Homework Solution
Chapter 10

Pb # 4.

In general a transition from $\ell-1 \rightarrow \ell$ gives $\Delta E_{rot} = \frac{\hbar^2}{I}\ell$

(ℓ is the rotational quantum number of the higher level)

So $\Delta E_{0\to1} = \frac{\hbar^2}{I}$ and $\Delta E_{5\to6} = 6\frac{\hbar^2}{I} = 6\,\Delta E_{0\to1}$

also $\Delta E = hf = \frac{hc}{\lambda}$

$$\Rightarrow \left.\begin{aligned} \Delta E_{0\to1} &= \frac{hc}{\lambda_{0\to1}} \\ \Delta E_{5\to6} &= \frac{hc}{\lambda_{5\to6}} \end{aligned}\right\} \Rightarrow \frac{\Delta E_{5\to6}}{\Delta E_{0\to1}} = 6 = \frac{\lambda_{0\to1}}{\lambda_{5\to6}}$$

and $\Delta E_{5\to6} = 6\,\Delta E_{0\to1}$

$$\Rightarrow \lambda_{0\to1} = 6\,\lambda_{5\to6} = 6\times1.35 = \boxed{8.10\text{ cm}}$$

$$f_{0\to1} = \frac{c}{\lambda_{0\to1}} = \frac{3\times10^8}{8.10\times10^{-2}} = \boxed{3.70\times10^9\text{ Hz}}$$

$$\Delta E_{0\to1} = \frac{\hbar^2}{I} = \frac{hc}{\lambda_{0\to1}} = h f_{0\to1} \Rightarrow I = \frac{\hbar^2}{h f_{0\to1}} =$$

$$I = \frac{(1.05\times10^{-34})^2}{6.63\times10^{-34}\times3.70\times10^9} = \boxed{4.49\times10^{-45}\text{ Kg}\cdot\text{m}^2}$$