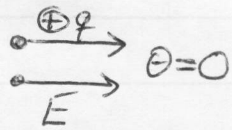
Chap 16

Easy

1.) Choose the direction of motion of the proton as $+x$:



(a) $\Rightarrow W = |\vec{F}||\Delta\vec{x}|\cos\theta = (q|\vec{E}|)|\Delta\vec{x}|\cos\theta$

$\Rightarrow W = (1.602\times10^{-19}\,C)(200\,N/C)(0.02\,m)\cos 0^\circ = \boxed{6.41\times10^{-19}\,J}$

(b) $\Delta PE_e = -W = \boxed{-6.41\times10^{-19}\,J}$ ← no change in KE

(c) By the definition of electric potential:

$\Delta V = \dfrac{\Delta PE_e}{q} = \dfrac{-6.41\times10^{-19}\,J}{1.602\times10^{-19}\,C} = \boxed{-4.00\,V}$ also could have used $\Delta V = -E_x\,\Delta x$

8.) Choose the direction of motion of the proton as $+x$:

(a) Use conservation of energy, $W_{nc} = \Delta PE + \Delta KE$

Since there are no non-conservative forces at work here; $W_{nc} = 0$

$\Rightarrow 0 = \Delta PE + \Delta KE \Rightarrow \Delta KE = -\Delta PE$

$\Rightarrow \frac{1}{2}m_p v_f^2 - \frac{1}{2}m_p v_i^2 = -(qV_f - qV_i) = -q\,\Delta V$

since the proton starts from rest, $v_i = 0$

$\Rightarrow \frac{1}{2}m_p v_f^2 = -q(\Delta V) \Rightarrow v_f^2 = \dfrac{-2q(\Delta V)}{m_p} \Rightarrow v_f = \sqrt{\dfrac{-2q(\Delta V)}{m}}$

since the proton moves through electric field only through the electric force, it will travel with the electric field and lower its potential $\Delta V = -120V$

$\Rightarrow v_f = \sqrt{\dfrac{-2(+1.602\times10^{-19}\,C)(-120V)}{1.67\times10^{-27}\,kg}} = \boxed{1.52\times10^{5}\,m/s}$

(b) Choose the direction of motion of the electron as $+x$;

We can use the same conservation of energy principle as part (a)

$\Rightarrow v_f = \sqrt{\dfrac{-2q(\Delta V)}{m_e}}$

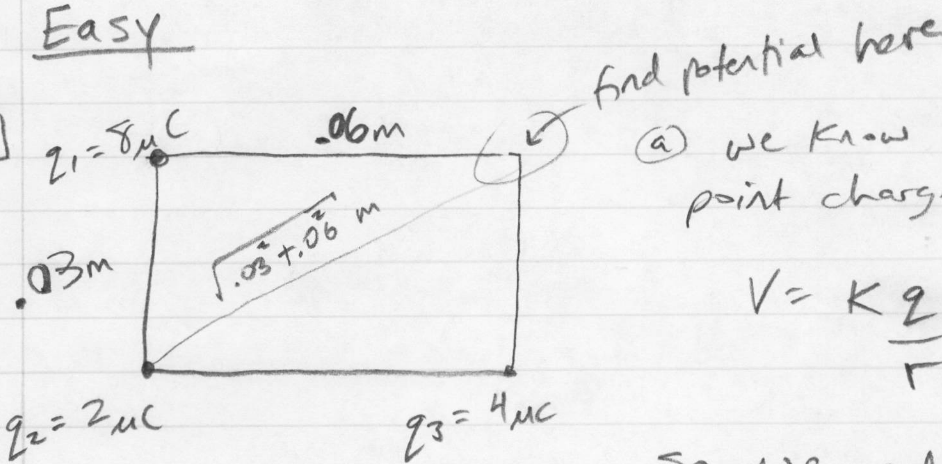
But here the electron will move opposite the electric field and thus its potential will increase, $\Delta V = +120V$

$\Rightarrow v_f = \sqrt{\dfrac{-2(-1.602\times10^{-19}C)(+120V)}{9.11\times10^{-31}\,kg}} = \boxed{6.50\times10^{6}\,m/s}$

Physics 1B - Chap 16 HW

Easy

[13]



(a) we know potential of a point charge from

$$V = K\frac{q}{r}$$

So we add up the potential for q_1 q_2 q_3

$$V_1 = \frac{Kq_1}{.06m} \; ; \; V_2 = \frac{Kq_2}{\sqrt{.03m + .06m}} \; ; \; V_3 = \frac{Kq_3}{.03m}$$

$V_1 = 1.2 \times 10^6$ V ; $V_2 = .27 \times 10^6$ V ; $V_3 = 1.2 \times 10^6$ V

since all are (+) just add → $\boxed{V_{total} = 2.67 \times 10^6 \text{ V}}$

(b) if $2\mu C \to -2\mu C$, we must subtract that value instead of adding it.
Thus $V_1 + V_3 - V_2 = \boxed{V_{TOT} = 2.13 \times 10^6 \text{ V}}$

[24] $Q = CV =$ (for // plates) $= \frac{\varepsilon_0 A}{d} V$; $V = 400$V

(a) double d, fix Q } $\boxed{\text{V must double} \to V = 800\text{V}}$

(b) double d, fix V } → q must be half → $\boxed{Q_f = Q_i/2}$

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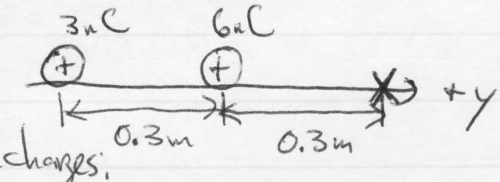
12.) Coordinate system was already chosen:



