1) Let's calculate the fluxes through B, C, D.

$$\Phi_B = \frac{q_{enc}}{\epsilon_0} = \frac{1}{\epsilon_0} Q \left[\frac{\frac{4}{3}\pi (R/2)^3}{\frac{4}{3}\pi R^3}\right] = \frac{Q}{8\epsilon_0}$$

$$\Phi_C = \frac{Q}{8\epsilon_0} \text{ also} \qquad \Phi_D = \frac{Q/2}{\epsilon_0} = \frac{Q}{2\epsilon_0}$$

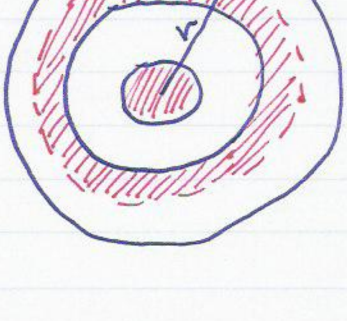
A) F
B) F flux through D is actually > flux through C.
C) F one should use C
D) T
E) F left face has zero flux
F) F same
G) T

2) A) F they are more like 1:2
B) F Both are positive ⇒ there must be a point where $\vec{E}$ cancels.
C) F sum of two positive #'s can't be zero.
D) T $\Delta U = q\Delta V$
E) F both positive ⇒ not a dipole
F) F no net work done ∵ potential same!

3) q same. $C = \frac{\epsilon_0 A}{d}$ (A)

4) $i = J \cdot A$ (E)

5)



$$LHS = \epsilon_0 \oint \vec{E}\cdot d\vec{A} = \epsilon_0 E\, 4\pi r^2$$

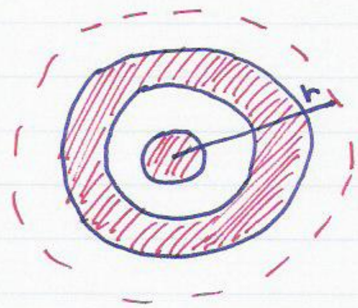
$$RHS = q_{enc} = \underset{\substack{\uparrow \\ \text{charge on solid sphere}}}{Q} + \underbrace{\rho\left[\tfrac{4}{3}\pi r^3 - \tfrac{4}{3}\pi b^3\right]}_{\text{contribution from shell.}}$$

→

$$\therefore \quad \epsilon_0 E 4\pi r^2 = Q + \rho \tfrac{4}{3}\pi \left[r^3 - b^3\right]$$

$$\Rightarrow \quad E = \frac{Q + \rho\frac{4}{3}\pi(r^3 - b^3)}{4\pi\epsilon_0 r^2}$$

$$= 1.62 \times 10^5 \, N/C \qquad C$$

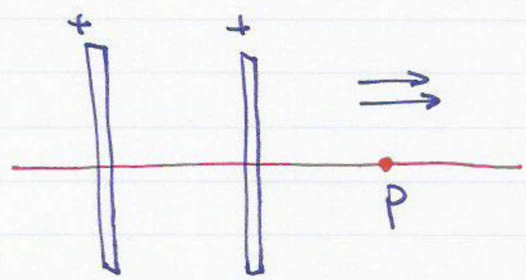
6) 

$$LHS = \epsilon_0 \int \vec{E} \cdot d\vec{A} = \epsilon_0 E 4\pi r^2$$

$$RHS = Q + \rho\left[\tfrac{4}{3}\pi c^3 - \tfrac{4}{3}\pi b^3\right]$$

$$\therefore \quad E = \frac{Q + \rho\frac{4}{3}\pi(c^3 - b^3)}{4\pi\epsilon_0 r^2}$$

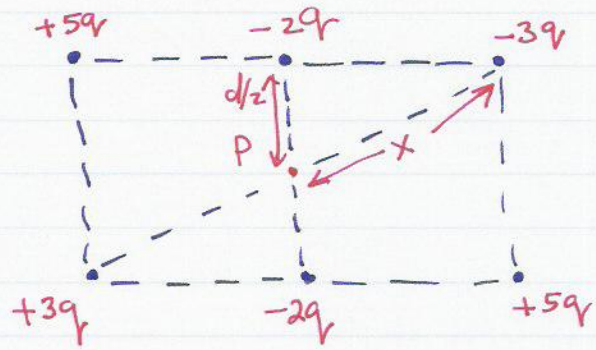
$$= 1.44 \times 10^5 \, N/C \qquad F$$

7) 

$$E = 2 \cdot \frac{\sigma}{2\epsilon_0}$$

$$= \frac{\sigma}{\epsilon_0}$$

$$= 8.58 \times 10^5 \, N/C \qquad E$$

8) 

pot due to +3q & −3q cancel out!

