Prb. #	ANSWERS
1	The potential difference is $$\Delta V = V_f - V_i = -5.00\text{ V} - 9.00\text{ V} = -14.0\text{ V}$$ and the total charge to be moved is $$Q = -N_A e = -(6.02\times10^{23})(1.60\times10^{-19}\text{ C}) = -9.63\times10^{4}\text{ C}$$ Now, from $\Delta V = \frac{W}{Q}$, we obtain $$W = Q\Delta V = (-9.63\times10^{4}\text{ C})(-14.0\text{ J/C}) = \boxed{1.35\text{ MJ}}$$ Note: Values of V_i and V_f may vary
2	Arbitrarily take $V = 0$ at point P. Then the potential at the original position of the charge is (by Equation 25.3) $$\Delta V = V - 0 = V = -\vec{E}\cdot\vec{s} = -EL\cos\theta \quad \text{(relative to } P\text{)}$$ At the final point a, $$V = -EL \quad \text{(relative to } P\text{)}$$ Because the table is frictionless and the particle-field system is isolated, we have $$(K+U)_i = (K+U)_f$$ or $$0 - qEL\cos\theta = \frac{1}{2}mv^2 - qEL$$ solving for the speed gives $$v = \sqrt{\frac{2qEL(1-\cos\theta)}{m}} = \sqrt{\frac{2(2.00\times10^{-6}\text{ C})(300\text{ N/C})(1.50\text{ m})(1-\cos60.0^\circ)}{0.0100\text{ kg}}} = \boxed{0.300\text{ m/s}}$$ Note: Given values of q & E may vary
3	(a) At a distance of 0.250 cm from an electron, the electric potential is $$V = k_e\frac{q}{r} = (8.99\times10^{9}\text{ N}\cdot\text{m}^2/\text{C}^2)\left(\frac{-1.60\times10^{-19}\text{ C}}{0.250\times10^{-2}\text{ m}}\right) = \boxed{-5.76\times10^{-7}\text{ V}}$$ (b) The difference in potential between the two points is given by $$\lvert\Delta V\rvert = \left\lvert k_e\frac{q}{r_2} - k_e\frac{q}{r_1}\right\rvert = k_e q\left(\frac{1}{r_2}-\frac{1}{r_1}\right)$$ Substituting numerical values, $$\lvert\Delta V\rvert = \left\lvert(8.99\times10^{9}\text{ N}\cdot\text{m}^2/\text{C}^2)(-1.60\times10^{-19}\text{ C})\times\left(\frac{1}{0.250\times10^{-2}\text{ m}} - \frac{1}{0.750\times10^{-2}\text{ m}}\right)\right\rvert$$ $$\lvert\Delta V\rvert = \boxed{3.84\times10^{-7}\text{ V}}$$ (c) The potential difference here can be solved the same way as in (b), where the only difference is the given value of r_1. (d) Because the charge of the proton has the same magnitude as that of the electron, only the sign of the answer to part (a) would change. Note: The value of q and the distances given may vary.

4	The total change in potential energy is the sum of the change in potential energy of the $q_1 - q_4$, $q_2 - q_4$, and $q_3 - q_4$ particle systems: $$U_e = q_4V_1 + q_4V_2 + q_4V_3 = q_4k_e\left(\frac{q_1}{r_1} + \frac{q_2}{r_2} + \frac{q_3}{r_3}\right)$$ $$U_e = (10.0\times10^{-6}\ \text{C})^2(8.99\times10^9\ \text{N}\cdot\text{m}^2/\text{C}^2) \times\left(\frac{1}{0.600\ \text{m}} + \frac{1}{0.150\ \text{m}} + \frac{1}{\sqrt{(0.600\ \text{m})^2 + (0.150\ \text{m})^2}}\right)$$ $$U_e = \boxed{8.95\ \text{J}}$$	Note: values of q, L, and W may vary.
5	Substituting given values into $V = \frac{k_eQ}{r}$, with $Q = Nq$: $$7.50\times10^3\ \text{V} = \frac{(8.99\times10^9\ \text{N}\cdot\text{m}^2/\text{C}^2)Q}{0.300\ \text{m}}$$ Substituting $Q = 2.50\text{x}10^{-7}$ and $q = 1.60\text{x}10^{-19}$ $$N = \frac{2.50\times10^{-7}\ \text{C}}{1.60\times10^{-19}\ \text{C}/e^-} = \boxed{1.56\times10^{12}\ \text{electrons}}$$	Note: given values of R and V may vary, which would affect the value of Q
6	For points on the surface and outside, the sphere of charge behaves like a charged particle at its center, both for creating field and potential. (a) Inside a conductor when charges are not moving, the electric field is zero and the potential is uniform, the same as on the surface, and $E = \boxed{0}$. $$V = \frac{k_eq}{R} = \frac{(8.99\times10^9\ \text{N}\cdot\text{m}^2/\text{C}^2)(26.0\times10^{-6}\ \text{C})}{0.140\ \text{m}} = \boxed{1.67\ \text{MV}}$$ (b) $$E = \frac{k_eq}{r^2} = \frac{(8.99\times10^9\ \text{N}\cdot\text{m}^2/\text{C}^2)(26.0\times10^{-6}\ \text{C})}{(0.200\ \text{m})^2} = \boxed{5.84\ \text{MN/C}}\ \text{away}$$ $$V = \frac{k_eq}{R} = \frac{(8.99\times10^9\ \text{N}\cdot\text{m}^2/\text{C}^2)(26.0\times10^{-6}\ \text{C})}{0.200\ \text{m}} = \boxed{1.17\ \text{MV}}$$	(c) $$E = \frac{k_eq}{R^2} = \frac{(8.99\times10^9\ \text{N}\cdot\text{m}^2/\text{C}^2)(26.0\times10^{-6}\ \text{C})}{(0.140\ \text{m})^2} = \boxed{11.9\ \text{MN/C}}\ \text{away}$$ $$V = \frac{k_eq}{R} = \boxed{1.67\ \text{MV}}$$ Note: For (a) and (b), the given r's may vary.
