Assignment (21)

(1) $E_J = \frac{\hbar^2 J(J+1)}{2\mu r_e^2}$, $\mu_{{}^{12}_{6}C-{}^{16}_{8}O} < \mu_{{}^{14}_{6}C-{}^{18}_{8}O} \rightarrow \Delta E_{J,{}^{12}_{6}C-{}^{16}_{8}O} > \Delta E_{J,{}^{14}_{6}C-{}^{18}_{8}O}$.

The rotational levels of ${}^{12}_{6}C-{}^{16}_{8}O$ have a bigger spacing between the energy levels.

(2) The trial function has the exact right form of the sollutions for the harmonic oscillator, so it's ground state energy is given by.
$E_0 = \frac{1}{2}h\nu_0 = \frac{1}{2}(6.026\times10^{-34}\ J\cdot s)(6.42\times10^{13}\ Hz) = 2.127\times10^{-20}J$.

(3) $r_e = 113.1$ pm
$k = 1902$ N/m

$${}^{13}C^{17}O + {}^{12}C^{16}O \rightarrow {}^{12}C^{17}O + {}^{13}C^{16}O.$$

ΔH°? $E^\circ_{vib} = \frac{1}{2}\hbar\omega_0 = \frac{1}{2}\hbar\sqrt{\frac{k}{\mu}}$

$\mu\{{}^{13}C^{17}O\} = \frac{13\cdot17}{13+17} = 7.3667$ amu. $\rightarrow E^\circ_{vib}\{{}^{13}C^{17}O\} = \frac{1}{2}\hbar\sqrt{\frac{1902 N/m}{(7.3667)(1.66\times10^{-27}kg)}} = 1.188\times10^{-19}J$

$\mu\{{}^{12}C^{16}O\} = \frac{12(16)}{12+16} = 6.8571$ amu. $\rightarrow E^\circ_{vib}\{{}^{12}C^{16}O\} = 1.232\times10^{-19}J$.

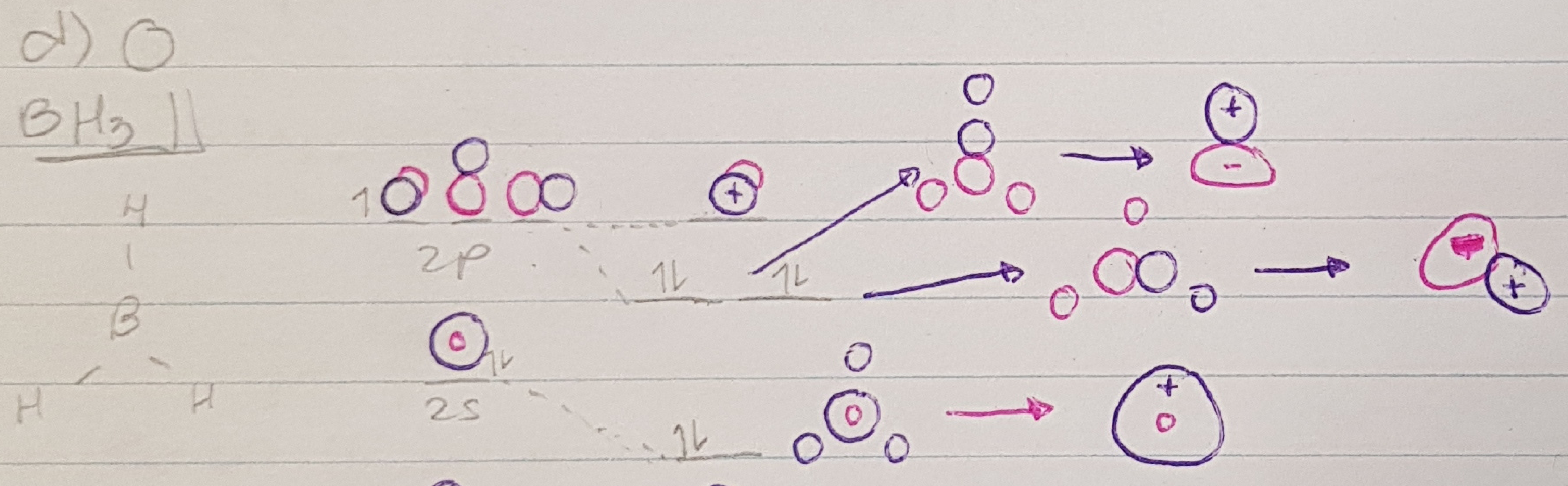
$\mu\{{}^{12}C^{17}O\} = \frac{12(17)}{12+17} = 7.0345$ amu. $\rightarrow E^\circ_{vib}\{{}^{12}C^{17}O\} = 1.216\times10^{-19}J$.

$\mu\{{}^{13}C^{16}O\} = \frac{13(16)}{13+16} = 7.1724$ amu. $\rightarrow E^\circ_{vib}\{{}^{13}C^{16}O\} = 1.204\times10^{-19}J$.

$\Delta H^\circ = E^\circ_{vib}\{{}^{12}C^{17}O\} + E^\circ_{vib}\{{}^{13}C^{16}O\} - E^\circ_{vib}\{{}^{13}C^{17}O\} - E^\circ_{vib}\{{}^{12}C^{16}O\}$
$= 0J$

(4) a) P
b) A
c) S
d) O

(5) BH_3



(6) $1s^1 2s^1 2p^1$

$L = 1$
$S = \frac{3}{2}$
$J = M_J = \frac{5}{2}$
$M_J = \frac{5}{2} \rightarrow M_J = M_L + M_S$
M_L can only be +1, $M_S = \frac{3}{2}$ → all electrons are alpha

$$|\Psi_{1s2s2p}\rangle = \frac{1}{\sqrt{3!}}\begin{vmatrix} \psi_{1s}\{\vec{r}_1\}\alpha\{1\} & \psi_{2s}\{\vec{r}_1\}\alpha\{1\} & \psi_{2p}\{\vec{r}_1\}\alpha\{1\} \\ \psi_{1s}\{\vec{r}_2\}\alpha\{2\} & \psi_{2s}\{\vec{r}_2\}\alpha\{2\} & \psi_{2p}\{\vec{r}_2\}\alpha\{2\} \\ \psi_{1s}\{\vec{r}_3\}\alpha\{3\} & \psi_{2s}\{\vec{r}_3\}\alpha\{3\} & \psi_{2p}\{\vec{r}_3\}\alpha\{3\} \end{vmatrix}.$$