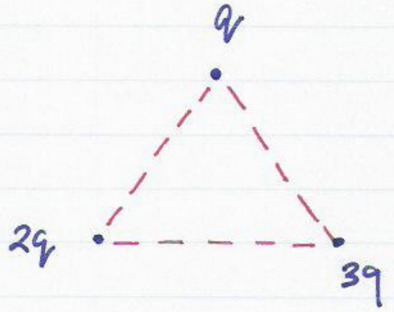
$$V = \frac{2\cdot(5q)}{4\pi\epsilon_0 x} + \frac{2(-2q)}{4\pi\epsilon_0 (\frac{d}{2})}$$

$$= \frac{10q}{4\pi\epsilon_0 (\frac{\sqrt{5}d}{2})} - \frac{4q}{4\pi\epsilon_0 (d/2)}$$

$$= 24.4 \, V \qquad B$$

$$x = \sqrt{d^2 + (d/2)^2}$$

$$= \frac{\sqrt{5}}{2} d$$

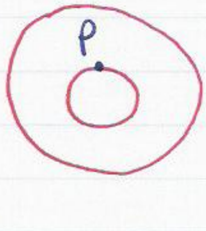
9) 

$$U = U_{21} + U_{31} + U_{32}$$

$$= \frac{(q)(2q)}{4\pi\epsilon_0 d} + \frac{(q)(3q)}{4\pi\epsilon_0 d} + \frac{(2q)(3q)}{4\pi\epsilon_0 d}$$

$$= \frac{11q^2}{4\pi\epsilon_0 d} = 59.29\ \text{J}$$

B

10) 

Potential on inner sphere (at P)

$$= \left(\begin{matrix}\text{pot. due}\\ \text{to B}\end{matrix}\right) + \left(\begin{matrix}\text{pot. due}\\ \text{to A}\end{matrix}\right)$$

potential at P due to B $= \dfrac{q_B}{4\pi\epsilon_0 R_B}$

potential at P due to A $= \dfrac{q_A}{4\pi\epsilon_0 R_A}$ (constant everywhere inside A)

$$q = \sigma \cdot A$$

$$\therefore \quad V = \frac{\sigma 4\pi R_B^2}{4\pi\epsilon_0 R_B} + \frac{\sigma \cdot 4\pi R_A^2}{4\pi\epsilon_0 R_A}$$

$$= \frac{\sigma}{\epsilon_0}(R_A + R_B) = 957\ \text{V}$$

D

11) $V_i = -2.0\ \text{V}$ $\quad V_f = 6.0\ \text{V}$

$$K_i + U_i = K_f + U_f$$

$$\frac{1}{2}mv_i^2 + U_i = \frac{1}{2}mv_f^2 + U_f$$

$$\Rightarrow \quad v_f = \sqrt{v_i + \frac{2(U_i - U_f)}{m}}$$

H

$$= \sqrt{v_i + \frac{2(qV_i - qV_f)}{m}} = 6.53\ \frac{m}{s}$$

12) $q = CV = \frac{\epsilon_0 A}{d} V = 9.53 \times 10^{-10}\ C = 0.953\ nC$ H

13) $E = \frac{q}{K \epsilon_0 A} = 7523.5\ N/C$ A

14) $V = \frac{q}{C_{eq.}}$

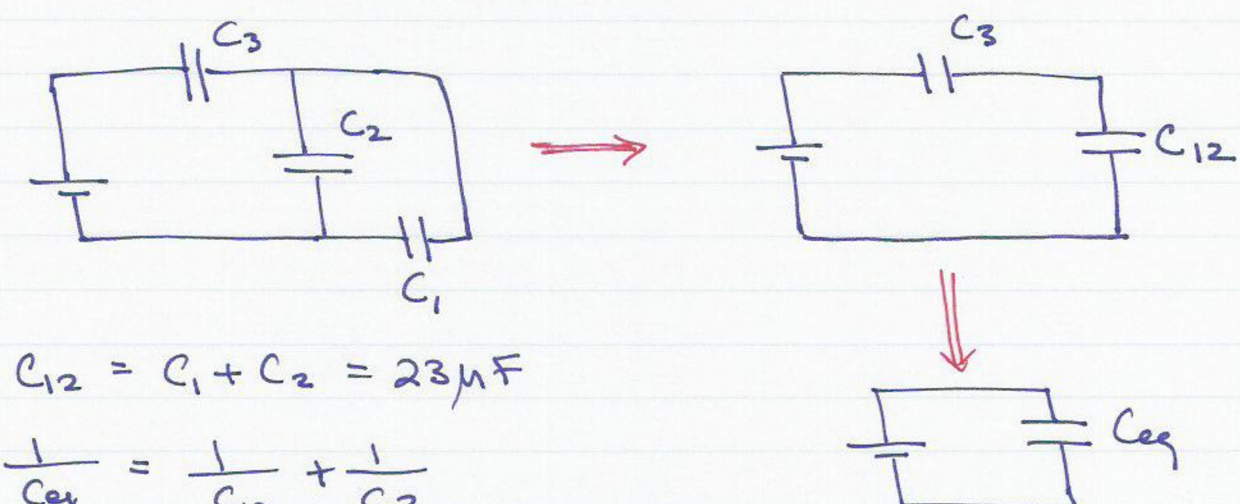
$C_{eq} = ?$

$C_1 = \frac{\epsilon_0 A}{(d/2)} = \frac{2\epsilon_0 A}{d}$ & $C_2 = K \cdot \frac{2\epsilon_0 A}{d}$

