Chapter 23 Electric Potential

I] Assignments

Questions: 2-6, 8, 10, 13, 15, 17, 19

Problems: 1, 2, 3, 5, 6, 7, 9, 11, 12, 14, 16, 18, 19, 22, 24, 25, 27, 29, 30, 34, 38, 39, 43, 44, 45, 46, 48, 49, 51, 52, 55, 56, 59, 60, 62, 66, 69, 72, 73, 76, 83, 84.

II] Solutions to selected Problems

23-2) $q_p = 1.60\times10^{-19}C$. $V_0 = 185V$, $V = -55V$.

$W = -\Delta U = -q_p(V - V_0) = -1.60\times10^{-19}C(-55-185)V$

$= +384\times10^{-19}J = 3.84\times10^{-17}J$

$= 240\,eV$

23-7) Breakdown of air occurs at

$E_{bd} = 3\times10^6\frac{V}{m}$, & $E = k\frac{Q}{r^2}$

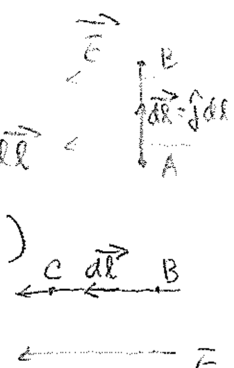
so $3.0\times10^6\frac{V}{m} = k\frac{Q}{(6.5\times10^{-2}m)^2}$

$\therefore Q = \dfrac{3.0\times10^6\frac{J}{C\cdot m}\times6.5^2\times10^{-4}m^2}{9.0\times10^9\frac{N\cdot m^2}{C^2}}$

$= \frac{3.0\times6.5^2}{9.0}\times10^{6-4-9}C = 141\times10^{-7}C$

$= 1.41\,\mu C$

23-11) $\vec{E} = -4.20\frac{N}{C}\hat{i}$



(a) $V_{BA} = V_B - V_A = -\int_A^B\vec{E}\cdot\vec{dl}$

$= 0 \quad (\because \vec{E}\perp\vec{dl})$

(b) $V_{CB} = V_C - V_B =$

$= -\int_B^C\vec{E}\cdot\vec{dl} \quad (\vec{E}\parallel\vec{dl})$

$= -\int_B^C E\,dl \overset{E=C}{=} -E\int_B^C dl = -E(-7.00m)$

$= -4.20\frac{V}{m}(+7.00m) = -29.4V$

(c) $V_{CA} = V_C - V_A = (V_C - V_B) - (V_B - V_A)$ ($V_B - V_A = 0$)

$= -29.4V$

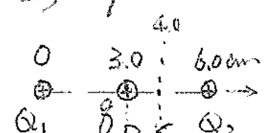
23-18) Across a membrane wall $t = 10^{-8}m$,

$V = 0.10V$

uniform electric field $\Rightarrow V = E\cdot t$

$\therefore E = \frac{V}{t} = \frac{0.10V}{10^{-8}m} = 10^7\frac{V}{m}$

23-27



$Q_1 = Q_2 = 25\mu C = Q$, $q = 0.18\mu C$

Move q from point P to point S

$V_P = k\frac{Q_1}{r_1} + k\frac{Q_2}{r_2}$

Since $r_1 = r_2 = 0.03m = 3.0\times10^{-2}m = r$

$\therefore V_P = 2k\frac{Q}{r} = 2\times9.0\times10^9\frac{N\cdot m^2}{C^2}\times\frac{2.5\times10^{-5}C}{3.0\times10^{-2}m}$

$= \frac{18\times2.5}{3.0}\times10^{9-5+2}V = 15\times10^6V = 1.5\times10^7V$

$V_S = k\frac{Q_1}{r_1'} + k\frac{Q_2}{r_2'}$ $\quad r_1' = 4.0\times10^{-2}m$, $r_2' = 2.0\times10^{-2}m$

$\therefore V_S = kQ\left[\frac{1}{4.0\times10^{-2}m} + \frac{1}{2.0\times10^{-2}m}\right]$

$= 9.0\times10^9\frac{N\cdot m^2}{C^2}\times2.5\times10^{-5}C\left[25+50\right]\frac{1}{m}$

