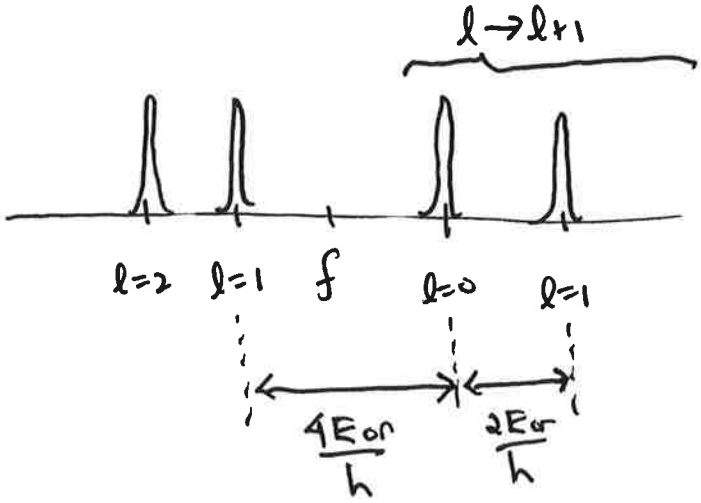
$$n = 7.67 \approx 8$$

- Lets take $n=8$. So the frequency associated with the transition from $n=0$ to $n=8$ is $8hf_o =$

$$8f_o = 7.18 \times 10^{14}\ Hz$$

- Now, what rotational state/ transitions lie nearby?
- Since $E_{or} = 1.32 meV$, we can find the ~~lines~~ absorption lines that lie on either side of

$$f = 7.18 \times 10^{14} Hz$$



$$\frac{2E_{or}}{h} = 6.38 e11 \, Hz$$

- So the transition from $(n=0, l=0)$ to $(n=8, l=1)$ is at $f = 7.18e14 \, Hz + 6.38e11 \, Hz$

$$f = 7.186e14 \, Hz$$

and from $(n=0, l=1)$ to $(n=8, l=2)$ is

$$f = 7.18e14 Hz + 2 \cdot 6.38e11 Hz$$

$$f = 7.193 e14 Hz$$

- And on the other side, from $(n=0, l=1)$ to $(n=8, l=0)$

$$f = 7.171e14 \, Hz$$

and from $(n=0, l=2)$ to $(n=8, l=1)$

$$f = 7.167e14 Hz$$

b) The absorption lines in fig 9-30 correspond to a transition between two very nearby vibrational states (n=0 to n=1). This is in the microwave spectrum. Our light is in the visible. So we cannot compare. But we can compare the gaps. Our gaps are

big gap: $\frac{4E_{or}}{h} = 12.76 \text{ e11 Hz}$

little gap: $\frac{2E_{or}}{h} = 6.38 \text{ e11 Hz}$

} Calculated

Observed: $8.72 \text{ e13} - 8.60 \text{e13} = 0.12 \text{e13}$

Big gap $\approx 12 \text{e11 Hz}$ ✓

Little gap $\approx 6 \text{e11 Hz}$ ✓