P25.3 (a) Energy of the proton-field system is conserved as the proton moves from high to low potential, which can be defined for this problem as moving from 120 V down to 0 V.

$$K_i + U_i + \Delta E_{\text{mech}} = K_f + U_f \qquad 0 + qV + 0 = \frac{1}{2}mv_p^2 + 0$$

$$\left(1.60\times10^{-19}\text{ C}\right)\left(120\text{ V}\right)\left(\frac{1\text{ J}}{1\text{ V}\cdot\text{C}}\right) = \frac{1}{2}\left(1.67\times10^{-27}\text{ kg}\right)v_p^2$$

$$v_p = \boxed{1.52\times10^5\text{ m/s}}$$

(b) The electron will gain speed in moving the other way,

from $V_i = 0$ to $V_f = 120$ V: $\quad K_i + U_i + \Delta E_{\text{mech}} = K_f + U_f$

$$0 + 0 + 0 = \frac{1}{2}mv_e^2 + qV$$

$$0 = \frac{1}{2}\left(9.11\times10^{-31}\text{ kg}\right)v_e^2 + \left(-1.60\times10^{-19}\text{ C}\right)\left(120\text{ J/C}\right)$$

$$v_e = \boxed{6.49\times10^6\text{ m/s}}$$

P25.6 $$E = \frac{|\Delta V|}{d} = \frac{25.0\times10^3\text{ J/C}}{1.50\times10^{-2}\text{ m}} = 1.67\times10^6\text{ N/C} = \boxed{1.67\text{ MN/C}}$$

P25.18 (a) $E_x = \frac{k_e q_1}{x^2} + \frac{k_e q_2}{(x-2.00)^2} = 0$ becomes $E_x = k_e\left(\frac{+q}{x^2} + \frac{-2q}{(x-2.00)^2}\right) = 0$.

Dividing by k_e, $\quad 2qx^2 = q(x-2.00)^2 \quad x^2 + 4.00x - 4.00 = 0$.

Therefore $E = 0$ when $x = \frac{-4.00 \pm \sqrt{16.0+16.0}}{2} = \boxed{-4.83\text{ m}}$.

(Note that the positive root does not correspond to a physically valid situation.)

(b) $V = \frac{k_e q_1}{x} + \frac{k_e q_2}{2.00-x} = 0$ or $V = k_e\left(\frac{+q}{x} - \frac{2q}{2.00-x}\right) = 0$.

Again solving for x, $\quad 2qx = q(2.00-x)$.

For $0 \le x \le 2.00$ $V = 0$ when $x = \boxed{0.667\text{ m}}$

and $\frac{q}{|x|} = \frac{-2q}{|2-x|}$. For $x < 0$ $x = \boxed{-2.00\text{ m}}$.

P25.22 (a) $V = \frac{k_e q_1}{r_1} + \frac{k_e q_2}{r_2} = 2\left(\frac{k_e q}{r}\right)$

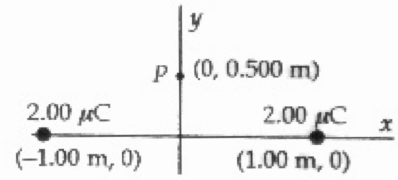

FIG. P25.22

$$V = 2\left(\frac{(8.99\times10^9\ \text{N}\cdot\text{m}^2/\text{C}^2)(2.00\times10^{-6}\ \text{C})}{\sqrt{(1.00\ \text{m})^2+(0.500\ \text{m})^2}}\right)$$

$$V = 3.22\times10^4\ \text{V} = \boxed{32.2\ \text{kV}}$$

P25.37 $V = a + bx = 10.0\ \text{V} + (-7.00\ \text{V/m})x$

(a) At $x = 0$, $V = \boxed{10.0\ \text{V}}$

At $x = 3.00$ m, $V = \boxed{-11.0\ \text{V}}$

At $x = 6.00$ m, $V = \boxed{-32.0\ \text{V}}$

(b) $E = -\frac{dV}{dx} = -b = -(-7.00\ \text{V/m}) = \boxed{7.00\ \text{N/C in the } +x \text{ direction}}$

P25.38 (a) For $r < R$ $V = \frac{k_e Q}{R}$

$$E_r = -\frac{dV}{dr} = \boxed{0}$$

(b) For $r \ge R$ $V = \frac{k_e Q}{r}$

$$E_r = -\frac{dV}{dr} = -\left(-\frac{k_e Q}{r^2}\right) = \boxed{\frac{k_e Q}{r^2}}$$

P25.45 $V = \int dV = \frac{1}{4\pi \epsilon_0}\int \frac{dq}{r}$

All bits of charge are at the same distance from O.

So $V = \frac{1}{4\pi\epsilon_0}\left(\frac{Q}{R}\right) = (8.99\times10^9\ \text{N}\cdot\text{m}^2/\text{C}^2)\left(\frac{-7.50\times10^{-6}\ \text{C}}{0.140\ \text{m}/\pi}\right) = \boxed{-1.51\ \text{MV}}$.

P25.48 Substituting given values into $V = \frac{k_e q}{r}$

$$7.50\times10^3\ \text{V} = \frac{(8.99\times10^9\ \text{N}\cdot\text{m}^2/\text{C}^2)q}{0.300\ \text{m}}.$$

Substituting $q = 2.50\times10^{-7}$ C,

$$N = \frac{2.50\times10^{-7}\ \text{C}}{1.60\times10^{-19}\ \text{C}/e^-} = \boxed{1.56\times10^{12}\ \text{electrons}}.$$