

**CHM102**  
**Assignment 5 (7-3-2017)**

1. Using the recursion relation of the Hermite polynomials,  
$$x H_v = v H_{v-1} + 0.5 H_{v+1}$$
derive the selection rule for the vibrational transitions for a harmonic oscillator.
2. Using the recursion relation given above, calculate the  $\langle x \rangle$  for a harmonic oscillator.
3. If the rotational constant B for the  $\text{H}^{35}\text{Cl}$  molecule is  $3.13 \times 10^{11}$  Hz, calculate its internuclear distance.
4. If the lines in the rotational spectrum of the  $\text{H}^{79}\text{Br}$  molecule are spaced by  $16.72 \text{ cm}^{-1}$ , calculate the internuclear distance of HBr.
5. What are the eigenvalues of the  $L^2$  and  $L_z$  operator for the following eigenfunctions of the rotor. (Write down the values by inspection of the eigenfunctions).
  - a)  $(1/4\pi)^{0.5}$
  - b)  $(3/4\pi)^{0.5} \cos \theta$
  - c)  $(3/8\pi)^{0.5} \sin \theta e^{-i\varphi}$
  - d)  $(3/8\pi)^{0.5} \sin \theta e^{i\varphi}$
  - e)  $(15/32\pi)^{0.5} \sin^2 \theta e^{-2i\varphi}$
6. Show that  $L^2$  and  $L_z$  operators commute.