1. What is the equivalent capacitance of the combination when it is charged through points A and B if \( C_1 = 3 \text{F} \), \( C_2 = 5 \text{F} \), \( C_3 = 3 \text{F} \) and \( C_4 = 6 \text{F} \)?

\[
\frac{1}{C_s} = \frac{1}{3} + \frac{1}{6} = \frac{3}{6}
\]

\[C_s = 2 \text{F}\]

\[
\frac{1}{C_p} = \frac{1}{3} + \frac{1}{5} + \frac{1}{3} = \frac{3}{10}
\]

\[C_p = 10 \text{F}\]
2. A certain wire has a resistance of 20 Ω. What is the resistance of a second wire, made of the same material, that is half as long and has half the diameter?

\[ R_1 = \frac{\rho L}{A} = 20 \Omega \]

\[ R_2 = \frac{\rho \left( \frac{L}{2} \right)}{\frac{1}{4} \pi \left( \frac{d}{2} \right)^2} = 2 \left( \frac{\rho L}{\frac{1}{4} \pi d^2} \right) = 20 \]

\[ = 40 \Omega \]

3. At what temperature would the resistance of a certain wire be 3 times its resistance at 20 degrees Centigrade? The coefficient of resistivity for the wire is 2.0 X 10^{-3} K^{-1}. Assume its length and cross sectional area does not change with temperature.

\[ R = \frac{\rho L}{A} \]

if \( L \cdot A \) do not change \( 3R = 3\rho \)

\[ 3\rho_0 = \rho_0 \left[ 1 + \alpha (T-T_0) \right] \]

\[ 3 = 1 + \alpha (T-T_0) \]

\[ T-T_0 = \frac{2}{\alpha} \]

\[ T = T_0 + \frac{2}{\alpha} = 20^\circ + \frac{2}{2 \times 10^{-3}} \]

\[ = 1000^\circ C \]
4. A car battery with a 12 V emf and internal resistance of 0.05 Ω is being charged by a 100 A current.

a. What is the potential difference across the terminals (i.e. the effective voltage of the battery)? (3 points)

b. What is the rate of energy conversion to chemical form? (2 points)

c. When the battery is providing 60 A to the starter motor, what is the effective voltage? (3 points)

d. What is the rate of energy loss inside the battery when the battery is providing 60 A to the starter motor? (2 points)

\[ V_{\text{eff}} = 12 + (100)(0.05) \]
\[ = 12 + 5 \]
\[ = 17 \text{ V} \]

\[ \text{Power} = VI \]
\[ = (12)(100) \]
\[ = 1200 \text{ Watts} \]

\[ V_{\text{eff}} = 12 - (60)(0.05) \]
\[ = 12 - 3 \]
\[ = 9 \text{ V} \]

\[ P = I^2 R = (60)^2 (0.05) = 180 \text{ Watts} \]
5. For the circuit shown below:

a) What is the magnitude and direction of the current in the center loop?
b) What is the magnitude of $\varepsilon_2$?

\[ \begin{array}{c}
\text{junction} \\
\downarrow 1 \text{A} \\
\uparrow 3 \text{A} \\
\end{array} \]

\[ \begin{array}{c}
\begin{array}{c}
7 \Omega \\
\text{20 V} \\
-23 \text{ V} \\
5 \Omega \\
3 \Omega \\
\end{array}
\end{array} \]

\[ \begin{array}{c}
\begin{array}{c}
- \\
+ \\
\end{array}
\end{array} \]

\[ \begin{array}{c}
\begin{array}{c}
\text{\text{\textleftarrow start here counter clockwise wise}} \\
\end{array}
\end{array} \]

a) Junction 1A entering + 3A leaving

$\Rightarrow$ other current is 2A entering (going left)

b) loop around outside

$+20 - (1)(7) - (3)(3) - \varepsilon_2 = 0$

$\varepsilon_2 = 4 \text{ V}$
6. A particle with mass 3 kg and negative charge of -15 C is accelerated through a potential difference of 10 V. This particle passes horizontally into a region in which there is a uniform magnetic field pointing into the page of magnitude 2 T as shown in the picture.

(a) Will the particle circulate clockwise or counterclockwise?
(b) What is the speed of the particle?
(c) What is the radius if the resulting motion?

\[ \vec{v} \times \vec{B} \text{ direction is up} \]
(-) \( \vec{v} \times \vec{B} \) is down \( \Rightarrow \) Force on negative particle is down
\( \Rightarrow \) clockwise

b) \( KE = PE \)
\[ \frac{1}{2} m v^2 = |q| V \]
\[ v = \left[ \frac{c|q| V}{m} \right]^{\frac{1}{2}} = \sqrt{\frac{(3)(15)(10)}{3}} = 10 \text{ m/s} \]

c) \( R = \frac{mv}{|q|B} = \frac{(3)(10)}{(15)(2)} = 1 \text{ m} \]