Pb # 8.

a) $E_{rot} = \frac{\hbar^2}{2I_{cm}} \ell(\ell+1) \qquad \ell = 0, 1, 2, \ldots$

$I_{cm} = \mu R_o^2 \qquad \mu = \frac{m_1 m_2}{m_1 + m_2} = \frac{1u \times 35u}{(1+35)u} = \frac{35u}{36}$

$\mu = 0.972 \times 1.6605 \times 10^{-27} = 1.6 \times 10^{-27}$ Kg

$R_o = 0.128$ nm

$\Rightarrow I_{cm} = 1.6 \times 10^{-27} \times (0.128 \times 10^{-9})^2 = 2.62 \times 10^{-47}$ Kg.m^2

$\ell = 0 \qquad E_{rot} = 0$

$\ell = 1 \qquad E_{rot} = \frac{\hbar^2}{2I_{cm}} 2 = \frac{\hbar^2}{I_{cm}} = \frac{(1.05 \times 10^{-34})^2}{2.62 \times 10^{-47}}$

$= 4.20 \times 10^{-22}\,J = \boxed{2.63 \times 10^{-3}\,eV}$

$\ell = 2 \qquad E_{rot} = \frac{\hbar^2}{2I_{cm}} 6 = 2.63 \times 10^{-3} \times 3 = \boxed{7.89 \times 10^{-3}\,eV}$

$\ell = 3 \qquad E_{rot} = \frac{\hbar^2}{2I_{cm}} 12 = 2.63 \times 10^{-3} \times 6 = \boxed{15.78 \times 10^{-3}\,eV}$

b)

$U = \frac{1}{2} k x^2$

x ↳ displacement from equilibrium position

$0.15 \times 1.6 \times 10^{-19} = \frac{1}{2} k (0.01 \times 10^{-9})^2 \Rightarrow k = 480$ N/m

$k = \mu \omega^2 \Rightarrow \omega = \sqrt{\frac{k}{\mu}} = \sqrt{\frac{480}{1.6 \times 10^{-27}}} = 5.5 \times 10^{14}$ rad/s

$f = \frac{\omega}{2\pi} = \boxed{8.72 \times 10^{13}\,HZ}$