16.19 Using conservation of energy, we have $KE_i + PE_i = KE_f + PE_f$.

But $PE_i = k \frac{q \alpha q \text{gold}}{r_i}$, and $r_i = \ldots$ Thus, $PE_i = 0$.

Also $KE_f = 0$ ($v_f = 0$ at turning point), so $PE_f = KE_i$, or

$$k \frac{q \alpha q \text{gold}}{r_{\text{min}}} = \frac{1}{2} m \alpha v^2,$$

and

$$r_{\text{min}} = \frac{2kq \alpha q \text{gold}}{m \alpha v^2} = \frac{2(8.99 \times 10^9 \text{ N m}^2/\text{C}^2)(2e)(79e)}{(6.6 \times 10^{-27} \text{ kg})(2 \times 10^7 \text{ m/s})^2} = 2.8 \times 10^{-14} \text{ m}.$$ 

16.23 (a) If $d$ is doubled while $A$ and $Q$ remain constant, then when $d$ doubles, $C$ is reduced by a factor of 2. Thus, if $Q$ remains constant, then

$$\Delta V_2 = \frac{Q_2}{C_2} = \frac{Q_1}{1/2C_1} = 2 \frac{Q_1}{C_1}, \text{ or } \Delta V_2 = 2 \Delta V_1 = 800 \text{ V}.$$ 

(b) If $d$ is doubled the capacitance reduced by a factor of 2. Thus, if $\Delta V$ is held constant:

$$Q_2 = C_2 \Delta V_2 = \left(\frac{1}{2} C_1\right) (\Delta V_1) = \frac{1}{2} C_1 \Delta V_1 = \frac{1}{2} Q_1,$$

or the charge must be halved.
16.29 (a) Using the rules for combining capacitors in series and in parallel, the circuit is reduced in steps as shown below. The equivalent capacitor is shown to be a 2 µF capacitor.

(b) From Fig. 3: \( Q_{ac} = C_{ac} \Delta V_{ac} = (2.0 \ \mu F)(12 \ \text{V}) = 24 \ \mu C. \)

From Fig. 2: \( Q_{ab} = Q_{bc} = Q_{ac} = 24 \ \mu C. \)

Thus, the charge on the 3.0 µF capacitor is: \( Q_{3} = 24 \ \mu C. \)

We now find the potential differences between the points indicated in Fig. 2:

\[ \Delta V_{ab} = \frac{Q_{ab}}{C_{ab}} = \frac{24 \ \mu C}{6.0 \ \mu F} = 4.0 \ \text{V}, \quad \text{and} \quad \Delta V_{bc} = \frac{Q_{bc}}{C_{bc}} = \frac{24 \ \mu C}{3.0 \ \mu F} = 8.0 \ \text{V} \]

Finally, using Fig. 1: \( Q_4 = C_4 \Delta V_{ab} = (4.0 \ \mu F)(4.0 \ \text{V}) = 16 \ \mu C, \)

and \( Q_2 = C_2 \Delta V_{ab} = (2.0 \ \mu F)(4.0 \ \text{V}) = 8.0 \ \mu C. \)

16.36 The initial charge on the 10.0 µF capacitor is \( Q = (12.0 \ \text{V})(10.0 \ \mu F) = 120 \ \mu C. \)

When the two capacitors are connected in parallel, the voltage across each capacitor is 3.0 V. Thus, the charge remaining on the 10.0 µF capacitor is: \( Q_{10} = C_{10} \Delta V = (10.0 \ \mu F)(3.0 \ \text{V}) = 30.0 \ \mu F. \)

The rest of the 120 µC initial charge is now stored on the new capacitor (i.e., \( Q_C = 120 \ \mu C - 30 \ \mu C = 90 \ \mu C). \) Thus, the second capacitor has a capacitance of:

\[ C = \frac{Q_C}{\Delta V} = \frac{90 \ \mu F}{3.0 \ \text{V}} = 30 \ \mu F. \]
16.39 (a) Each capacitor has voltage $V$, so:

$W = \frac{1}{2} (C_1 + C_2) \Delta V^2 = \frac{1}{2} (25 \times 10^{-6} \text{ F} + 5.0 \times 10^{-6} \text{ F})(100 \text{ V})^2 = 0.15 \text{ J}$.

(b) When in series the equivalent capacitance is $4.167 \mu\text{F}$, and

$0.15 \text{ J} = \frac{1}{2} (4.167 \times 10^{-6} \text{ F}) \Delta V'^2$, or $\Delta V' = 270 \text{ V}$.

17.14 (a) The resistance of the wire is: $R = \frac{\Delta V}{I} = \frac{12 \text{ V}}{0.40 \text{ A}} = 30 \Omega$, and

(b) $\rho = \frac{RA}{L} = \frac{30 \Omega \pi (4.0 \times 10^{-3} \text{ m})^2}{3.2 \text{ m}} = 4.7 \times 10^{-4} \Omega\text{m}$

17.33 (a) The energy $W = $ power times the time used. Thus,

$W = Pt = (90 \text{ J/s})(3600 \text{ s}) = 3.2 \times 10^5 \text{ J}$.

(b) The power consumed by the color set is,

$P = \Delta VI = (120 \text{ V})(2.5 \text{ A}) = 300 \text{ W}$.

Thus, $t = \frac{W}{P} = \frac{3.24 \times 10^5 \text{ J}}{300 \text{ W}} = 1.1 \times 10^3 \text{ s} = 18 \text{ min}$.

17.47 The resistance of the 4.0 cm length of wire between the feet is:

$R = \frac{\rho L}{A} = \frac{(1.7 \times 10^{-8} \Omega \text{ m})(0.040 \text{ m})}{\pi(1.1 \times 10^{-2} \text{ m})^2} = 1.8 \times 10^{-6} \Omega$.

The voltage between the feet is:

$\Delta V = IR = (50 \text{ A})(1.8 \times 10^{-6} \Omega) = 9.0 \times 10^{-5} \text{ V} = 90 \mu\text{V}$

17.49 (a) From the definition of current, we see that: $\Delta Q = I(\Delta T)$.

From this, we see that the charge can be found by finding the total area under a curve of $I$ versus $t$. Thus,

$Q = (\text{area of rectangle } A_1) + 2(\text{area of triangle } A_2)$

$+ (\text{rectangular area } A_3)$.

$Q = (2 \text{ A})(5 \text{ s}) + 2\left(\frac{(1 \text{ s})(4 \text{ A})}{2}\right) + (1 \text{ s})(4 \text{ A}) = 10 \text{ C} + 4 \text{ C} + 4 \text{ C} = 18 \text{ C}$.

(b) The constant current would be: $I = \frac{\Delta Q}{\Delta t} = \frac{18 \text{ C}}{5 \text{ s}} = 3.6 \text{ A}$. 