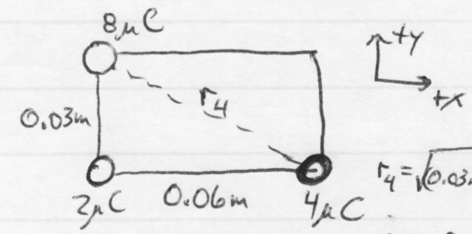
Use the sum of electric potentials for the charges:

$$V_3 = k_e \frac{q_3}{r_3} = \left(8.99\times10^9 \frac{Nm^2}{C^2}\right)\frac{3\times10^{-9}C}{(0.6m)} = 45.0V$$

$$V_6 = k_e \frac{q_6}{r_6} = \left(8.99\times10^9 \frac{Nm^2}{C^2}\right)\frac{6\times10^{-9}C}{(0.3m)} = 180V$$

$$\Rightarrow V_{Tot_1} = V_3 + V_6 = 45.0V + 180V = \boxed{220V}$$

14.) Choose up as +y and to the right as +x;



$r_4 = \sqrt{(0.03)^2 + (0.06)^2}$

$r_4 = 0.067m$

$$W_{Tot_1} = q_8(\Delta V_{Tot})$$

so calculate the work due to each source charge separately. Start with potential

First, for the 2μC charge: $\Delta V_2 = V_{2f} - V_{2i} = k_e \frac{q_2}{r_{2f}} - k_e \frac{q_2}{r_{2i}}$

$$\Rightarrow \Delta V_2 = k_e q_2\left(\frac{1}{r_{2f}} - \frac{1}{r_{2i}}\right) = k_e q_2\left(\frac{1}{\infty} - \frac{1}{0.03m}\right) = \left(8.99\times10^9 \frac{Nm^2}{C^2}\right)(2\times10^{-6}C)\left(\frac{-1}{0.03m}\right)$$

$$\Rightarrow \Delta V_2 = -5.99\times10^5 V$$

Next, for the 4μC charge: $\Delta V_4 = V_{4f} - V_{4i} = k_e \frac{q_4}{r_{4f}} - k_e \frac{q_4}{r_{4i}}$

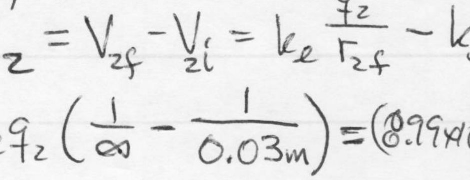
$$\Rightarrow \Delta V_4 = k_e q_4\left(\frac{1}{r_{4f}} - \frac{1}{r_{4i}}\right) = k_e q_4\left(\frac{1}{\infty} - \frac{1}{0.067m}\right) = \left(8.99\times10^9 \frac{Nm^2}{C^2}\right)(4\times10^{-6}C)\left(\frac{-1}{0.067m}\right)$$

$$\Rightarrow \Delta V_4 = -5.36\times10^5 V$$

$$\Rightarrow \Delta V_{Tot_1} = \Delta V_2 + \Delta V_4 = -5.99\times10^5V + (-5.36\times10^5V) = -1.135\times10^6V$$

$$\Rightarrow W_{Tot_1} = q_8(\Delta V_{Tot_1}) = (8\times10^{-6}C)(-1.135\times10^6V) = \boxed{-9.08J}$$

15.) Make a diagram of the situation:



(a) Sum the individual potentials:

$$V_1 = k_e \frac{Q_1}{r_1} = \left(8.99\times10^9 \frac{Nm^2}{C^2}\right)\frac{5\times10^{-9}C}{0.175m} = 257V$$

$$V_2 = k_e \frac{Q_2}{r_2} = \left(8.99\times10^9 \frac{Nm^2}{C^2}\right)\frac{-3\times10^{-9}C}{0.175m} = -154V$$

$$\Rightarrow V_{tot_1} = V_1 + V_2 = 257V - 154V = \boxed{103V}$$

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15.) Use the potential energy equation for point charges:

(b.) $PE = k_e \frac{q_1 q_2}{r_{12}} = (8.99\times10^9 \frac{Nm^2}{C^2}) \frac{(5\times10^{-9}C)(-3\times10^{-9}C)}{(0.35m)} = \boxed{-3.85\times10^{-7}J}$

For a positive charge and a negative charge, a zero potential energy will be defined at $r=\infty$. So, the negative sign in our answer means that it would take positive work to separate the unlike charges to $r=\infty$.

22.) Use the definition of capacitance: $C = Q/\Delta V \Rightarrow Q = (\Delta V)C$

(a.) $\Rightarrow Q = (12V)(4\times10^{-6}F) = 48.0\times10^{-6}C = \boxed{48.0\mu C}$

(b.) Use same equation: $Q = (1.5V)(4\times10^{-6}F) = 6.00\times10^{-6}C = \boxed{6.00\mu C}$

note that the capacitance didn't change when the battery did.

23.) For a parallel-plate capacitor: $C = \varepsilon_0 \frac{A}{d}$

(a.) $\Rightarrow C = (8.85\times10^{-12} \frac{C^2}{N\cdot m^2}) \frac{1\times10^6 m^2}{800m} = \boxed{1.1\times10^{-8}F} = 11\times10^{-9}F = 11nF$

(b.) A parallel-plate capacitor will have a uniform electric field

$\Rightarrow \Delta V = (E)\Delta x$ By the definition of capacitance: $C = \frac{Q}{\Delta V} \Rightarrow Q = C(\Delta V)$

$\Rightarrow Q_{max} = C(\Delta V_{max}) = C(E_{max}(\Delta x)) = (1.1\times10^{-8}F)(3.0\times10^6\frac{N}{C})(800m)$

$\Rightarrow Q_{max} = \boxed{27C}$ ← quite a bit!!

