HW #6 Solutions

Ch. 19

Q19) No, the total energy supplied by the battery is not stored in the capacitor. Some of the energy is dissipated as heat, as the charge flows from the battery to the capacitor through the resistor. Recall from lecture that as the capacitor was charging the light glowed for a while, until the capacitor was fully charged. That light represents energy, so by conservation of energy, the battery has to supply the energy needed to light the bulb, or send current through a resistor, in addition to the energy stored in the capacitor.

P27) The current choices are up to you, but for example, make I_1 to the left through the 22 ohm resistor, I_2 to the right through the 15 ohm resistor, and I_3 to the right through the 6 V battery. Then $I_1 = I_2 + I_3$.

Going around the top loop counterclockwise starting between the battery and the 15 ohm resistor gives

$$-I_2 \times 15 + -I_1 \times 22 + 9 = 0$$

Going around the bottom loop in a clockwise direction gives

$$-I_2 \times 15 + -6 = 0.$$

Solving the bottom loop equation gives $I_2 = -0.4$ A. This shows that the current through the 15 ohm resistor actually goes from right to left, not left to right as we assumed when setting up the currents.

Plugging -0.4 A into the top loop equation and solving for I_1 gives $I_1 = 15/22 = 0.68$ A.

The problem doesn't ask for it, but using the junction equation gives $I_3 = 1.08$ A

P31) Set I_1 to be down through the 12 ohm resistor, I_2 up through the 6 ohm resistor, and I_3 up through the 10 ohm resistor. Then from the bottom junction we get $I_1 = I_2 + I_3$.

Going around the left hand loop counterclockwise starting between the 8 ohm and the 12 ohm resistor gives

$$-I_1 \times 8 + -I_2 \times 6 + 6 + -I_1 \times 12 = 0,$$

which simplifies to

$$-I_1 \times 20 + -I_2 \times 6 = -6.$$

Going around the right hand loop counterclockwise starting below the 10 ohm resistor gives

$$-I_3 \times 10 + 3 + -I_3 \times 2 + I_2 \times 6 = 0,$$

which simplifies to

$$I_2 \times 6 + -I_3 \times 12 = -3$$

Replacing I_1 in the left loop equation with $I_2 + I_3$ gives

$$-(I_2 + I_3) \times 20 + -I_2 \times 6 = -6$$
or
$$-I_2 \times 26 + -I_3 \times 20 = -6$$

Multiply this last equation by $\frac{6}{26}$ to get $-I_2 \times 26 \times \frac{6}{26} + -I_3 \times 20 \times \frac{6}{26} = -6 \times \frac{6}{26}$

Simplifying gives $-I_2 \times 6 + -I_3 \times 4.615 = -1.38$.

Now add this equation to the last equation on the previous page. The I_2 terms cancels and we get:

$$-I_3 \times 12 + -I_3 \times 4.615 = -3 + -1.38 = -4.38$$
or
$$-I_3 \times 16.615 = -4.38$$
so
$$I_3 = 0.264A$$

Plugging this value into the first equation on this page and solving for I_2 gives $I_2 = 0.0277$ A.

Now using the junction equation gives $I_1 = 0.264 + 0.0277 = 0.292$ A.

P51) In section 19-6 you will find the equation $V_c = V_0 e^{-t/RC}$ which describes the discharge of a capacitor. If you set $V_c = 0.01\ V_0$ and solve for t, you will find that t = 0.092 s. Note RC = (6700 ohms) x (3.0 x 10-6 farad) = 0.020 s.

$$0.01V_0 = V_0 e^{-t/0.020}$$

Canceling out the V_0 and taking the natural log of both sides gives:

$$\ln(0.01) = \ln(e^{-t/0.020})$$
$$-4.605 = -t/0.020$$
$$t = -4.605 \times -.020 = 0.092 \text{ s.}$$

Ch. 20

Q6) The two iron bars cannot both be magnets, or they would repel when like ends were brought together. One must be a magnet and the other is just iron.

Q10) By the RHR, particle **a** is positive, particle **c** is negative and since it does not deflect, particle **b** is neutral.

P10) The angle between v and B is 90 degrees, so F=qvB = 1.05 x 10^{-13} N. The right hand rule says the force is South, but since it is an electron, the force is North.

AP1) The voltage across the 2 uF capacitor is 12 V. Since the capacitors have the same charge, and the charge is given by Q=CV, we have

$$3uF \times V_3 \quad = 4uF \times V_4 \quad .$$

But we also know that $V_3 + V_4 = 12V$.

Solving these 2 equations in 2 unknowns gives $V_3 = \dfrac{4}{7} \times 12 = 6.8V$, and $V_4 = \dfrac{3}{7} \times 12 = 5.1V$.

Alternatively, one could find the equivalent capacitance of the two capacitors. They are in series so

$\dfrac{1}{C} = \dfrac{1}{C_1} + \dfrac{1}{C_2} = \dfrac{1}{3} + \dfrac{1}{4} = \dfrac{4}{12} + \dfrac{3}{12} = \dfrac{7}{12}$, so C = 12/7 = 1.71 uF.

Now use Q = CV = 1.71 uF x 12 V= 20.5 x 10^{-6} C. But this is the charge on each capacitor. So

using Q = CV to find V we have V_3 = Q/C=20.5/3 = 6.8 V and V_4 = 20.5/4 = 5.1 V.

AP2)

a) The voltmeter is in parallel with the 2800 ohm resistor. The equivalent resistance of the two is 2724 ohms. Adding the resistance of the ammeter gives 2729 ohms.

b) I = V/R = 12/2729 = 0.004397 A

c) V = IR = 0.004397 x 2724 = 11.98 volts

d) R = V/I = 2725 ohms

AP3) F = ILB = mg. Solving for I gives I = $\dfrac{mg}{LB} = \dfrac{0.005 \times 9.8}{0.10 \times 0.05} = 9.8A$