Homework # 6 Chapter 20

P20.5 $\Delta U = -\frac{1}{2}m\left(v_f^2 - v_i^2\right) = -\frac{1}{2}\left(9.11\times10^{-31}\text{ kg}\right)\left[\left(1.40\times10^5\text{ m/s}\right)^2 - \left(3.70\times10^6\text{ m/s}\right)^2\right] = 6.23\times10^{-18}\text{ J}$

$\Delta U = q\Delta V$: $\quad +6.23\times10^{-18} = \left(-1.60\times10^{-19}\right)\Delta V$

$\Delta V = \boxed{-38.9\text{ V. The origin is at highest potential.}}$

P20.9 (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 $x < 0$ $\quad x = \boxed{-2.00\text{ m}}$.

P20.11 $V = \sum_i k\frac{q_i}{r_i}$

$V = \left(8.99\times10^9\right)\left(7.00\times10^{-6}\right)\left[\frac{-1}{0.010\,0} - \frac{1}{0.010\,0} + \frac{1}{0.038\,7}\right]$

$V = \boxed{-1.10\times10^7\text{ V} = -11.0\text{ MV}}$

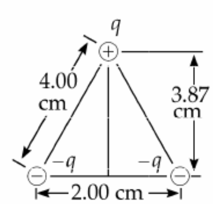

FIG. P20.11

P20.20 Using conservation of energy for the alpha particle-nucleus system,

we have $K_f + U_f = K_i + U_i$.

But $U_i = \dfrac{k_e q_\alpha q_{\text{gold}}}{r_i}$

and $r_i \approx \infty$.

Thus, $U_i = 0$.

Also $K_f = 0$ ($v_f = 0$ at turning point),

so $U_f = K_i$

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or $$\frac{k_e q_\alpha q_{\text{gold}}}{r_{\min}} = \frac{1}{2} m_\alpha v_\alpha^2$$

$$r_{\min} = \frac{2k_e q_\alpha q_{\text{gold}}}{m_\alpha v_\alpha^2} = \frac{2\left(8.99\times10^9 \text{ N}\cdot\text{m}^2/\text{C}^2\right)(2)(79)\left(1.60\times10^{-19} \text{ C}\right)^2}{\left(6.64\times10^{-27} \text{ kg}\right)\left(2.00\times10^7 \text{ m/s}\right)^2} = 2.74\times10^{-14} \text{ m} = \boxed{27.4 \text{ fm}}.$$

P20.21 $V = a + bx = 10.0 \text{ V} + (-7.00 \text{ V/m})x$

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

P20.23 $V = 5x - 3x^2y + 2yz^2$

Evaluate $\vec{E}$ at $(1, 0, -2)$

$$E_x = -\frac{\partial V}{\partial x} = \boxed{-5 + 6xy} = -5 + 6(1)(0) = -5$$
$$E_y = -\frac{\partial V}{\partial y} = \boxed{+3x^2 - 2z^2} = 3(1)^2 - 2(-2)^2 = -5$$
$$E_z = -\frac{\partial V}{\partial z} = \boxed{-4yz} = -4(0)(-2) = 0$$
$$E = \sqrt{E_x^2 + E_y^2 + E_z^2} = \sqrt{(-5)^2 + (-5)^2 + 0^2} = \boxed{7.07 \text{ N/C}}$$

P20.10 $U_e = q_4V_1 + q_4V_2 + q_4V_3 = q_4\left(\frac{1}{4\pi\epsilon_0}\right)\left(\frac{q_1}{r_1} + \frac{q_2}{r_2} + \frac{q_3}{r_3}\right)$

$$U_e = \left(10.0\times10^{-6}\text{ C}\right)^2\left(8.99\times10^9\text{ N}\cdot\text{m}^2/\text{C}^2\right)\left(\frac{1}{0.600\text{ m}} + \frac{1}{0.150\text{ m}} + \frac{1}{\sqrt{(0.600\text{ m})^2 + (0.150\text{ m})^2}}\right)$$

$$U_e = \boxed{8.95\text{ J}}$$

P20.13 $U = U_1 + U_2 + U_3 + U_4$

$$U = 0 + U_{12} + (U_{13} + U_{23}) + (U_{14} + U_{24} + U_{34})$$

$$U = 0 + \frac{k_eQ^2}{s} + \frac{k_eQ^2}{s}\left(\frac{1}{\sqrt{2}} + 1\right) + \frac{k_eQ^2}{s}\left(1 + \frac{1}{\sqrt{2}} + 1\right)$$

$$U = \frac{k_eQ^2}{s}\left(4 + \frac{2}{\sqrt{2}}\right) = \boxed{5.41\frac{k_eQ^2}{s}}$$

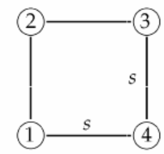

FIG. P20.13