30.) If the capacitors are in parallel $\Rightarrow C_{eq.} = C_1 + C_2 + C_3$

(a.) $\Rightarrow C_{eq.} = 5\mu F + 4\mu F + 9\mu F = \boxed{18.0\mu F}$

(b.) If the capacitors are in series $\Rightarrow \frac{1}{C_{eq.}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$

$\Rightarrow \frac{1}{C_{eq}} = \frac{1}{5\mu F} + \frac{1}{4\mu F} + \frac{1}{9\mu F} = 0.2/\mu F + 0.25/\mu F + 0.11/\mu F = 0.561/\mu F \Rightarrow C_{eq.} = \frac{1}{0.561/\mu F} \Rightarrow C_{eq.} = \boxed{1.78\mu F}$

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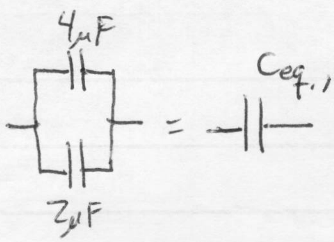
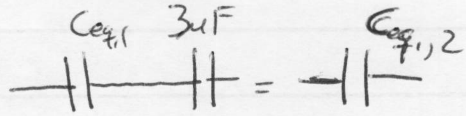
Easy



31.) First combine the two capacitors that

(a) are in parallel:

$C_{eq,1} = C_2 + C_4 = 2\mu F + 4\mu F = 6\mu F$



Next, we need to combine this equivalent capacitor with the $3\mu F$ capacitor in series:

$$\frac{1}{C_{eq,2}} = \frac{1}{C_{eq,1}} + \frac{1}{C_3} = \frac{1}{6\mu F} + \frac{1}{3\mu F} = \frac{1}{6\mu F} + \frac{2}{6\mu F} = \frac{3}{6\mu F} = \frac{1}{2\mu F} \Rightarrow C_{eq,2} = \boxed{2\mu F}$$

(b.) The charge on the equivalent capacitor ($C_{eq,2}$) would be:

$Q_{eq.} = (C_{eq,2})\Delta V_{bat.} = (2\mu F)(12V) = 24\mu C$ ← charge on $C_{eq,2}$

Since we can reduce $C_{eq,2}$ into $C_{eq,1}$ and $3\mu F$ in series, this means that $C_{eq,1}$ and $3\mu F$ both have that amount of charge.

$\Rightarrow Q_3 = \boxed{24\mu C}$ ← charge on $3\mu F$ capacitor

The electric potential drop across the $3\mu F$ capacitor is:

$\Delta V_3 = \frac{Q_3}{C_3} = \frac{24\mu C}{3\mu F} = \boxed{8.00\,V}$ ← potential difference across $3\mu F$ capacitor

This means that $C_{eq,1}$ has a drop of $12V - 8V = 4V$. This will be the equivalent drop across both the $2\mu F$ and $4\mu F$ capacitors.

$\Rightarrow \Delta V_2 = \Delta V_4 = \boxed{4.00\,V}$ ← potential difference across $2\mu F$ and $4\mu F$ capacitors

This means the charge on the $2\mu F$ capacitor is:

$Q_2 = C_2(\Delta V_2) = 2\mu F(4V) = \boxed{8.00\mu C}$ ← charge on $2\mu F$ capacitor

And the charge on the $4\mu F$ capacitor is:

$Q_4 = C_4(\Delta V_4) = 4\mu F(4V) = \boxed{16.0\mu C}$ ← charge on $4\mu F$ capacitor

Physics 1B - Chap 16 HW

Easy

48 // plates: $A = 2\ cm^2 = 2(.01\ m)^2 = 2\times10^{-4}\ m^2$

$d = 2mm = 2\times10^{-3}\ m$
$K_{water} = 80$ (book pg 557)
$V = 6V$

(a) to get E field we use $E = \frac{\Delta V}{\Delta d} = \frac{6V}{2\times10^{-3}m} = \boxed{3\times10^{3}\frac{V}{m}}$

(b) to get charge on the plates we have
$Q = CV = \left(\frac{K\varepsilon_0 A}{d}\right)V = \boxed{4.25\times10^{-10}\ C = Q_{wat}}$

(c) if it was air instead of water, we don't have $K = 80$, we have $K = 1$

∴ C will decrease by 80 & $Q = CV$ so Q will also decrease by 80

$Q_{air} = \frac{1}{80} Q_{water} = \boxed{5.31\times10^{-12}\ C = Q_{air}}$

Using plug & chug:

$Q_{air} = \left(\frac{K\varepsilon_0 A}{d}\right)V$ w/ $K = 1$

to get same answer.

Chap 16

Easy

43.) First, find the capacitance of the capacitor:

$$C = \varepsilon_0 \frac{A}{d} = \left(8.85\times10^{-12}\frac{C^2}{Nm^2}\right)\frac{(2cm^2)}{(5mm)}\frac{(1000mm)}{(1m)}\frac{1m^2}{(100cm)^2} = 3.54\times10^{-13}F$$

We can then find the energy stored by:

$$W = \tfrac{1}{2}C(\Delta V)^2 = \tfrac{1}{2}(3.54\times10^{-13}F)(12V)^2 = \boxed{2.55\times10^{-11}J}$$

47.) Initially, the charge on the capacitor is given by:

$$Q_i = (\Delta V)_i C_i = (100 C_i)\ \text{Volts}$$

Then, when the battery is disconnected and the glass dielectric inserted:

$$Q_f = (\Delta V)_f C_f = (25V)C_f$$

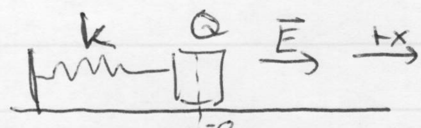
But, the charge didn't leave $\Rightarrow Q_i = Q_f$

$$\Rightarrow (100V)C_i = (25V)C_f \Rightarrow C_f = 4C_i$$

Recall that ~~for~~ a parallel-plate capacitor: $C = K\varepsilon_0\frac{A}{d}$

$$\Rightarrow K_f\varepsilon_0\frac{A_f}{d_f} = 4K_i\varepsilon_0\frac{A_i}{d_i} \Rightarrow K_f = 4K_i \text{ where } K_i = K_{air} = 1$$

$$\Rightarrow K_{glass} = \boxed{4.0} \leftarrow \text{unitless}$$



Medium

9.) Choose the direction of the electric field as the positive x-direction.