$\therefore \frac{1}{C_{eq}} = \frac{1}{2\epsilon_0 A/d} + \frac{1}{2K\epsilon_0 A/d} = \frac{d}{2\epsilon_0 A}\left[1 + \frac{1}{K}\right]$

$\therefore V = \frac{q}{C_{eq}} = \frac{qd}{2\epsilon_0 A}\left(1 + \frac{1}{K}\right) = 139.6\ V$ C

15.



$C_{12} = C_1 + C_2 = 23\mu F$

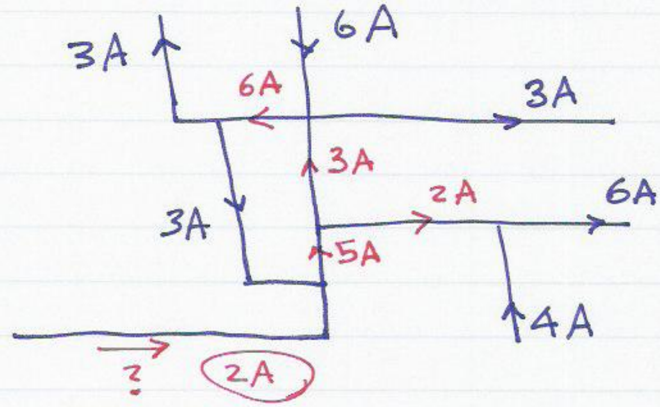
$\frac{1}{C_{eq}} = \frac{1}{C_{12}} + \frac{1}{C_3}$

$\Rightarrow C_{eq} = 10.7\mu F$ C

16) charge delivered by battery $q = C_{eq} V$
$= 449.3\ \mu C$

$V_{12} = \frac{q}{C_{12}} = 19.53\ V$

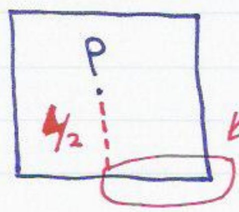
$\therefore q_2 = C_2 V_2 = C_2 V_{12} = 293 \times 10^{-6}\ C$ B

17) 

current marked in red are determined by Kirchhoff's law

ans : 2A

18) $V_d = \dfrac{i}{neA} = 11.9 \text{ m/s}$ B

19) 

consider this portion

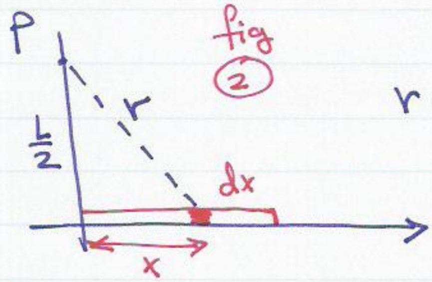


fig 2

1

$$r = \sqrt{x^2 + (L/2)^2}$$

$$\lambda = \frac{(q/8)}{(L/2)} = \frac{q}{4L} \quad 2$$

1

$$dV = \frac{dq}{4\pi\epsilon_0 r} = \frac{\lambda\, dx}{4\pi\epsilon_0 \sqrt{x^2 + L^2/4}}$$

2

$$V = \int_0^{L/2} \frac{\lambda\, dx}{4\pi\epsilon_0 \sqrt{x^2 + L^2/4}} = \frac{\lambda}{4\pi\epsilon_0} \ln\left(x + \sqrt{x^2 + L^2/4}\right)\Bigg|_0^{L/2}$$

3

$$= \frac{\lambda}{4\pi\epsilon_0}\left[\ln\left(\frac{L}{2} + \sqrt{\frac{L^2}{4} + \frac{L^2}{4}}\right) - \ln\frac{L}{2}\right]$$

$$= \frac{\lambda}{4\pi\epsilon_0} \ln\left[\frac{L/2 + L/2 \cdot \sqrt{2}}{L/2}\right] = \frac{\lambda}{4\pi\epsilon_0} \ln(1+\sqrt{2})$$

2

$$\therefore \quad V_{tot} = 8 \times \frac{\lambda}{4\pi\epsilon_0} \ln(1+\sqrt{2})$$

(simply add because scalar)

$$= \frac{q}{2\pi\epsilon_0 L} \ln(1+\sqrt{2}) \quad // \quad \left(\because\ \lambda = \frac{q}{4L}\right)$$