1. (6 points) An air-filled, parallel-plate capacitor is connected to a battery and allowed to fully charge. While still connected to the battery, the plate separation is changed so that the charge increases by 25%. By what percentage did the distance between the plates change?

   (A) The distance decreased by 20%

   (B) The distance increased by 20%

   (C) The distance decreased by 25%

   (D) The distance increased by 25%

   (E) The distance decreased by 56%

   (F) The distance increased by 56%

   (G) The distance decreased by 36%

   (H) The distance increased by 36%

   Points Per Response:
   A: 6
   B: 4
   C: 2
   D:
   E: 2
   F:
   G: 2
   H:

2. (4 points) In a simple RC-circuit like the one shown below, it takes a time T for the capacitor to be fully charged according to the "5 time constant" rule *if* the capacitor was uncharged when the switch was closed. What if instead, the capacitor already had half of the full charge when the switch was closed? Which of the following describes how much time t it would take to reach full charge?

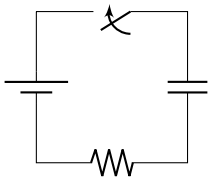
   (A) $t = T$

   (B) $0.5T < t < T$

   (C) $t = 0.5T$

   (D) $0 < t < 0.5T$

   (E) It is impossible to tell without values.



   Points Per Response:
   A:
   B: 4
   C:
   D: 1
   E:

3. (6 points) A variable resistor is created using a 2.00 m long bar that has a rectangular cross-section that is 2.00 mm by 1.00 mm. The material in the bar has a resistivity of 1.20×10^{-6} Ωm. For a particular application, a 3.00-V battery will be attached to the bar which will provide the only resistance in the circuit. If there is supposed to be 2.00 A of current in the circuit, what distance x from the left end of the bar should the circuit be connected? Use the figure below for reference.

(A) 1.11 m

(B) 1.60 m

(C) 0.900 m

(D) 0.610 m

(E) 1.25 m

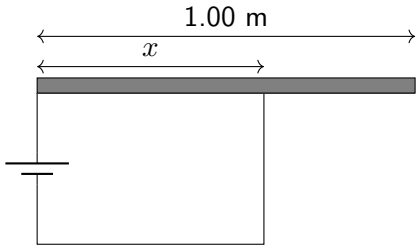
(F) 0.166 m

(G) 1.84 m

(H) The bar is not long enough for this to happen under these conditions.

Points Per Response:

A: 2
B:
C:
D:
E:
F:
G:
H: 6



4. (8 points) How much charge is stored on the capacitor in the circuit below a very long time after the switch is closed?

(A) 1.88 mC

(B) 1.41 mC

(C) 5.64 mC

(D) 2.82 mC

(E) 0.743 mC

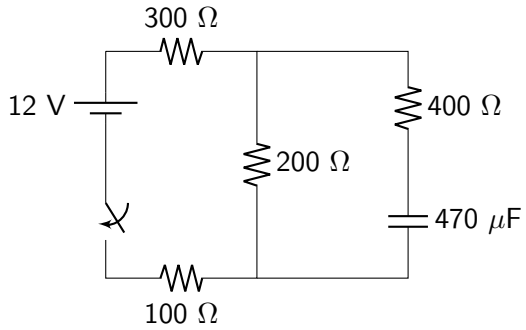
(F) 3.37 mC

(G) 6.74 mC

(H) 8.59 mC

Points Per Response:

A: 8
B: 5
C: 3
D: 5
E:
F:
G:
H:



5. (8 points) In the circuit below you are given two of the currents and know that they are moving in the direction shown. What is the potential difference $V_A - V_B$?

