1)
   a) $V = 6.0$ V, capacitance, $C = 1 \times 10^{-12}$ F, therefore from $C = Q/V$, where Q is the charge stored on each capacitor plate…$Q = CV = 6 \times 10^{-12}$F.

   b) $V = 6.0$ V, capacitance, $C = 1 \times 10^{-3}$ F, therefore from $C = Q/V$, where Q is the charge stored on each capacitor plate…$Q = CV = 6 \times 10^{-3}$F.

2)

   a) Given that $C = \varepsilon_0 A/d$, where we want C to be 1×10^{-6}F and we're also given $d = 0.001$m, then using the value for $\varepsilon_0 = 8.85 \times 10^{-12} C^2/N.m^2$, $A = Cd/\varepsilon_0 = 113$ m^2.

   b) Given that $C = k\varepsilon_0 A/d$, where we're told C is 1×10^{-6}F, $A = 1$ m^2 and $k = 4.0$ what is d? $d = k\varepsilon_0 A/C = 0.035$mm.

3)

   Voltage across a capacitor is itself a function of the separated charge: $V = Q/C$. Therefore when we integrate $\int V dQ = \int Q/C \, dQ = \frac{1}{2} Q^2/C = \frac{1}{2} VQ$.

4)
   a) Power = energy output/ time. Energy $= 200W \times 0.001s = 0.2$J

   b) From Energy stored $= \frac{1}{2} VQ = \frac{1}{2} V^2 C$… $V^2 = 2 \times 0.2J/(160 \times 10^{-6}F) = 50V$.

   c) Using $Q = CV$…$Q = 160 \times 10^{-6}F \times 50V = 8 \times 10^{-3}C$

5)

   a) (i)The capacitor is isolated, and given the conservation of charge, no change in the charge on the capacitor plates will occur (However, the electric field around those charges will be changed!). (ii) Remember the definition $C = k\varepsilon_0 A/d$, therefore the capacitance increases by k. (iii) $V=Q/C$. If Q is constant and C increases by k, therefore V decreases by k. (iv) Stored energy $= \frac{1}{2} VQ$ therefore decreases by k.

   b) (i) Now an emf source is connected in series. This will provide whatever charge is required to maintain the voltage across the capacitor - (ii) Again, from the definition $C = k\varepsilon_0 A/d$, capacitance increases by k. but using $Q=VC$, If V is constant and C increases by k, therefore Q increases by k. (iii) constant (iv). Stored energy $= \frac{1}{2} VQ$ therefore increases by k.

6)

a) Using $Q = CV$, therefore $Q = 3.0V \times 2.0 \times 10^{-6}F = 6.0 \times 10^{-6}$ C. Note that the positive terminal of the battery connects with the left-hand plate of the capacitor.

b) Stored energy in the capacitor $= \frac{1}{2} VQ = 3.0V \times 6.0 \times 10^{-6}C = 9.0 \times 10^{-6}J$

c) Power provided by the emf source $P = VI$. Work done $= \int P dt$ and note that $I = dQ/dt$, therefore Work done $= \int V(dQ/dt)\, dt = \int V dQ = 18 \times 10^{-6}J$.

d) As the capacitor charges, a current flows around the circuit. From the principle of the conservation of energy, the energy dissipated in the resistor will = Work done - stored energy in the capacitor $= 9.0 \times 10^{-6}J$.

7)

a) Note that the voltage across separate branches of a parallel circuit is the same. The total charge stored $(Q_1 + Q_2) = (C_1 + C_2)V$. If and equivalent capacitor was made: $C_p = C_1 + C_2$, then the stored charge remains the same except $(Q_1 + Q_2) = C_pV$.

b) $C_p = C_1 + C_2 = 6 \times 10^{-6}$ F.

8)

a) Note that the magnitude of the charge on each capacitor plate in series has to be the same. In the diagram $+Q$ at (a) is matched by $-Q$ at (b), but if the section (b)-(c) conforms to the principle of conservation of charge, then (c) must also have $+Q$ and correspondingly (d) has $-Q$. The voltage across C_1 is $V_1 = Q/C_1$ and across C_2, $V_2 = Q/C_2$. The total voltage between (a) and (d) is $V_s = V_1 + V_2$, so an equivalent capacitor that satisfies $V = Q/C_s$ would be defined by $1/C_s = 1/C_1 + 1/C_2$.

b) Using $1/C_s = 1/C_1 + 1/C_2$, $1/C_s = 1/2 \times 10^{-6}$ F $+ 1/4 \times 10^{-6}$ F. Therefore $C_s = 1.3 \times 10^{-6}$ F

9)

The current equals the flow of ions across the cell. First find the total charge discharged = current (C/s) $\times$ time (s) $= 0.5A \times 3600 = 1800$ C. Now each ion carries the charge of two electrons $= 2 \times e^-$ ($e^- = 1.6 \times 10^{-19}C$) so the number of ions discharged = total charge divided by the charge on one ion $= 1800/(2e^-) = 5.7 \times 10^{-21}$.

10)

Current = (density of carriers) × (Area) × (carrier charge) × (drift velocity, v_d).

$10A = (5.8 \times 10^{28})$ m^{-3} × (Pi × $(0.001)^2$) m^2 × 1.6×10^{-19}C × v_d

hence, $v_d = 3.43 \times 10^{-4}$.

11)

Resistance = resistivity × length / area

Resistance of nerve fibre = 2 ohm.m × 0.3m / (Pi × $(5 \times 10^{-6})^2$) = 7.6×10^9 ohms.

12)

Using the same relation ship as in Q 11) but this time solving for Area:

Area = Pi × radius^2 = resistivity × length / resistance. Hence

radius^2 = (1/Pi) × 1.72×10^{-8} ohm.m × 2.0m/ 0.010 ohms.

Then radius = 1.05×10^{-3} m.

13)

a) Using Ohm's Law: V =IR , I = V/R = 6A.

b) Charge = $\int I dt$ = 6A × 10s = 60C.

c) (Work done *against* electrical forces)/Q = Potential difference. In the battery the charges are moved *with* the electrical forces thus Work done = -QV = -720J

d) The electrical forces in the resistor are working against the flow of charges. Since there are no other components to the circuit the voltage across the resistor = 12V. Then, Work done = QV = 720J.

e) Total work done by the electrical fields on the charges = 720J – 720J = 0. You could also think of this problem as moving a charge around a closed loop (i.e. the entire circuit) and the integral of the electric field around any closed loop is zero, hence the potential difference is zero and therefore QV = 0.

f) The work done by the electrical fields is transformed into heat energy in the resistor. When this dissipates the heat energy is given off = work done by electric field = 720J.

g) The ultimate source of the energy is the chemical energy from the reactions in the battery.

14)

    a) Using V =IR, V = I × (1ohms + 2ohms + 6ohms), therefore I = 6V/9ohms =0.67A

    b) For 1 ohm: V =I×1ohms = 0.67 V; for 2 ohm: V =I×2ohms = 1.33 V; for 6 ohm: V =I×6ohms = 4.0 V

15)

    a) Net V around circuit = 1.5V. Total R = 10 ohms. Therefore I = V/R = 0.15A

    b) Moving clockwise from the first battery describe the potential difference across each battery with respect to the clockwise direction. Note that the resistors act electrically like a battery facing the wrong way, hence the negative value for the voltage drop across each resistor. Make sure that Kirchoff's Loop law hold and that the net change in potential around the circuit = 0V