a.) There are no non-conservative forces at work here $\Rightarrow W_{nc} = 0$

$$\Rightarrow 0 = \Delta PE + \Delta KE \Rightarrow 0 = \Delta PE_{spring} + \Delta PE_{elect.} + \Delta KE$$

Since the velocity at equilibrium and at the endpoint is zero. $\Rightarrow \Delta KE = 0$

$$\Rightarrow \Delta PE_{spring} = -\Delta PE_{elec.} \qquad \Delta PE_{elec} = -W = -F\cdot\Delta x$$

$$\Delta PE_{spring} = \tfrac{1}{2}kx_f^2 - \tfrac{1}{2}kx_i^2 = \tfrac{1}{2}kx_f^2 - 0 = \tfrac{1}{2}kx_f^2$$

$$\Delta PE_{elec.} = -F_e\cdot\Delta x = -Q|\vec{E}|(x_f - x_i) = -Q|\vec{E}|x_f$$

$$\Rightarrow \tfrac{1}{2}kx_f^2 = Q|\vec{E}|x_f \Rightarrow x_f = \frac{2Q|\vec{E}|}{k} = \frac{2(50\times10^{-6}C)(5\times10^{5}V/m)}{100 N/m} = \boxed{0.500m}$$

Chap 16

Medium

9) At the equilibrium position, the net force will balance:

b. $\Rightarrow \Sigma F_{equil} = 0 = F_{electric} - F_{spring} \Rightarrow F_{elec.} = F_{spring}$

$\Rightarrow Q|\vec{E}| = k x_{equil.} \Rightarrow x_{equil} = \frac{Q|\vec{E}|}{k} = \frac{(50\times10^{-6}C)(5\times10^{5} V/m)}{100\ N/m} = \boxed{0.250 m}$

19.) Choose the initial direction of motion of the alpha particle as $+x$:

Since the forces at work here are all conservative $\Rightarrow W_{nc} = 0$

By energy conservation: $0 = \Delta KE + \Delta PE_{elec.} \Rightarrow \Delta KE = -\Delta PE_{elec.}$

Start with: $\Delta KE = \frac{1}{2}m_\alpha v_f^2 - \frac{1}{2}m_\alpha v_i^2 = -\frac{1}{2}m_\alpha v_i^2$ since at its closest point, $v_f = 0$

$\Delta PE_{elec.} = k_e \frac{q_\alpha q_{Gold}}{d} = k_e \frac{(2e)(79e)}{d} = k_e \frac{158e^2}{d}$

$\Rightarrow -\frac{1}{2}m_\alpha v_i^2 = -k_e \frac{158e^2}{d} \Rightarrow d = k_e \frac{2(158)e^2}{m_\alpha(v_i^2)} = (8.99\times10^9 \frac{Nm^2}{C^2}) \frac{316(1.602\times10^{-19}C)^2}{(6.64\times10^{-27}kg)(2\times10^7 m/s)^2}$

$\Rightarrow d = \boxed{2.74\times10^{-14} m}$

21.) Choose the center of the spherical object as $r=0$; with $V = k_e \frac{q}{r}$

$\Rightarrow r = k_e \frac{q}{V}$

At $V = 100V \Rightarrow r_{100} = (8.99\times10^9 \frac{Nm^2}{C^2}) \frac{(8\times10^{-9}C)}{100V} = \boxed{0.719 m}$

At $V = 50V \Rightarrow r_{50} = (8.99\times10^9 \frac{Nm^2}{C^2}) \frac{(8\times10^{-9}C)}{50V} = \boxed{1.44 m}$

At $V = 25V \Rightarrow r_{25} = (8.99\times10^9 \frac{Nm^2}{C^2}) \frac{(8\times10^{-9}C)}{25V} = \boxed{2.88 m}$

The radii are inversely proportional to the electric potential.

25.) Since the electric field is uniform $\Rightarrow |\vec{E}| = \frac{\Delta V}{\Delta x} = \frac{20V}{1.80\times10^{-3}m} = \boxed{1.11\times10^4 \frac{V}{m}}$

a.

b. Since it is a parallel-plate capacitor $\Rightarrow C = \epsilon_0 \frac{A}{d} = (8.85\times10^{-12} \frac{C^2}{Nm^2}) \frac{7.60 cm^2}{1.80\times10^{-3}m} \frac{1 m^2}{(100cm)^2}$

$\Rightarrow C = \boxed{3.74\times10^{-12} F} = 3.74 pF$

Chap 16
Medium

25.) Use the definition of capacitance: $C = \frac{Q}{\Delta V} \Rightarrow Q = (\Delta V)C$

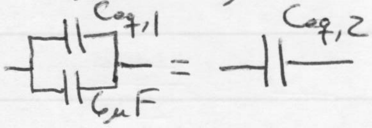
$\Rightarrow Q = (20V)(3.74 \times 10^{-12} F) = \boxed{+7.47 \times 10^{-11} C}$ on one plate

the other plate will have $\boxed{-7.47 \times 10^{-11} C}$.

33.) First, combine the two capacitors that

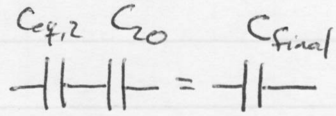
(a) are in series: $\frac{1}{C_{eq,1}} = \frac{1}{C_{15}} + \frac{1}{C_3} = \frac{1}{15\mu F} + \frac{1}{3\mu F} = \frac{1}{15\mu F} + \frac{5}{15\mu F} = \frac{6}{15\mu F}$

$\Rightarrow C_{eq,1} = \frac{15}{6}\mu F = 2.50\mu F$



Next, combine the two capacitors that are in parallel:

$C_{eq,2} = C_{eq,1} + C_6 = 2.50\mu F + 6.00\mu F = 8.50\mu F$



Finally, combine the two capacitors that are in series:

$\Rightarrow \frac{1}{C_{final}} = \frac{1}{C_{eq,2}} + \frac{1}{C_{20}} = \frac{1}{8.50\mu F} + \frac{1}{20\mu F} = 0.118/\mu F + 0.05/\mu F = 0.168/\mu F$

$\Rightarrow C_{final} = \boxed{5.95\mu F}$

(b) The charge on the equivalent capacitor (C_{final}) would be:

$Q_{final} = (C_{final})\Delta V = (5.95\mu F)(15V) = 89.4\mu C$

Since we can reduce C_{final} into $C_{eq,2}$ and C_{20} in series, this means that $C_{eq,2}$ and C_{20} both have that amount of charge.