(A) -7.05 V

(B) +7.05 V

(C) -20.9 V

(D) +20.9 V

(E) -4.93 V

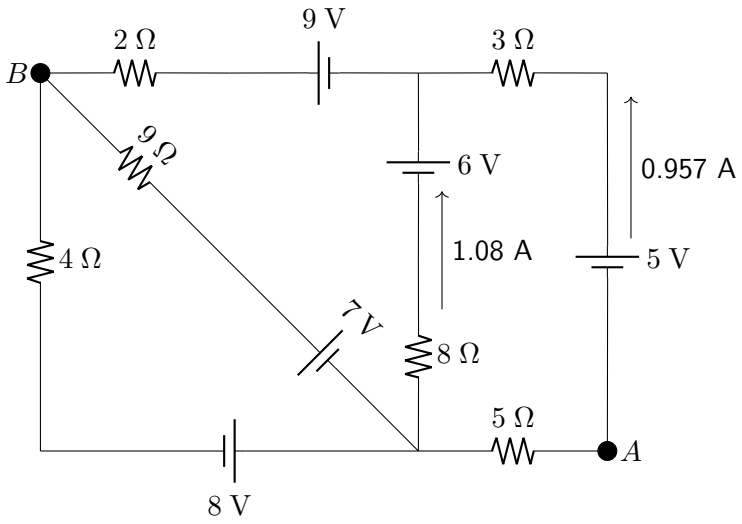
(F) +4.93 V

(G) -16.7 V

(H) +16.7 V

Points Per Response:

A: 8
B: 6
C: 3
D: 3
E: 1
F:
G:
H:



6. (6 points) In the circuit below, you know that $C_1 > C_2$. What do you know about the charges stored on the capacitors (Q_1 and Q_2 respectively) and the potential at A relative to the potential at B?

(A) $Q_1 > Q_2$ and $V_A > V_B$

(B) $Q_1 = Q_2$ and $V_A > V_B$

(C) $Q_1 < Q_2$ and $V_A > V_B$

(D) $Q_1 > Q_2$ and $V_A = V_B$

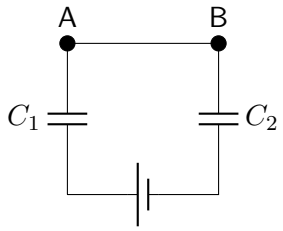
(E) $Q_1 = Q_2$ and $V_A = V_B$

(F) $Q_1 < Q_2$ and $V_A = V_B$

(G) $Q_1 > Q_2$ and $V_A < V_B$

(H) $Q_1 < Q_2$ and $V_A < V_B$

Points Per Response:
A:
B: 3
C:
D: 3
E: 6
F: 3
G:
H:



7. (8 points) The figure below shows 3 incandescent light bulbs that behave like resistors with the labeled values. What is the power dissipated in the brightest light bulb?

(A) 2.92 W

(B) 1.90 W

(C) 0.0893 W

(D) 1.20 W

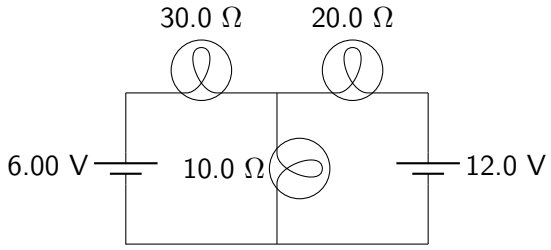
(E) 7.20 W

(F) 32.4 W

(G) 10.8 W

(H) 16.2 W

Points Per Response:
A: 8
B: 6
C: 6
D:
E:
F:
G:
H:



8. (4 points) Assuming the battery has been connected to the circuit for a long time, which resistors DO NOT contribute to calculating the power dissipated across the battery's internal resistance?

(A) R_4 and R_6

(B) R_4, R_6 and r

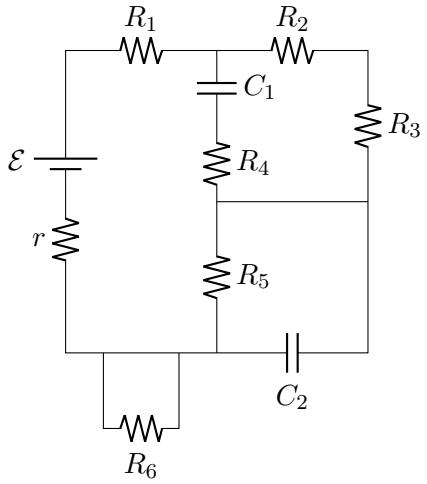
(C) R_2 and R_3

(D) R_4 and R_5

(E) Only r contributes

(F) R_5 and R_6

Points Per Response:
A: 4
B: 2
C:
D: 1
E:
F: 1



9. (8 points) An air-filled capacitor is connected in series to a battery of potential V. The initial charge on the capacitor is Q_0 after being connected to the battery for a long time. If the charge on the capacitor is supposed to increase to $4Q_0$ while staying connected to the battery, what percentage of the volume should be filled with a dielectric of $\kappa = 8.00$? Assume the dielectric filled the whole plate area but only part of the separation distance as shown below.

