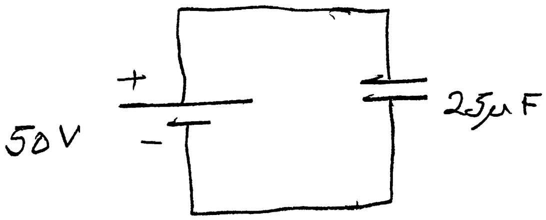
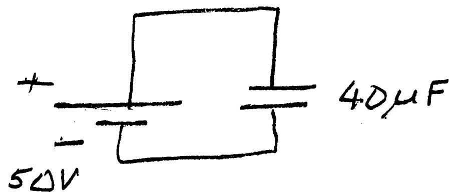
HOMEWORK - SOLNS # 7

16-37 FIRST CALCULATE CHARGE ON $25\mu F$ and $40\mu F$

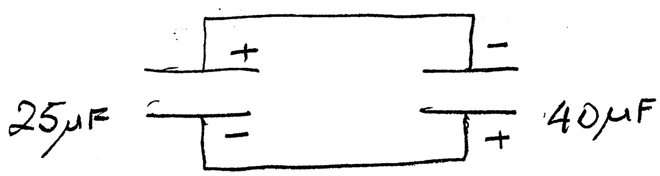
$$Q = CV$$





$$Q_{25} = (50 \times 25 \times 10^{-6})\,C = 1.25 \times 10^{-3}\ C$$

$$Q_{40} = (50 \times 40 \times 10^{-6})\,C = 2.00 \times 10^{-3} C.$$

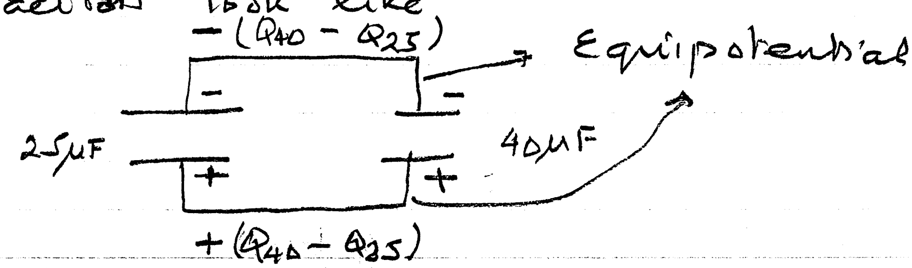


Note: + to −
− to +

Charge is conserved so Total charge now is

$$Q_{40} - Q_{25} = (2 \times 10^{-3} - 1.25 \times 10^{-3})\,C = 7.5 \times 10^{-4} C = 750 \mu C$$

and the capacitors look like



Because conductor is equipotential $V_{25} = V_{40}$

$$\frac{Q_{25}}{25 \times 10^{-6}} = \frac{Q_{40}}{40 \times 10^{-6}} = V_{25} = V_{40}$$

$$\frac{7.5 \times 10^{-4} - Q_{40}}{25 \times 10^{-6}} = \frac{Q_{40}}{40 \times 10^{-6}} \qquad Q_{40} = 462 \mu C.$$

$$Q_{25} = 750 - 462 \mu C = 288 \mu C, \qquad V_{40} = \frac{Q_{40}}{40} = 11.5V.$$