$\Rightarrow Q_{20} = \boxed{89.4\mu C}$ ← charge on 20μF capacitor

The electric potential drop across the 20μF capacitor is:

$\Delta V_{20} = \frac{Q_{20}}{C_{20}} = \frac{89.4\mu C}{20\mu F} = 4.47V$

This means that $C_{eq,1}$ and C_6 have potential drops of $15V - 4.47V = 10.53V$

this means the charge on the 6μF capacitor is:

$Q_6 = \cancel{(C_{final})} \Delta V_6 = (6\mu F)(10.53V) = \boxed{63.2\mu C}$ ← charge on 6μF capacitor

Chap 16

Medium

33.) The charge on the first equivalent capacitor ($C_{eq,1}$) is:

(b.) $Q_{eq,1} = (C_{eq,1})\Delta V_{eq,1} = (2.50\mu F)(10.53V) = 26.3\mu C$

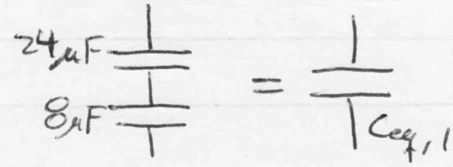
(cont.)

Since C_{15} and C_3 are in series they will both have the same charge on them. They will also be equivalent to $Q_{eq,1}$.

$\Rightarrow Q_{15} = Q_3 = Q_{eq,1} = \boxed{26.3\mu C}$ ← charge on $3\mu F$ and $15\mu F$ capacitors.

34.) First, combine the two capacitors that

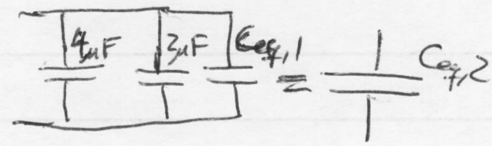
(a.) are in series:



$\frac{1}{C_{eq,1}} = \frac{1}{C_8} + \frac{1}{C_{24}} = \frac{1}{8\mu F} + \frac{1}{24\mu F} = \frac{3}{24\mu F} + \frac{1}{24\mu F}$

$\Rightarrow \frac{1}{C_{eq,1}} = \frac{4}{24\mu F} = \frac{1}{6\mu F} \Rightarrow C_{eq,1} = 6\mu F$

Next, combine the three capacitors that are in parallel:



$C_{eq,2} = C_4 + C_2 + C_{eq,1} = 4\mu F + 2\mu F + 6\mu F = \boxed{12\mu F}$ ← find C_{eq}.

(b.) The potential difference across the three capacitors in parallel ($C_4, C_2, C_{eq,1}$) has to be the same. All will be 36V

$\Rightarrow \Delta V_4 = \Delta V_2 = \Delta V_{eq,1} = 36V$

$\Rightarrow Q_4 = (C_4)\Delta V_4 = (4\mu F)36V = \boxed{144\mu C}$ ← charge on $4\mu F$ capacitor

$\Rightarrow Q_2 = (C_2)\Delta V_2 = (2\mu F)(36V) = \boxed{72.0\mu C}$ ← charge on $2\mu F$ capacitor

$\Rightarrow Q_{eq,1} = (C_{eq,1})\Delta V_{eq,1} = (6\mu F)(36V) = 216\mu C$

Since C_{24} and C_8 are in series they will both have the same charge on them. They will also be equivalent to $Q_{eq,1}$.

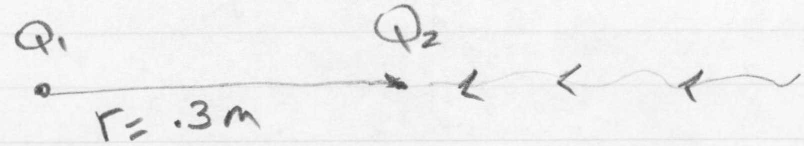
$\Rightarrow Q_{24} = Q_8 = Q_{eq,1} = \boxed{216\mu C}$ ← charge on $24\mu F$ and $8\mu F$ capacitors.

Physics 1B - Chap 16

Medium

$\boxed{16}$ $Q_1 = 9 \times 10^{-9} C$ @ origin

$Q_2 = +3 \times 10^{-9} C$ @ $x = .3m$ (starts @ ∞)



$$W = -PE = -(q\Delta V) = -Q_2(V_f - V_i)$$

$$V_i = V_\infty = 0 \qquad V_f = \frac{KQ_1}{r} = 270V$$

W (done $\underline{\text{by}}$ charge) $= -Q_2(270V) = -8.1 \times 10^{-7}$ J

so work done $\underline{\text{on}}$ charge $= \boxed{+8.1 \times 10^{-7} J}$

You could also use the formula

$PE = \frac{Kq_1q_2}{r}$ for 2 point charges (page 539)

and note that work on the pair is equal to the PE they gain.