7	$$\oint E\,dA = E(2\pi rl) = \frac{q_{in}}{\epsilon_0} \quad E = \frac{q_{in}/l}{2\pi\epsilon_0 r} = \frac{\lambda}{2\pi\epsilon_0 r}$$ for the field outside the metal rod. (a) At $r = 3.00$ cm, $\vec{E} = \boxed{0}$ (b) At $r = 10.0$ cm, $$\vec{E} = \frac{30.0\times10^{-9}\ \text{C}}{2\pi(8.85\times10^{-12}\ \text{C}^2/\text{N}\cdot\text{m}^2)(0.100\ \text{m})} = \boxed{5\,400\ \text{N/C, outward}}$$ (c) At $r = 100$ cm, $$\vec{E} = \frac{30.0\times10^{-9}\ \text{C}}{2\pi(8.85\times10^{-12}\ \text{C}^2/\text{N}\cdot\text{m}^2)(1.00\ \text{m})} = \boxed{540\ \text{N/C, outward}}$$	Note: given radii and charge density may vary.

8	(a) At the center of the sphere, the total charge is zero, so $E = \frac{k_e Q r}{a^3} = \boxed{0}$ (b) At a distance of 10.0 cm = 0.100 m from the center, $E = \frac{k_e Q r}{a^3} = \frac{(8.99 \times 10^9\ \text{N}\cdot\text{m}^2/\text{C})(26.0 \times 10^{-6}\ \text{C})(0.100\ \text{m})}{(0.400\ \text{m})^3} = \boxed{365\ \text{kN/C}}$ (c) At a distance of 40.0 cm = 0.400 m from the center, all of the charge is enclosed, so $E = \frac{k_e Q}{r^2} = \frac{(8.99 \times 10^9\ \text{N}\cdot\text{m}^2/\text{C})(26.0 \times 10^{-6}\ \text{C})}{(0.400\ \text{m})^2} = \boxed{1.46\ \text{MN/C}}$ (d) At a distance of 60.0 cm = 0.600 m from the center, $E = \frac{k_e Q}{r^2} = \frac{(8.99 \times 10^9\ \text{N}\cdot\text{m}^2/\text{C})(26.0 \times 10^{-6}\ \text{C})}{(0.600\ \text{m})^2} = \boxed{649\ \text{kN/C}}$ The direction for each electric field is $\boxed{\text{radially outward}}$. Note: charge values may vary.
9	(a) Inside surface: consider a cylindrical gaussian surface of arbitrary length ℓ within the metal. Since E inside the conducting shell is zero, the total charge inside the gaussian surface must be zero: $\oint \vec{\mathbf{E}} \cdot d\vec{\mathbf{A}} = \frac{q_{\text{in}}}{\epsilon_0} \rightarrow 0 = \frac{(\lambda + \lambda_{\text{inner}})\ell}{\epsilon_0}$ so $\lambda_{\text{inner}} = \boxed{-\lambda}$. (b) Outside surface: consider a cylindrical gaussian surface of arbitrary length ℓ outside the metal. The total charge within the gaussian surface is $q_{\text{wire}} + q_{\text{cylinder}} = q_{\text{wire}} + (q_{\text{inner surface}} + q_{\text{outer surface}})$ $\lambda\ell + 2\lambda\ell = \lambda\ell + (-\lambda\ell + \lambda_{\text{outer}}\ell) \rightarrow \lambda_{\text{outer}} = \boxed{3\lambda}$ (c) Gauss's law: $\oint \vec{\mathbf{E}} \cdot d\vec{\mathbf{A}} = \frac{q_{\text{in}}}{\epsilon_0}$ $E 2\pi r \ell = \frac{3\lambda\ell}{\epsilon_0} \rightarrow E = 2\frac{3\lambda}{4\pi \epsilon_0 r} = \boxed{6k_e \frac{\lambda}{r}, \text{ radially outward}}$