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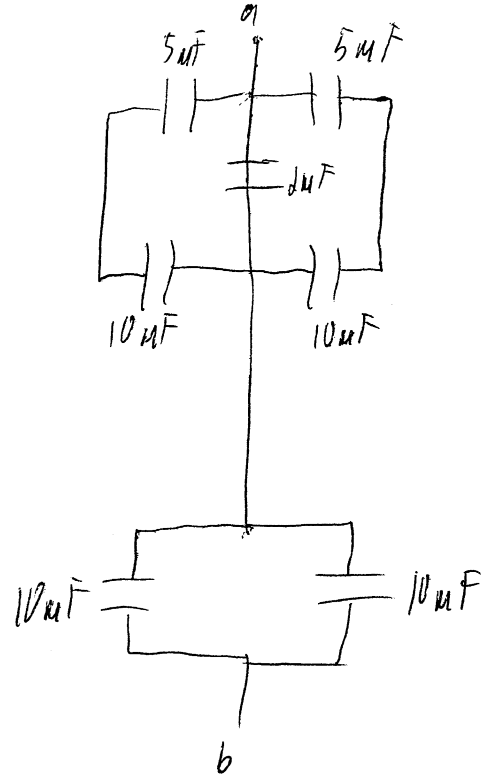

→ 20μF.

For TWO Capacitors.

$$\boxed{\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} \quad \text{series}}$$

$$\boxed{C_p = C_1 + C_2 \quad \text{parallel}}$$

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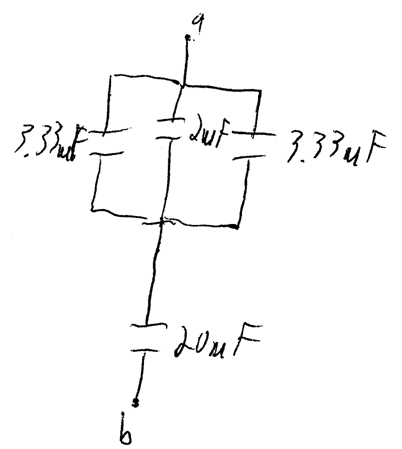


add 5μF and 10μF in series

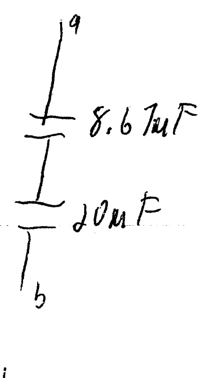
$$\frac{1}{C_s} = \frac{1}{5} + \frac{1}{10} = \frac{3}{10}$$

$$C_s = 10/3 = 3.33\mu F.$$

Next 3.33μF, 2μF and 3.33μF in parall

hence

=



8.67μF and 20μF in series

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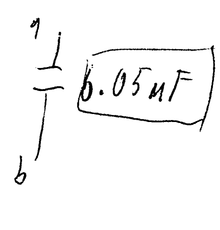

$$\frac{1}{C_{ab}} = \frac{1}{8.67} + \frac{1}{20}$$

$$C_{ab} = 6.05\mu F$$

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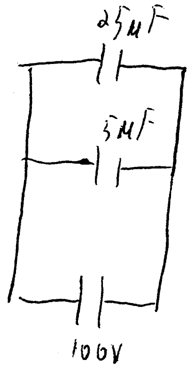
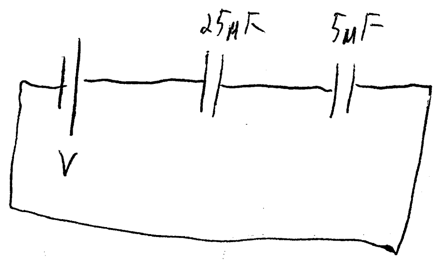


$$U_E = \frac{Q^2}{2C} = \frac{1}{2}CV^2$$

(a.) $U_E = \frac{1}{2}(100V)^2(25\mu F + 5\mu F)$

$U_E = 0.15\ J$

(b)



In Series

$$\frac{1}{C} = \frac{1}{5} + \frac{1}{25} = \frac{6}{25} \qquad C = \frac{25}{6}\mu F$$

$0.15\ J = \frac{1}{2}V^2\left((25\mu F)^{-1} + (5\mu F)^{-1}\right)^{-1}$

$\boxed{V = 268\ V}$

C reduces from $30\mu F$ to $4.16\mu F$ hence V^2 must increase by $\frac{30}{4.16}$

