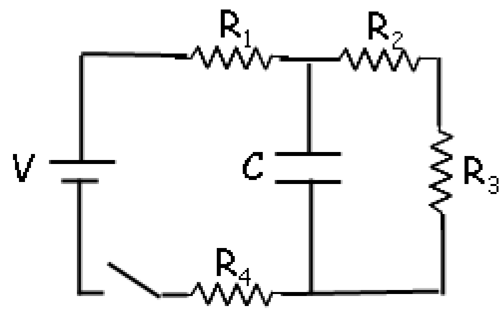
A circuit is constructed with four resistors, one capacitor, one battery and a switch as shown. The values for the resistors are: $R_1 = R_2 = 54\ \Omega$, $R_3 = 83\ \Omega$ and $R_4 = 70\ \Omega$. The capacitance is $C = 78\ \mu F$ and the battery voltage is $V = 24$ V.



1) The switch has been open for a long time when at time t = 0, the switch is closed. What is $I_1(0)$, the magnitude of the current through the resistor R_1 just after the switch is closed?

$$I_1(0) = \frac{V}{R_1 + R_4}$$

I1(0)=24 V/(54+70)Ω = .19 A

2) What is $I_1(\infty)$, the magnitude of the current that flows through the resistor R_1 a very long time after the switch has been closed?

$$I_1(\infty) = \frac{V}{R_1 + R_2 + R_3 + R_4}$$

I1=24 V/(54+54+83+70)Ω = .0919 A

3) What is $Q(\infty)$, the charge on the capacitor after the switch has been closed for a very long time?

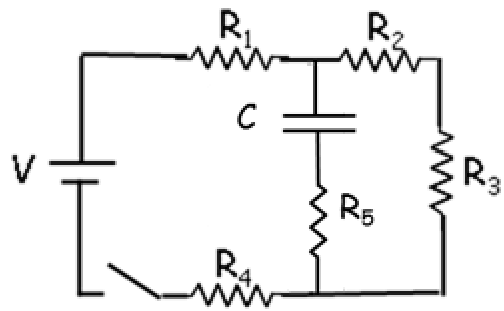
1. A current loop equation to find the voltage across the capacitor, Vc
   First note I1=I4 at t->infinity

   V-I1 R1-Vc-I4 R4=0 so Vc=V-I1 R1-I4 R4 = 24-4.96-70(.0919) = 12.607 V

2. Now use Q=VC

Q=VcC= 12.607 V(78 F)x 10^{-6}=983.346 μC

4)



Consider the circuit above, with R_5 = 60 Ω in series with the capacitor. Once again, the switch has been open for a long time when at time t = 0, the switch is closed. What is $I_1(0)$, the magnitude of the current through the resistor R_1 just after the switch is closed?

At t=0

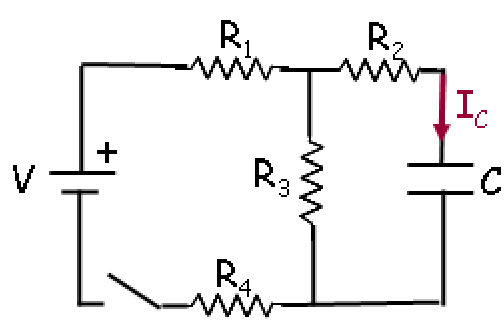
V=IR1+IR523+IR4, where R235 is the equivalent resistance you get when you collapse R2, R3 and R5 into a single resistor. R23=R2+R3=137 Ω and 1/R235=1/R23+1/R5=(.007+.0167)1/ Ω so that R235=42.25 Ω

So I=V/(R1+R523+R4)=24 V/(42.25 Ω+54 Ω+70 Ω)=.144 A

4) Continuing with the new circuit, what is Q(∞), the charge on the capacitor after the switch has been closed for a very long time?

   Find I at a very long time. V=I(R1+R2+R3+R4), I=24/261=.09A
   Find V across C: V=IR23=12.59V
   Use Q=VC=(12.5V)(78uF)=982uC

A circuit is constructed with four resistors, one capacitor, one battery and a switch as shown. The values for the resistors are: $R_1 = R_2 = 57$ Ω, R_3= 81 Ω and R_4 = 123 Ω. The capacitance is C = 38 μF and the battery voltage is V = 12 V. The positive terminal of the battery is indicated with a + sign.



1) The switch has been open for a long time when at time t = 0, the switch is closed. What is $I_4(0)$, the magnitude of the current through the resistor R_4 just after the switch is closed?

$$R_{equiv}(0) = R_1 + R_4 + \frac{R_2 R_3}{R_2 + R_3} \Rightarrow I_4(0) = \frac{V}{R_{equiv}(0)}$$

Requiv=213.24 Ω

I4(0)=12 V/(Requiv)= .056 A

2) What is Q(∞), the charge on the capacitor after the switch has been closed for a very long time?

$$Q(\infty) = I(\infty) R_3 C = CV \frac{R_3}{R_1 + R_3 + R_4}$$

Q=12 V 38 μF 81Ω/(57+81+123) Ω = 141 μC

3) After the switch has been closed for a very long time, it is then opened. What is $Q(t_{open})$, the charge on the capacitor at a time t_{open} = 729 μs after the switch was opened?

$$\tau = (R_2 + R_3)C \Rightarrow Q(t_{open}) = Q(\infty) e^{-t_{open}/\tau}$$

T=(R2+R3)C=5244μs

Q(729 μs)=141 μC exp(-729 μs/T)=123 μs

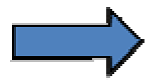
4) What is $I_{C,max}$(closed), the current that flows through the capacitor whose magnitude is maximum during the time when the switch is closed? A positive value for the current is defined to be in the direction of the arrow shown.

$$V_3(0) = V - I_4(0)(R_1 + R_4) \Rightarrow I_{C,\max}(0) = \frac{V_3(0)}{R_2} = \frac{V - I_4(0)(R_1 + R_4)}{R_2}$$

Ic=.033 A

5) What is $I_{C,max}$(open), the current that flows through the capacitor whose magnitude is maximum during the time when the switch is open? A positive value for the current is defined to be in the direction of the arrow shown.

$$I(t_{open}) = \frac{dQ(t_{open})}{dt_{open}} = -\frac{Q(\infty)}{\tau} e^{-t_{open}/\tau}$$



$$I_{C,\max}(0, open) = -\frac{Q(\infty)}{\tau} = -\frac{Q(\infty)}{(R_2 + R_3)C}$$

Ic=-.026 A