$= 9.0\times2.5\times75\times10^{9-5}\frac{N\cdot m}{C}$

$= 1688\times10^4V = 1.688\times10^7V$

$\therefore W_{ext} = \Delta U_{P\to S} = q\Delta V_{P\to S} = q(V_S - V_P)$

$= 1.8\times10^{-7}C\times(1.688-1.50)\times10^7V$

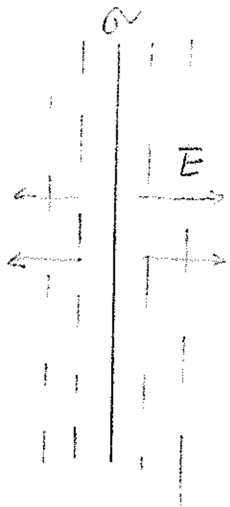
$= 1.8\times0.188\,J = 0.338\,J$

23-43) Plane Symmetry and $\sigma = 0.75\ \mu C/m^2$

$E = \frac{\sigma}{2\epsilon_0} = \frac{7.5\times10^{-7} C/m^2}{2\times8.85\times10^{-12} \frac{C^2}{N m^2}}$

$= \frac{75}{2\times8.85}\times10^{-8+12}\ \frac{N}{C}$

$= 4.24\times10^{4}\ \frac{V}{m}$



$\Delta V = 100V = E\cdot d$

$\therefore\ d = \frac{\Delta V}{E} = \frac{100V}{4.24\times10^{4} V/m}$

$= 2.36\times10^{-3} m = 2.36\ mm$

Equipotential surfaces will be surfaces // to the charged metal plate and with a separation of 2.36 mm between any two adjacent surfaces

23-45). $p = 4.8\times10^{-30}$ C.m, $r = 4.1\times10^{-9}$ m

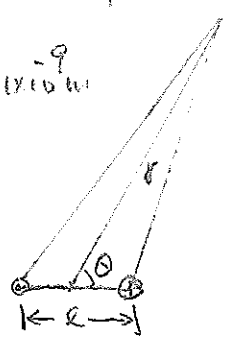
$V = k\frac{p\cos\theta}{r^2}$

(a) $\theta = 0°$

$\therefore\ V = k\frac{p\cos0°}{r^2}$

$= 9.0\times10^{9}\frac{N\cdot m^2}{C^2}\ \frac{4.8\times10^{-30} C m}{(4.1\times10^{-9} m)^2}$

$= \frac{9.0\times4.8}{4.1^2}\times10^{9-30+18}\ V = 2.57\times10^{-3} V$



(b) $\theta = 45°$ 0.707

$V = k\frac{p\cos45°}{r^2}$

$= \frac{9.0\times4.8}{4.1^2}\times10^{-3}\times0.707\ V = 1.82\times10^{-3} V$

(c) $\theta = 180° - 45° = 135°$

$V = k\frac{p\cos(135°)}{r^2}$ $\leftarrow (-0.707)$

$= -1.82\times10^{-3} V$

23-51). $V = y^2 + 2.5xy - 3.5xyz$

$E_x = -\frac{\partial V}{\partial x} = -\left[0 + 2.5y - 3.5yz\right]$

$E_y = -\frac{\partial V}{\partial y} = -\left[2y + 2.5x - 3.5xz\right]$

$E_z = -\frac{\partial V}{\partial z} = -\left[0 + 0 - 3.5xy\right]$

$\therefore\ \vec{E} = \hat{i}E_x + \hat{j}E_y + \hat{k}E_z$

$= -\left[(2.5y - 3.5yz)\hat{i} + (2y + 2.5x - 3.5xz)\hat{j} + 3.5xy\hat{k}\right]$

23-56) $K = \frac{1}{2}mV^2$

(a) $m_e = 9.11\times10^{-31}$ kg, $K = 1.5$ keV $= 2.4\times10^{-16}$ J

$\therefore\ 2.4\times10^{-16} J = \frac{1}{2}(9.11\times10^{-31} kg)V^2$

$\therefore\ V_e = \sqrt{\frac{2\times2.4\times10^{-16}}{9.11\times10^{-31}}}\ \frac{m}{s} = \sqrt{\frac{20\times2.4}{9.11}\times10^{14}}\ \frac{m}{s}$

$= 2.30\times10^{7}\ \frac{m}{s}$

(b) $m_p = 1.67\times10^{-27}$ kg $K = 1.5$ keV $= 2.4\times10^{-16}$ J

$\therefore\ V_p = \sqrt{\frac{2\times2.4\times10^{-16}}{1.67\times10^{-27}}} = \sqrt{\frac{20\times2.4}{1.67}\times10^{10}}\ \frac{m}{s}$

$= 5.36\times10^{5}\ \frac{m}{s}$