PHY 2049 — Solutions

Test I – 26 Sept. 2016 V. I —

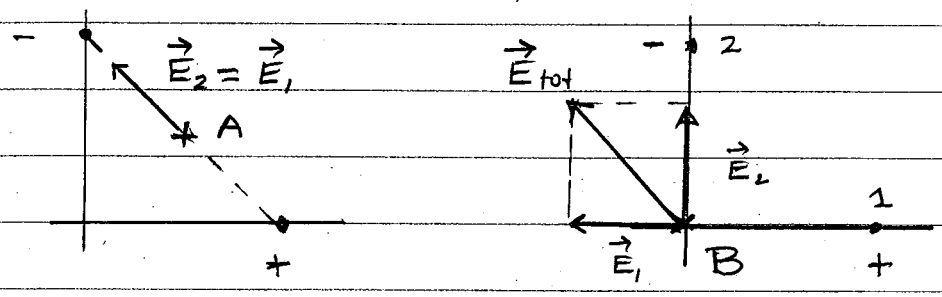
(1) (a) Strength of $E \rightarrow E = kq_1/r^2$, $q_1 = q = 3.00\times10^{-6}$ C

4/ pt. A $\rightarrow r = a/\sqrt{2} = 1.41$ m $\Rightarrow$ $\boxed{E_1 = 1.35\times10^{4}\ V/m}$

pt B $\rightarrow r = a = 2.0$ m $\Rightarrow$ $\boxed{E_1 = 6.74\times10^{3}\ V/m}$

(b)

4/



pt A pt B

6/ (c) $\boxed{E = 2E_1 = 2.70\times10^{4}\ V/m}$ $\rightarrow$ 45° up to the left

6/ (d) $\boxed{E = \sqrt{2}E_1 = 9.54\times10^{3}\ \frac{V}{m}}$ $\rightarrow$ 45° up to the left

(2) (a) $A = 0.120\ m^2$, $d = 1.50\times10^{-3}$ m

3/ parallel plate cap. $\rightarrow$ $\boxed{C = \varepsilon_0 A/d = 7.08\times10^{-10}\ F}$

(b) $q = 2.00\times10^{-7}$ C $= CV \Rightarrow V = q/C = 282$ V

5/ $\rightarrow$ $\boxed{E = V/d = 1.88\times10^{5}\ V/m}$ direction up

Alternatively, $E = \sigma/\varepsilon_0 = q/\varepsilon_0 A \rightarrow$ same result

3/ (c) $\boxed{U = q^2/2C = 2.82\times10^{-5}\ J}$

Alternatively, $U = \frac{1}{2}CV^2 = \frac{1}{2}qV \rightarrow$ same result

4/ (d) Battery disconnected $\rightarrow$ charge does not change

$\kappa = 2.80 \rightarrow E' = E/\kappa \rightarrow$ $\boxed{V' = V/\kappa = 101\ V}$

(e) New energy $\rightarrow U' = \frac{1}{2}qV' = U/\kappa$

5/ Work $\rightarrow W = U' - U = (1/\kappa - 1)U \rightarrow$ $\boxed{W = -1.82\times10^{-5}\ J}$

$W < 0 \Rightarrow$ work done by slab

(3) (a) $q_p = e = 1.602\times10^{-19}\,C$, $q_u = 92e = 1.474\times10^{-17}\,C$.

6/ No kinetic energy at pt. of closest approach
$\Rightarrow$ energy $= U = kq_p q_u / r_c$ with $r_c = 3.0\times10^{-15}\,m$
$\rightarrow$ $\boxed{U = 7.08\times10^{-12}\,J}$

$1\,J = 1.602\times10^{-19}\,J \Rightarrow \boxed{U = 44.2\,MeV}$

4/ (b) When $r = 3r_c$, $\boxed{U' = \frac{1}{3}U = 2.36\times10^{-12}\,J}$

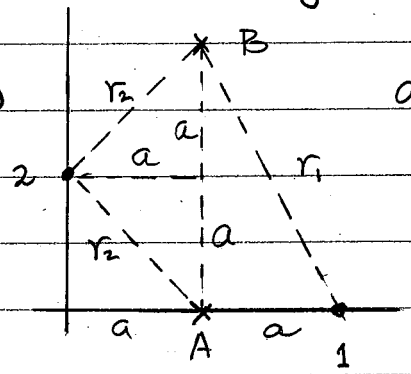
(c) Energy conservation $\Rightarrow K + U' = U \Rightarrow K = U - U' = \frac{2}{3}U$

5/ Now $K = \frac{1}{2}m_p v^2 \Rightarrow \boxed{v = \sqrt{2K/m_p} = 7.52\times10^{7}\,m/s}$

(d) For $r >> r_c$, $U \cong 0 \Rightarrow$ energy $= K_\infty = 7.08\times10^{-12}\,J$

5/ (since energy conserved) $\Rightarrow \boxed{v_\infty = \sqrt{2K_\infty/m_p} = 9.21\times10^{7}\,m/s}$

(4) (a)



4/ $a = 5.0\,m \rightarrow r_1 = \sqrt{a^2 + (2a)^2} = \sqrt{5}\,a$

$\rightarrow \boxed{r_1 = 11.18\,m}$

$\boxed{r_2 = \sqrt{2}\,a = 7.07\,m}$

(b) At point A, $V_A = V_1 + V_2 = kq_1/a + kq_2/\sqrt{2}a$

6/ $q_2 = 2.5\times10^{-6}\,C$, $q_1 = 2q_2 \Rightarrow \boxed{V_A = kq_2/a\,(2 + 1/\sqrt{2}) = 12.2\,kV}$

(c) At point B, $V_B = V_1 + V_2 = kq_1/r_1 + kq_2/r_2$

5/ $\rightarrow \boxed{V_B = 7.20\,kV}$

(d) $q_T = -4.0\times10^{-9}\,C \Rightarrow W = q_T(\Delta V) = q_T(V_B - V_A)$

5/ $\rightarrow \boxed{W = 1.99\times10^{-5}\,J}$ $W > 0 \Rightarrow$ work on charge.