Physics 1B – Chap 16 HW

Med

$\boxed{32}$ C_1 & C_2 in parallel $= C_1 + C_2 = 9\,pF$

C_1 & C_2 in series $= \left(\frac{1}{C_1} + \frac{1}{C_2}\right)^{-1} = 2\,pF$

solve:

$$C_1 = 9 - C_2 \rightarrow \left(\frac{1}{9-C_2} + \frac{1}{C_2}\right)^{-1} = 2$$

common den & exp (−1)

$$\longrightarrow \left[\frac{C_2}{C_2(9-C_2)} + \frac{9-C_2}{C_2(9-C_2)}\right] = \frac{1}{2}$$

$$\cancel{C_2} + 9 - \cancel{C_2} = \frac{1}{2} C_2(9 - C_2)$$

$$9 = 4.5\,C_2 - .5\,C_2^2$$

standard form & mult x2

$$C_2^2 - 9C_2 + 18 = 0$$

$$(C_2 - 6)(C_2 - 3) = 0$$

quad form or factor

$$C_2 = 6\,\mu F \text{ or } C_2 = 3\,\mu F$$

$$\boxed{\text{Thus one capacitor is } 6\,\mu F \text{ \& other is } 9-6 = 3\,\mu F}$$

(or one is $3\,\mu F$ & other is $9-3 = 6\,\mu F$, but this is the same solution again)

Physics 1B – Chap 16 HW

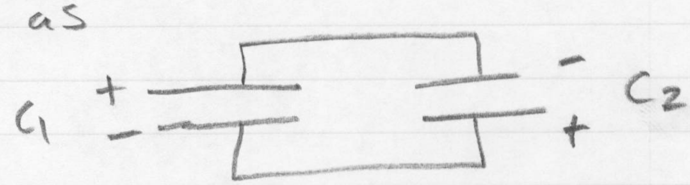
Med

$\boxed{37}$ (C1) 25 μF & (C2) 40 μF each w/ 50V Battery

(a) C_1 has $Q_1 = C_1 V = \boxed{1.25\times10^{-3}\,C = Q_1}$

C_2 has $Q_2 = C_2 V = \boxed{2.00\times10^{-3}\,C = Q_2}$

(b) connect capacitors as



much of the charge will cancel since (+) plate is connected to (−) plate.

$$Q_{Net} = (2-1.25)\times10^{-3}\,C = 7.5\times10^{-4}\,C$$

$Q = CV$

Since the capacitors are in parallel, $\Delta V_1 = \Delta V_2$

so $\dfrac{Q_1}{C_1} = \dfrac{Q_2}{C_2}$ and $Q_1 + Q_2 = 7.5\times10^{-4}\,C$

$$\underbrace{Q_1 = \frac{C_1}{C_2}Q_2 = \frac{25}{40}Q_2 = \frac{5}{8}Q_2 \; ; \; Q_1 = 7.5\times10^{-4}\,C - Q_2}_{=\text{equals}=}$$

$$\frac{5}{8}Q_2 = 7.5\times10^{-4}\,C - Q_2$$

$$\boxed{Q_2 = 4.6\times10^{-4}\,C \; ; \; Q_1 = 2.9\times10^{-4}\,C}$$

$$\text{Final } \Delta V_2 = \frac{Q_2}{C_2} = \frac{4.6\times10^{-4}\,C}{40\,\mu F} = \boxed{11.5\,V = \Delta V_2}$$

Chap 16

Medium

38.) First, let's find the charge on the first capacitor (initially)

$Q_{1i} = C_1(\Delta V_{1i}) = (10\mu F)(12V) = 120\mu C$

Also, initially on the second capacitor: $Q_{2i} = C_2(\Delta V_{2i}) = C(0) = 0$

Finally, after the two capacitors are connected: $\Delta V_{1f} = \Delta V_{2f} = 3V$

Also, since charge is conserved: $Q_{total} = 120\mu C = Q_{1f} + Q_{2f}$

Finally, the charges will be:

$Q_{1f} = C_1(\Delta V_{1f}) = (10\mu F)(3V) = 30\mu C$

$\Rightarrow Q_{2f} = 120\mu C - Q_{1f} = 120\mu C - 30\mu C = 90\mu C$

$\Rightarrow C_2 = \dfrac{Q_{2f}}{\Delta V_{2f}} = \dfrac{90\mu C}{3V} = \boxed{30.0\mu F}$ ← capacitance of 2nd capacitor

44.) Since the two capacitors are hooked up in parallel, they will both

(a) have the same potential difference.

For the first, $W_1 = \frac{1}{2}C_1(\Delta V_1)^2 = \frac{1}{2}(25\mu F)(100V)^2 = 0.125\,J$

For the second, $W_2 = \frac{1}{2}C_2(\Delta V_2)^2 = \frac{1}{2}(5\mu F)(100V)^2 = 0.025\,J$

$\Rightarrow$ Energy Stored $= W_{Tot} = W_1 + W_2 = 0.125J + 0.025J = \boxed{0.150J}$

(b.) When the two capacitors are now connected in series, their new equivalent capacitance will be: $\frac{1}{C_{eq.}} = \frac{1}{C_1} + \frac{1}{C_2} = \frac{1}{25\mu F} + \frac{1}{5\mu F} = \frac{1}{25\mu F} + \frac{5}{25\mu F}$

$\Rightarrow \frac{1}{C_{eq.}} = \frac{6}{25\mu F} \Rightarrow C_{eq} = \frac{25}{6}\mu F = 4.17\mu F$

The total energy stored for this system will be:

$W = \frac{1}{2}(C_{eq.})(\Delta V)^2 \Rightarrow (\Delta V)^2 = \frac{2(W)}{C_{eq}} \Rightarrow (\Delta V) = \sqrt{\frac{2(W)}{C_{eq}}}$

The potential difference ~~is for~~ this system is:

$\Rightarrow \Delta V = \sqrt{\dfrac{2(0.150J)}{4.17\times10^{-6}F}} = \boxed{268V}$

Chap 16
Medium

45.) As found before, for a parallel-plate capacitor: $C = \varepsilon_0 \frac{A}{d}$

$$\Rightarrow C = (8.85\times10^{-12}\ \tfrac{C^2}{N\cdot m^2})\ \frac{1\times10^{6}\,m^2}{800\,m} = 1.1\times10^{-8}\,F$$

