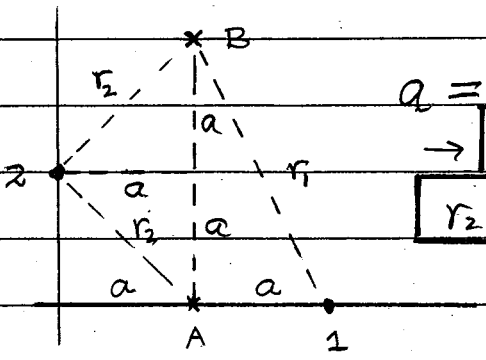
PHY 2049 — Solutions
Test I – 26 Sept. 2016 — V. II

(1) (a) 4/



$q = 4.0\ m \rightarrow r_1 = \sqrt{a^2 + (2a)^2} = \sqrt{5}\,a$

$\rightarrow \boxed{r_1 = 8.94\ m}$

$\boxed{r_2 = \sqrt{2}\,a = 5.66\ m}$

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

$q_1 = 5.0\times10^{-6}\ C$, $q_2 = 2q_1 \Rightarrow \boxed{V_A = kq_1/a\,(1+\sqrt{2}) = 27.1\ kV}$

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

$\rightarrow \boxed{V_B = 20.9\ kV}$

5/ (d) $q_T = -2.0\times10^{-9}\ C \rightarrow W = q_T\,\Delta V = q_T(V_B - V_A)$

$\rightarrow \boxed{W = 1.24\times10^{-5}\ J}$ $W>0 \Rightarrow$ <u>work on charge</u>

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

6/ At point of closest approach, no kinetic energy

$\Rightarrow$ energy $= U = kq_p q_u/r_c$ with $r_c = 4.5\times10^{-15}\ m$

$\rightarrow \boxed{U = 4.72\times10^{-12}\ J}$

$1\ J = 1.602\times10^{-19}\ eV \Rightarrow \boxed{U = 29.4\ MeV}$

4/ (b) When $r = 2r_c$, $\boxed{U' = \tfrac{1}{2}U = 2.36\times10^{-12}\ J}$

5/ (c) Energy conservation $\Rightarrow K + U' = U \Rightarrow K = U - U' = U'$

Now $K = \tfrac{1}{2}m_p v^2 \Rightarrow \boxed{v = \sqrt{2K/m_p} = 5.31\times10^7\ m/s}$

5/ (d) For $r \gg r_c$, $U \cong 0 \Rightarrow$ energy $= K_\infty = 4.72\times10^{-12}\ J$

(since energy conserved.)

$\Rightarrow \boxed{v_\infty = \sqrt{2K_\infty/m_p} = 7.52\times10^7\ m/s}$

③ (a) $A = 0.140\ m^2$, $d = 1.20 \times 10^{-3}\ m$

3/ parallel plate capac → $\boxed{C = \varepsilon_0 A/d = 1.033 \times 10^{-9}\ F}$

(b) $q = 1.50 \times 10^{-7}\ C = CV \Rightarrow V = q/C = 145.2\ V$

5/ → $\boxed{E = V/d = 1.21 \times 10^5\ V/m}$ direction up

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

(c) $\boxed{U = q^2/2C = 1.089 \times 10^{-5}\ J}$

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

(d) Battery stays connected → V does not change → $\boxed{V' = 145\ V}$

4/ $K = 2.10 \rightarrow C' = KC \Rightarrow \boxed{q' = C'V = Kq = 3.15 \times 10^{-7}\ C}$

(e) New energy → $U' = \frac{1}{2} q'V = KU$

5/ Work = $\boxed{U' - U = (K-1)U = 1.20 \times 10^{-5}\ J}$

$W > 0 \Rightarrow$ work done on the slab

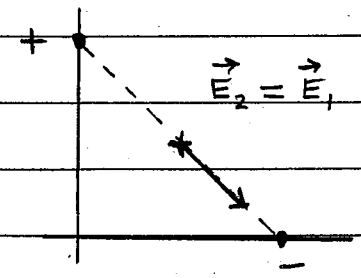
④ (a) strength of E → $E = kq/r^2$, $q_2 = q = 5.0 \times 10^{-6}\ C$

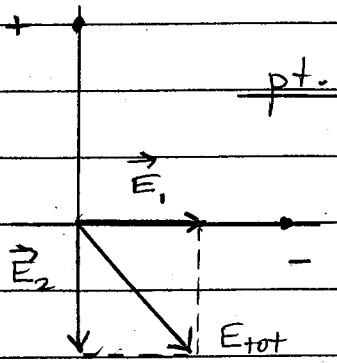
4/ pt. A → $r = a\sqrt{2} = 2.121\ m$ → $\boxed{E_2 = 9.99 \times 10^3\ V/m}$

pt. B → $r = a = 3.00\ m$ → $\boxed{E_2 = 4.99 \times 10^3\ V/m}$

(b)

4/





6/ (c) $\boxed{E = 2E_2 = 2.00 \times 10^4\ \frac{V}{m}}$ → 45° down to the right

(d) $\boxed{E = \sqrt{2} E_2 = 7.07 \times 10^3\ V/m}$ → 45° down to the right

6/