1. **SSM** ***REASONING AND SOLUTION*** Combining Equations 19.1 and 19.3, we have

$$W_{AB} = \text{EPE}_A - \text{EPE}_B = q_0(V_A - V_B) = (+1.6\times10^{-19}\,\text{C})(0.070\,\text{V}) = \boxed{1.1\times10^{-20}\,\text{J}}$$

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2. ***REASONING*** When the electron moves from the ground to the cloud, the change in its electric potential energy is $\Delta(\text{EPE}) = \text{EPE}_{\text{cloud}} - \text{EPE}_{\text{ground}}$. (Remember that the change in any quantity is its final value minus its initial value.) The change in the electric potential energy is related to the change ΔV in the potential by $\Delta(\text{EPE}) = q_0 \Delta V$ (Equation 19.4), where q_0 is the charge on the electron. This relation will allow us to find the change in the electron's potential energy.

SOLUTION The difference in the electric potentials between the cloud and the ground is $\Delta V = V_{\text{cloud}} - V_{\text{ground}} = 1.3 \times 10^8$ V, and the charge on an electron is $q_0 = -1.60 \times 10^{-19}$ C. Thus, the change in the electron's electric potential energy when the electron moves from the ground to the cloud is

$$\Delta(\text{EPE}) = q_0\,\Delta V = \left(-1.60\times10^{-19}\text{ C}\right)\left(1.3\times10^{8}\text{ V}\right) = \boxed{-2.1\times10^{-11}\text{ J}}$$

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3. ***REASONING AND SOLUTION*** The only force that acts on the α-particle is the conservative electric force. Therefore, the total energy of the α-particle is conserved as it moves from point *A* to point *B*:

$$\underbrace{\tfrac{1}{2}mv_A^2 + \text{EPE}_A}_{\substack{\text{Total energy at}\\ \text{point } A}} = \underbrace{\tfrac{1}{2}mv_B^2 + \text{EPE}_B}_{\substack{\text{Total energy at}\\ \text{point } B}}$$

Since the α-particle starts from rest, $v_A = 0$ m/s. The electric potential V is related to the electric potential energy EPE by $V = \text{EPE}/q$ (see Equation 19.3). With these changes, the equation above gives the kinetic energy of the α-particle at point *B* to be

$$\tfrac{1}{2}mv_B^2 = \text{EPE}_A - \text{EPE}_B = q\left(V_A - V_B\right)$$

Since an α-particle contains two protons, its charge is $q = 2e = 3.2 \times 10^{-19}$ C. Thus, the kinetic energy (in electron-volts) is

$$\tfrac{1}{2}mv_B^2 = q\left(V_A - V_B\right) = \left(3.2\times10^{-19}\text{ C}\right)\left[+250\text{ V} - \left(-150\text{ V}\right)\right]$$

$$= 1.28\times10^{-16}\text{ J}\left(\frac{1.0\text{ eV}}{1.6\times10^{-19}\text{ J}}\right) = \boxed{8.0\times10^{2}\text{ eV}}$$

5. ***REASONING*** The energy to accelerate the car comes from the energy stored in the battery pack. Work is done by the electric force as the charge moves from point *A* (the positive terminal), through the electric motor, to point *B* (the negative terminal). The work W_{AB} done by the electric force is given by Equation 19.4 as the product of the charge and the potential difference $V_A - V_B$, or $W_{\text{AB}} = q_0(V_A - V_B)$. The power supplied by the battery pack is the work divided by the time, as expressed by Equation 6.10a.

SOLUTION According to Equation 6.10a, the power *P* supplied by the battery pack is

$$P = \frac{W_{AB}}{t} = \frac{q_0\left(V_A - V_B\right)}{t} = \frac{(1200\text{ C})(290\text{ V})}{7.0\text{ s}} = 5.0\times10^4\text{ W}$$

Since 745.7 W = 1 hp (see the page facing the inside of the front cover of the text), the power rating, in horsepower, is

$$\left(5.0\times10^4\text{ W}\right)\left(\frac{1\text{ hp}}{745.7\text{ W}}\right) = \boxed{67\text{ hp}}$$

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6. ***REASONING*** The translational speed of the particle is related to the particle's translational kinetic energy, which forms one part of the total mechanical energy that the particle has. The total mechanical energy is conserved, because only the gravitational force and an electrostatic force, both of which are conservative forces, act on the particle (see Section 6.5). Thus, we will determine the speed at point A by utilizing the principle of conservation of mechanical energy.

SOLUTION The particle's total mechanical energy E is

$$E = \underbrace{\tfrac{1}{2}mv^2}_{\substack{\text{Translational}\\\text{kinetic}\\\text{energy}}} + \underbrace{\tfrac{1}{2}I\omega^2}_{\substack{\text{Rotational}\\\text{kinetic}\\\text{energy}}} + \underbrace{mgh}_{\substack{\text{Gravitational}\\\text{potential}\\\text{energy}}} + \underbrace{\tfrac{1}{2}kx^2}_{\substack{\text{Elastic}\\\text{potential}\\\text{energy}}} + \underbrace{\text{EPE}}_{\substack{\text{Electric}\\\text{potential}\\\text{energy}}}$$

Since the particle does not rotate, the angular speed ω is always zero and since there is no elastic force, we may omit the terms $\tfrac{1}{2}I\omega^2$ and $\tfrac{1}{2}kx^2$ from this expression. With this in mind, we express the fact that $E_B = E_A$ (energy is conserved) as follows:

$$\tfrac{1}{2}mv_B^2 + mgh_B + \text{EPE}_B = \tfrac{1}{2}mv_A^2 + mgh_A + \text{EPE}_A$$

This equation can be simplified further, since the particle travels horizontally, so that $h_B = h_A$, with the result that

$$\tfrac{1}{2}mv_B^2 + \text{EPE}_B = \tfrac{1}{2}mv_A^2 + \text{EPE}_A$$

Solving for v_A gives

$$v_A = \sqrt{v_B^2 + \frac{2\left(\text{EPE}_B - \text{EPE}_A\right)}{m}}$$

According to Equation 19.4, the difference in electric potential energies $\text{EPE}_B - \text{EPE}_A$ is related to the electric potential difference $_{VB} - {}_{VA}$:

$$\text{EPE}_B - \text{EPE}_A = q_0\left(V_B - V_A\right)$$

Substituting this expression into the expression for v_A gives

$$v_A = \sqrt{v_B^2 + \frac{2q_0\left(V_B - V_A\right)}{m}} = \sqrt{(0\text{ m/s})^2 + \frac{2\left(-2.0\times10^{-5}\text{ C}\right)\left(-36\text{ V}\right)}{4.0\times10^{-6}\text{ kg}}} = \boxed{19\text{ m/s}}$$