1. The energy of \( \text{H}_2^+ \) is \(-16.3\) eV, and the energy of \( \text{H}_2 \) is \(-31.7\) eV. The ionization energy is the difference between these values:

\[
E_{\text{ion}}(\text{H}_2) = E(\text{H}_2^+) - E(\text{H}_2) = -16.3\text{ eV} + 31.7\text{ eV} = 15.4\text{ eV}
\]

2. Let the negative charge on the sphere be \(-q\). Then the potential energy between the sphere and either of the protons is

\[
U_e = -\frac{1}{4\pi\varepsilon_0} \frac{qe}{R_{\text{eq}}/2}
\]

The total energy of the system includes the repulsion of the protons and the attraction of the negative sphere for each of the protons:

\[
E = U_p + 2U_e = \frac{1}{4\pi\varepsilon_0} \frac{e^2}{R_{\text{eq}}} - 2 \frac{1}{4\pi\varepsilon_0} \frac{qe}{R_{\text{eq}}/2} = \frac{1}{4\pi\varepsilon_0} \frac{e}{R_{\text{eq}}} (e - 4q)
\]

Inserting the value of \( R_{\text{eq}} = 0.106\) nm and \( E = -B = -2.7\) eV, we can solve to find

\[
q = 0.30e
\]

This quantity of charge is roughly consistent with the fraction of \( \psi^2 \) that appears between the two protons in Figure 9.3a.

3. (a) Each mole contains \(6.022 \times 10^{23}\) molecules, so

\[
E = \frac{410 \times 10^3}{6.022 \times 10^{23}} \frac{\text{J/mole}}{\text{molecules/mole}} \cdot \frac{1}{1.602 \times 10^{-19}} \frac{\text{J/eV}}{\text{J/eV}} = 4.25\text{ eV/molecule}
\]

(b) \[
E = \frac{106 \times 10^3}{6.022 \times 10^{23}} \frac{\text{J/mole}}{\text{molecules/mole}} \cdot \frac{1}{1.602 \times 10^{-19}} \frac{\text{J/eV}}{\text{J/eV}} = 1.10\text{ eV/molecule}
\]

(c) \[
E = \frac{945 \times 10^3}{6.022 \times 10^{23}} \frac{\text{J/mole}}{\text{molecules/mole}} \cdot \frac{1}{1.602 \times 10^{-19}} \frac{\text{J/eV}}{\text{J/eV}} = 9.80\text{ eV/molecule}
\]

4. NO has 15 electrons, NF has 16, and OF has 17. A total of 8 electrons will occupy the \(1s\) and \(2s\) bonding and antibonding states, and 6 electrons can be placed in the three \(2p\) bonding states. The remaining electrons in each molecule must go into the \(2p\) antibonding states: one in NO, two in NF, and three in OF. So we would expect NO to