$\boxed{49}$

(a) $C = \dfrac{K \varepsilon_0 A}{d}$ $\qquad A = 175\,cm^2 \left(\dfrac{m}{100\,cm}\right)^2 = 0.0175\,m$

$= \dfrac{2.1\,(8.85 \times 10^{-12} \frac{C^2}{Nm^2})(0.0175\,m)}{(.04 \times 10^{-3}\,m)}$

$= \underline{8.13 \times 10^{-9}\,F}$

For Teflon
From Table 16.1
on p 557 we
know that
$\kappa = 2.1$.
and
$E_{max} = 60 \times 10^6\, V/m$

(b) $E_{max} = 60 \times 10^6\, V/m$

$V_{max} = E_{max}\, d$

$= (60 \times 10^6\, V/m)(.04 \times 10^{-3}\,m)$

$\underline{V_{max} = 2400\,V}$

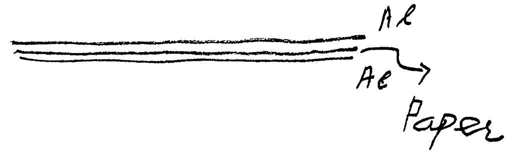
50

$C = 9.5 \times 10^{-8} F$

$A = Lw \quad w = 7 \times 10^{-2} m$

$d = \cancel{.004 \times 10^{-3} m} + .025 \times 10^{-3} m = 2.5 \times 10^{-5} m$

$\kappa = 3.70$



$$C = \frac{\kappa \varepsilon_0 A}{d} = \frac{\kappa \varepsilon_0 L w}{d}$$

$$L = \frac{dC}{\kappa \varepsilon_0 w} = \frac{(2.5 \times 10^{-5} m)(9.5 \times 10^{-8} F)}{3.70 (8.85 \times 10^{-12} \frac{C^2}{Nm})(7 \times 10^{-2} m)}$$

$$\boxed{L = 1.04 m}$$

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$$C_p = C_1 + C_2 \rightarrow ①$$

$$\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2}, \quad C_s = \frac{C_1 C_2}{C_1 + C_2} \rightarrow ②$$

Multiply ① and ②

$$C_s C_p = C_1 C_2, \quad C_1 = \frac{C_s C_p}{C_2}$$

substitute in ① $\quad C_p = \frac{C_s C_p}{C_2} + C_2.$

or

$$C_p C_2 = C_s C_p + C_2^2$$

$$C_2^2 - C_p C_2 + C_s C_p = 0$$

Solve quadratic $\quad C_2 = \frac{C_p \pm \sqrt{C_p^2 - 4 C_s C_p}}{2}$

$$C_1 = C_p - C_2 = \frac{2C_p - C_p \mp \sqrt{C_p^2 - 4 C_s C_p}}{2}$$

$$= \frac{C_p \mp \sqrt{C_p^2 - 4 C_s C_p}}{2}.$$

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Homework #7 Solutions

Ch. 17: 1, 5, 8, 15, 19, 21, . . .

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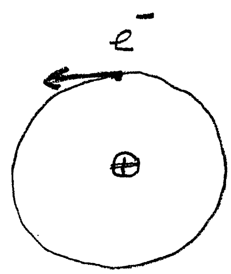
(5) The period of the electron in its orbit is $T = \frac{2\pi r}{v}$.

The current represented by the orbiting electron is

$$I = \frac{\Delta Q}{\Delta t} = \frac{|e|}{T} = \frac{v|e|}{2\pi r}$$



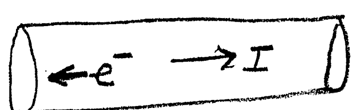
$$= \frac{(2.19 \times 10^{6}\ m/s)(1.60 \times 10^{-19}\ C)}{2\pi (5.29 \times 10^{-11}\ m)}$$

$$= 1.05 \times 10^{-3}\ C/s$$

$$\boxed{I = 1.05\ mA}$$

(1) The charge that moves past the cross section:

$$\Delta Q = I(\Delta t)$$



\# of electrons:

Electrons drift to left, direction of I is to right*

$$n = \frac{\Delta Q}{|e|} = \frac{I(\Delta t)}{|e|}$$

$$= \frac{(80.0 \times 10^{-3}\ C/s)[(10.0\ min)(60.0\ sec/min)]}{1.60 \times 10^{-19}\ C}$$

$$\boxed{n = 3.00 \times 10^{20}\ electrons}$$

* Remember that electrons move in the opposite direction of the conventional current.

