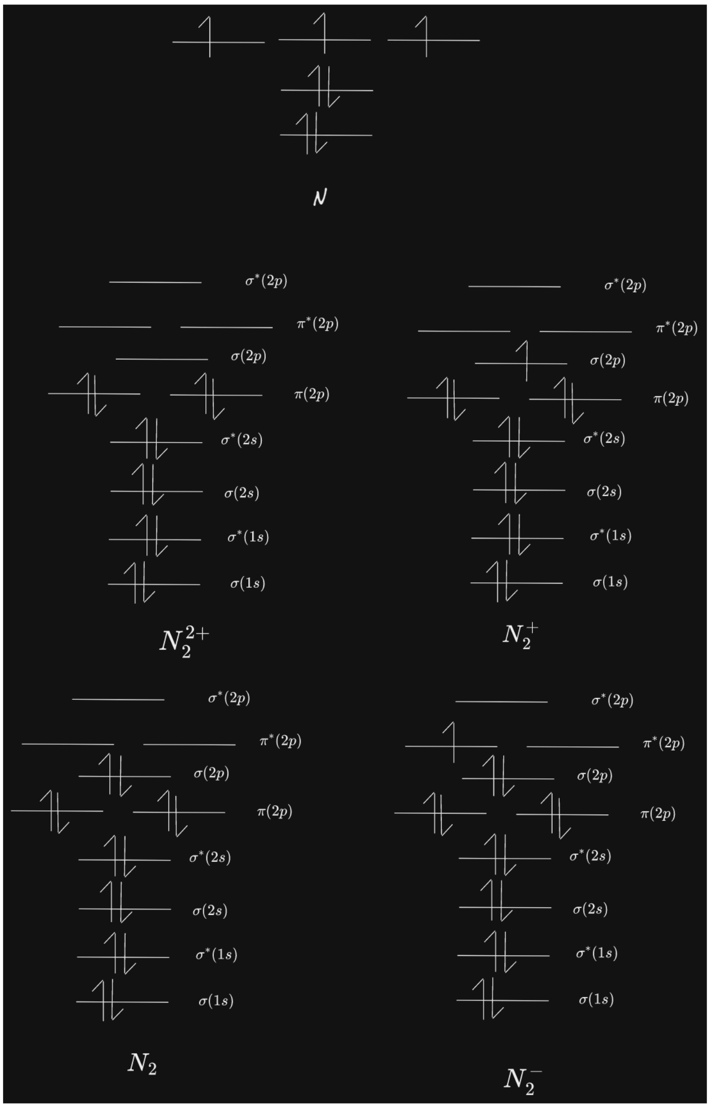
# July 12 Problems

Created: ### 2022-07-12

**10.1: Arrange the species $N_2^{+2}, N_2^+, N_2, N_2^-$ in order of increasing bond length and determine the ground state term symbol of each.**

$$\text{Electron Configuration of N: } 1s^1 2s^2 2p^3$$




$$BO = \frac{1}{2}[\text{Number of bonding e} - \text{Number of antibonding e}]$$

$$BO_{N_2^{2+}} = \frac{1}{2}(8-4) = 2$$

$$BO_{N_2^+} = \frac{1}{2}(9-4) = 2.5$$

$$BO_{N_2} = \frac{1}{2}(10-4) = 3$$

$$BO_{N_2^-} = \frac{1}{2}(10-5) = 2.5$$

$$BO : N_2^{2+} < N_2^+ = N_2^- < N_2$$

$$\text{Bond length: } N_2 < N_2^+ = N_2^- < N_2^{2+}$$

$$\text{Term symbol:}\begin{array}{l} N_2^{2+} :^1 \Sigma \\ N_2^{+} :^2 \Sigma \\ N_2 :^1 \Sigma \\ N_2^{-} :^2 \Pi \end{array}$$

**10-2 Calculate the molar energy of repulsion between two H nuclei at the $H_2$ bond length (74.1 pm); This is the minimum energy which must be overcome by the electrons in order to form a bond. For comparison, is the gravitational attraction between the nuclei significant? The gravitational potential energy is:**

$$E_{grav} = -\frac{Gm_1m_2}{r}; G = 6.673 \times 10^{-11} Nm^2kg^{-2}$$

$$E = \frac{e^2}{4\pi\epsilon_o R} = \frac{(1.602 \times 10^{-19})^2}{4\pi(8.854 \times 10^{-12})(74.1 \times 10^{-12})} = 3.11 \times 10^{-18} J$$

$$\text{Molar energy: } E \times N_A = 3.11 \times 10^{-18} J(6.022 \times 10^{23} mol^{-1}) = 1.87 \times 10^6 Jmol^{-1}$$

$$E_{grav} = -\frac{Gm_1m_2}{r} = -\frac{(6.673 \times 10^{-11})(1.67262192 \times 10^{-27})^2}{(74.1 \times 10^{-12})} = -2.52 \times 10^{-54} J$$

$\therefore$ The value of the gravitational energy is much smaller compared to the calculated energy.

Thus, the gravitational energy is insignificant.