The potential difference between the Earth and clouds is:

$$\Delta V = |\vec{E}|\cdot\Delta x = (3.0\times10^{6}\ V/m)(800m) = 2.4\times10^{9}\,V$$

The energy that is available to release is:

$$W = \tfrac{1}{2}C(\Delta V)^2 = \tfrac{1}{2}(1.1\times10^{-8}F)(2.4\times10^{9}V)^2 = \boxed{3.2\times10^{10}\,J}$$

56.) The electric potential due to a point charge will be given by:

(a) $V = k_e \frac{q}{r}$ for the $1\mu C$ charge, $r = 0.5m$ at point P

$$\Rightarrow V_1 = (8.99\times10^{9}\ \tfrac{Nm^2}{C^2})\ \frac{1\times10^{-6}C}{(0.5m)} = \boxed{1.80\times10^{4}\,V}$$

(b) For the $-2\mu C$ charge, $r = 0.5m$ at point P

$$\Rightarrow V_2 = (8.99\times10^{9}\ \tfrac{Nm^2}{C^2})\ \frac{-2\times10^{-6}C}{(0.5m)} = \boxed{-3.6\times10^{4}\,V}$$

(c) The total electric potential will be: $V_{Tot} = V_1 + V_2 = 1.8\times10^{4}V - 3.6\times10^{4}V$

$\Rightarrow V_{Tot} = \boxed{-1.8\times10^{4}\,V}$ ← electric potential at point P

(d) The work required to move a charge to point P from infinity is:

$$W = q(\Delta V) = q(V_p - V_\infty)$$

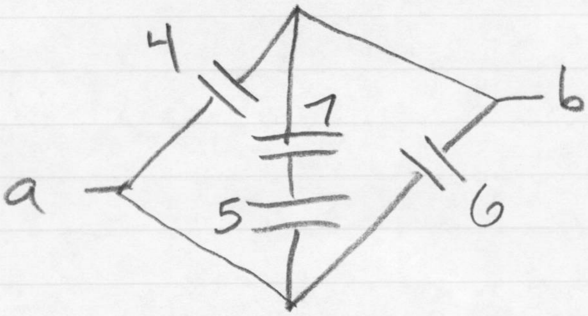
when the separation distance is $\infty \Rightarrow V_\infty = 0$ $(\frac{1}{r} \to 0)$

$$\Rightarrow W = q(V_p) = (3\times10^{-6}C)(-1.8\times10^{4}V) = \boxed{-0.054\,J}$$

Physics 1B - Chap 16 HW

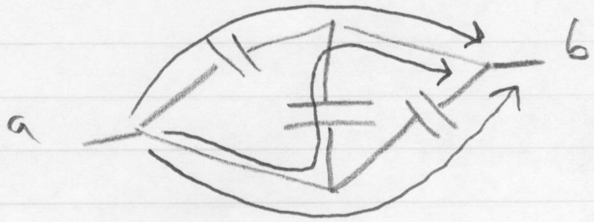
Hard

$\boxed{42}$ Find C_{eq}



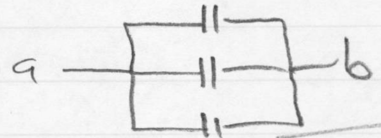
all units μF

First : central branch (7) & (5) series = 2.92



Now they are in parallel even if it is hard to see. Examine paths for each on from $a \to b$

Since each capacitor has a unique path from $a \to b$ it is like



so add in parallel

$$C_{eq} = 4 + 2.92 + 6 = \boxed{12.92\ \mu F = C_{eq}}$$

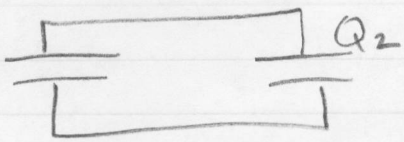
Physics 1B - Chap 16 HW

Hard

$\boxed{55}$) C_1 unknown, $V = 100 \rightarrow Q = 100C_1$

Now connected to $C_2 = 10\,\mu F$ uncharged

$Q = 100C_1$ still, but spread over both capacitors



$Q_1 + Q_2 = Q = 100C_1$

In parallel $\rightarrow \Delta V_1 = \Delta V_2 \rightarrow \frac{Q_1}{C_1} = \frac{Q_2}{C_2} = 30V$ (given)

Thus: $Q_1 = 30C_1$ $\quad$ $Q_2 = (30)(10\,\mu F)$

$Q_2 = 300\,\mu F$

so $Q_1 + Q_2 = 100C_1 \rightarrow 30C_1 + 300\,\mu F = 100C_1$

$\frac{300\,\mu F}{70} = \frac{70C_1}{70}$

$\boxed{C_1 = 4.3\,\mu F}$

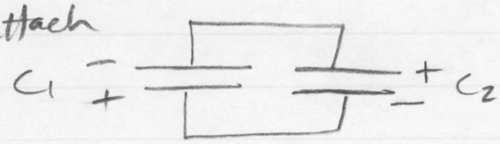
$\boxed{61}$ $C_1 = 6\,\mu F$ $\quad$ $C_{eq} = 8\,\mu F$

$C_2 = 2\,\mu F$ $\quad$ $V = 250V$

$Q_1 = C_1V = 1.5\,mC$

$Q_2 = C_2V = .5\,mC$

Now attach



$Q_{net} = Q_1 - Q_2 = 1.0\,mC$

$C_1 = 3C_2$ and $V_1 = V_2$ (b/c parallel)

so $Q = CV \rightarrow Q_1 = 3Q_2$ and $Q_1 + Q_2 = Q_{TOT} = 1\,mC$

$3Q_2 + Q_2 = 1\,mC$

$\boxed{\begin{array}{l} \text{So } Q_2 = .25\,mC \\ Q_1 = .75\,mC \end{array}}$

Chap 16

Hard

51.) Looking at the definition of density: $\rho = \frac{m}{Vol.}$

(a.)

$$\Rightarrow Vol. = \frac{m}{\rho} = \frac{1\times10^{-12}\,kg}{1100\,kg/m^3} = \boxed{9.09\times10^{-16}\,m^3}$$

