$2E_0 + \frac{3}{2}E_0 + 2E_0 = \frac{11}{2}E_0$.

Q51 $\boxed{\text{B}}$ The first derivative of the $\langle E \rangle$ expression is set to zero yielding $Z^* = 1.8497$ when $Z = 2$. This value of Z^* yields $E = -58.20$ eV.

Q52 $\boxed{\text{E}}$ The product of the charges on the electrons is $(-e)(-e) = e^2$ and their separation is $|\mathbf{r}_1 - \mathbf{r}_2|$.

Q53 $\boxed{\text{C,F}}$ The $S = 1$ (triplet) state is spin symmetric and so the spin state must be option F (see FT Section 13-4). For overall antisymmetry, the spatial part must be anti-symmetric and only option C satisfies this and is also normalized.

Q54 $\boxed{\text{G}}$ The degeneracy of a hydrogen energy level is $2n^2$. Hence the degeneracy of the $n = 1$ state is 2, the degeneracy of the $n = 4$ state is 32 and so the total degeneracy is $2 \times 32 = 64$. The Pauli principle here makes no restrictions upon state occupancy.

Q55 $\boxed{\text{D}}$ Compare FT Eq. 13-12 with FT Section 1-10.

Q56 $\boxed{\text{A}}$ The spin-orbit term gives zero for a state with $l = 0$.

Q57 $\boxed{\text{H}}$ Use Eq. 25 of Unit 16 with $n = 2, l = 0$ and the second equation in the hint.

Q58 $\boxed{\text{C}}$ Use the equation on page 13 of Unit 16, together with $n = 2$ and the first equation in the hint.

Q59 $\boxed{\text{E}}$ Use Unit 16, Eq. 25 with $n = 2, l = 1$ and the second expression in the hint.

Q60 $\boxed{\text{A}}$ The Darwin term is zero for all but $l = 0$ states.

Q61 $\boxed{\text{B,D}}$ A is false since the total energy of the ion includes the interaction energy of the protons which varies with R. C is false since there may be alternative forms of ψ_1 and ψ_2 giving lower energy. E is false, combining the falsities of A and C. F is false, combining the falsities of A and C, as well as ignoring the dependence of the total energy on R.

Q62 $\boxed{\text{G}}$ We first dissociate the ion into a hydrogen atom and a free proton (2.79 eV) and then ionize the hydrogen atom into a proton and an electron (13.61 eV). So the necessary energy is $2.79 + 13.61$ eV $= 16.40$ eV.

Q63 $\boxed{\text{E}}$ We first dissociate the ion into a hydrogen atom and a free proton, which requires 2.79 eV. We now excite the hydrogen atom to its first excited state which requires $13.61(1 - \frac{1}{4}) = 10.21$ eV. So the total necessary energy is 13.00 eV.

Q64 $\boxed{\text{A}}$ The value is given in Section 3.2 of Unit 16, part B.

Q65 $\boxed{\text{G}}$ If it takes 31.7 eV to completely dissociate H_2, then 2×13.6 eV less is required to obtain two H atoms in their ground states. So the required energy is $(31.7 - 2 \times 13.6)$ eV $= 4.5$ eV.