(8) Assuming that, on average, each aluminum atom contributes one electron, the density of charge carriers is the same as the number of atoms per cubic meter.

$$n = \frac{\text{density}}{\text{mass per atom}}$$

M = mass/mol.

N_A = Avogadro's No

$$= \frac{\rho}{M/N_A}$$

$$= \frac{N_A \rho}{M}$$

$$= \frac{(6.02 \times 10^{23}/\text{mol})\left[(2.7\,\text{g/cm}^3)(10^6\,\text{cm}^3/1\,\text{m}^3)\right]}{26.98\,\text{g/mol}}$$

$$\Rightarrow n = 6.0 \times 10^{28}/\text{m}^3$$

Then, the drift speed of the electrons in the wire:

$$v_d = \frac{I}{n|e|A}$$

$$= \frac{5.0\,\text{C/s}}{(6.0 \times 10^{28}/\text{m}^3)(1.60 \times 10^{-19}\,\text{C})(4.0 \times 10^{-6}\,\text{m}^2)}$$

$$\boxed{v_d = 1.3 \times 10^{-4}\,\text{m/s}}$$

(15)

(a) $R = \frac{\Delta V}{I} = \frac{12\,V}{0.40\,A} = \boxed{30\,\Omega}$

(b) From $R = \frac{\rho L}{A}$,

$$\rho = \frac{R \cdot A}{L}$$

$$= \frac{(30\,\Omega)\left[\pi(0.40\times10^{-2}\,m)^2\right]}{3.2\,m}$$

$$\Rightarrow \boxed{\rho = 4.7\times10^{-4}\,\Omega\cdot m}$$

(19) The volume of material in the wire is constant:

$$V = AL_0 = (\pi r_0^2)L_0 = \text{constant}.$$

So, as the wire is stretched to decrease its radius, the length increases such that

$$(\pi r_f^2)L_f = (\pi r_0^2)L_0.$$

This gives

$$L_f = \left(\frac{r_0}{r_f}\right)^2 L_0 = \left(\frac{r_0}{0.25\,r_0}\right)^2 L_0 = (4.0)^2 L_0 = 16L_0.$$

The new resistance is —

$$R_f = \rho \frac{L_f}{A_f} = \rho \frac{L_f}{\pi r_f^2} = \rho \frac{16 L_0}{\pi (r_0/4)^2}$$

$$= 16(4)^2 \rho \frac{L_0}{\pi r_0^2} = 256 R_0$$

$$= 256 (1.00 \Omega)$$

$$\Rightarrow \boxed{R_f = 256 \Omega}$$

(21) From Definition of Resistance

$$\Delta V = I_i R_i = I_f R_f .$$

$\therefore$ The current in Antarctica is increased because on cooling the resistance reduces

$$I_f = I_i \left(\frac{R_i}{R_f} \right)$$

$$= I_i \left[\frac{R_0 [1 + \alpha (T_i - T_0)]}{R_0 [1 + \alpha (T_f - T_0)]} \right]$$

$$= (1.00 A) \left(\frac{1 + [3.90 \times 10^{-3} (°C)^{-1}](58.0°C - 20.0°C)}{1 + [3.90 \times 10^{-3} (°C)^{-1}](-88.0°C - 20.0°C)} \right)$$

$$\Rightarrow \boxed{I_f = 1.98 A}$$