ASTR 792 HW 9

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5.1

Let $r_0 = .741\ \mathring{A} = .07\ nm$

a

The rotational energy of a rigid rotor is

$$E(J) = J(J+1)\frac{\hbar^2}{2\mu r_0^2}$$

For H_2, the reduced mass μ is

$$\mu = \frac{m_H^2}{2m_H} = \frac{m_H}{2}$$

$$\rightarrow E(J) = J(J+1)\frac{(hc)^2}{4\pi^2 m_H c^2 r_0^2}$$

$$= J(J+1)\frac{(1240\ eVnm)^2}{4\pi^2 \cdot 938 \cdot 10^6\ eV \cdot (.0741\ nm)^2}$$

$$= J(J+1) \cdot .00756\ eV$$

For the $J = 0$ state, $E(0) = 0$, so we can simply calculate the energy of each state.

J = 1

$$\rightarrow \frac{E(1)}{k} = 2 \cdot \frac{.00756\ eV}{k} = \frac{.0151\ eV}{k}$$

J = 2

$$\rightarrow \frac{E(2)}{k} = 2(3) \cdot \frac{.00756\ eV}{k} = \frac{.0454\ eV}{k}$$

J = 3

$$\rightarrow \frac{E(3)}{k} = 3(4) \cdot \frac{.00756\ eV}{k} = \frac{.0902\ eV}{k}$$

c

J = 2 → 0

We calculated the energy difference from the $J = 2 \to 0$ state above. We can simply use

$$E = h\nu = \frac{hc}{\lambda}$$
$$\to \lambda = \frac{hc}{E} = \frac{1240\ eVnm}{.454\ eV}$$
$$= 2731.21\ nm$$

J = 3 → 1

We can find this by

$$\Delta E(J = 3 \to 1) = (.0902 - .0151)eV = .0751\ eV$$
$$\to \lambda = \frac{1240\ eVnm}{.0751\ eV}$$
$$= 16511.32\ nm$$