We can next find radius since we were told it is spherical in nature: $Vol = \frac{4}{3}\pi r^3 \Rightarrow r^3 = \frac{3(Vol.)}{4\pi} \Rightarrow r = \sqrt[3]{\frac{3(Vol.)}{4\pi}}$

$$\Rightarrow r = \sqrt[3]{\frac{3(9.09\times10^{-16}\,m^3)}{4\pi}} = 6.01\times10^{-6}\,m$$

The surface area of a sphere is: $S.A. = 4\pi r^2 = 4\pi\,(6.01\times10^{-6}\,m)^2$

$$\Rightarrow S.A. = \boxed{4.54\times10^{-10}\,m}$$

(b.) We can estimate its capacitance by using the parallel-plate capacitor formula: $C = K\varepsilon_0 \frac{A}{d} = (5)\left(8.85\times10^{-12}\frac{C^2}{Nm^2}\right)\frac{4.54\times10^{-10}\,m}{(100\times10^{-9}\,m)}$

$$\Rightarrow C = \boxed{2.01\times10^{-13}\,F}$$

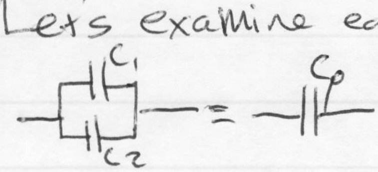
(c.) Use the definition of capacitance: $C = Q/\Delta V \Rightarrow Q = (\Delta V)C$

$$\Rightarrow Q = (100\times10^{-3}\,V)(2.01\times10^{-13}\,F) = \boxed{2.01\times10^{-14}\,C}$$

with each electronic charge being $1.602\times10^{-19}\,C$

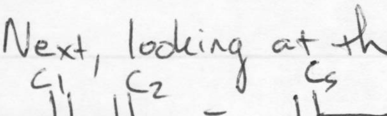
$$\Rightarrow \# = \frac{Q}{e} = \frac{2.01\times10^{-14}\,C}{1.602\times10^{-19}\,C} = 1.25\times10^{5} \text{ charges}$$

54.) Let's examine each one separately; first, the parallel capacitors:



$$\Rightarrow C_p = C_1 + C_2 \Rightarrow C_2 = C_p - C_1$$

Next, looking at the series capacitors:



$$\Rightarrow \frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} \Rightarrow \frac{1}{C_s} = \frac{C_2}{C_1C_2} + \frac{C_1}{C_1C_2} = \frac{C_2+C_1}{C_1C_2}$$

$$\Rightarrow C_s = \frac{C_1C_2}{C_1+C_2}$$

Chap 16
Hard

54.) Substituting in for C_2 gives us:
(cont.)
$$C_s = \frac{C_1(C_p - C_1)}{C_1 + (C_p - C_1)} = \frac{C_1 C_p - C_1^2}{C_p} \Rightarrow C_s C_p = C_1 C_p - C_1^2$$

$$\Rightarrow C_1^2 - C_1 C_p + C_s C_p = 0$$ use the quadratic formula with C_1 being x

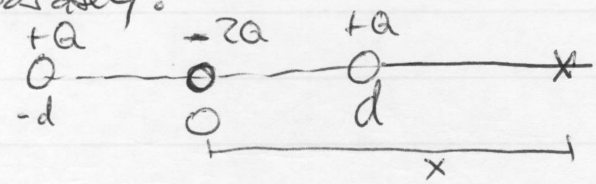
$$\Rightarrow C_1 = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{+C_p \pm \sqrt{(-C_p)^2 - 4(1)(C_s C_p)}}{2}$$

$$\Rightarrow C_1 = \boxed{\frac{C_p}{2} \pm \frac{1}{2}\sqrt{C_p^2 - 4C_s C_p}}$$

and $C_2 = C_p - C_1 = C_p - \left(\frac{C_p}{2} \pm \frac{1}{2}\sqrt{C_p^2 - 4C_s C_p}\right)$

$$\Rightarrow C_2 = \boxed{\frac{C_p}{2} \mp \frac{1}{2}\sqrt{C_p^2 - 4C_s C_p}}$$

63.) Coordinate system has already been chosen, calculate the electric
a.) potential from each charge separately:



$$\Rightarrow V_1 = k_e\left(\frac{Q}{x+d}\right)$$
$$V_2 = k_e\left(\frac{-2Q}{x}\right)$$
$$V_3 = k_e\left(\frac{Q}{x-d}\right) \Rightarrow \Sigma V = V_1 + V_2 + V_3 = k_e\frac{Q}{(x+d)} - k_e\frac{2Q}{x} + k_e\frac{Q}{(x-d)}$$

$$\Rightarrow V_{Tot.} = k_e Q\left(\frac{1}{(x+d)} - \frac{2}{x} + \frac{1}{(x-d)}\right)$$ get a common denominator

$$\Rightarrow V_{Tot.} = k_e Q\left(\frac{x(x-d)}{x(x^2-d^2)} - \frac{2(x^2-d^2)}{x(x^2-d^2)} + \frac{x(x+d)}{x(x^2-d^2)}\right)$$

$$\Rightarrow V_{Tot.} = k_e Q\left(\frac{(x^2 - xd) - (2x^2 - 2d^2) + (x^2 + xd)}{x^3 - xd^2}\right)$$

$$\Rightarrow V_{Tot.} = k_e Q\left(\frac{2d^2}{x^3 - xd^2}\right) = \boxed{\frac{2k_e Q d^2}{x^3 - xd^2}}$$

Chap 16

Hard

63.) When $x >> d$, this means that $x^2 - d^2 \approx x^2$

b. $\Rightarrow V_{tot} = \frac{2k_e Q d^2}{x^3 - xd^2} = \frac{2k_e Q d^2}{x(x^2-d^2)} \approx \boxed{\frac{2k_e Q d^2}{x^3}}$