(A) 85.7%

(B) 50.0%

(C) 91.4%

(D) 76.2%

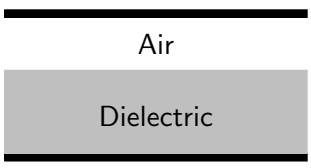
(E) 33.3%

(F) 28.2%

(G) 44.1%

(H) 10.8%

Points Per Response:
A: 8
B:
C: 6
D: 4
E:
F:
G: 4
H:



10. (8 points) Four identical 1.0 μF capacitors are connected to a battery of potential $V = 10$ V as seen below. How much does the charge delivered by the battery change when the switch closes?

(A) Charge increases by 20 μC

(B) Charge decreases by 20 μC

(C) Charge increases by 16 μC

(D) Charge decreases by 16 μC

(E) Charge increases by 12 μC

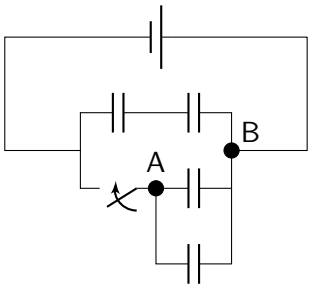
(F) Charge decreases by 12 μC

(G) Charge increases by 8.0 μC

(H) Charge decreases by 8.0 μC

Points Per Response:

A: 8
B: 5
C: 1
D: 4
E:
F:
G:
H:



11. (4 points) In the previous circuit what happens to $|V_{AB}|$, the absolute value of the potential difference between A and B when the switch closes?

(A) $|V_{AB}|$ increases

(B) $|V_{AB}|$ decreases

(C) $|V_{AB}|$ does not change

Points Per Response:

A: 4
B:
C:

12. (6 points) What is the effective resistance of the circuit below? Treat each resistor as identical with resistance R.

(A) $\frac{R}{3}$

(B) $\frac{R}{2}$

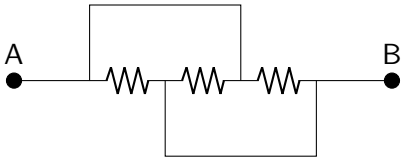
(C) $\frac{3R}{2}$

(D) $\frac{2R}{3}$

(E) R

(F) $2R$

(G) $3R$



Points Per Response:
A: 6
B: 4
C:
D:
E: 2
F:
G: 3

13. (8 points) A battery with $\mathcal{E} = 12$ V is connected with $R_1 = 6.0\ \Omega$, $R_2 = 3.0\ \Omega$, and $C = 4.0\ \mu$F as shown below. The switch is closed until the capacitor reaches 50% of maximum charge then the switch is immediately opened. How long does it take for the capacitor to fall below 1.0% of maximum charge from the time the switch was opened?

(A) 141 μs

(B) 46.9 μs

(C) 166 μs

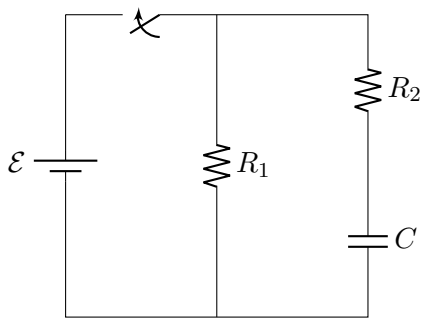
(D) 55.3 μs

(E) 88.3 μs

(F) 11.1 μs

(G) 74.2 μs

(H) 249 μs



Points Per Response:
A: 8
B: 6
C: 6
D: 4
E:
F:
G:
H:

14. (8 points) A spherical capacitor is created using two concentric spherical shells of radius 2.00 and 5.00 m respectively. What is the capacitance of this capacitor if there is only air between the shells?

(A) 371 pF

(B) 148 pF

(C) 927 pF

(D) 538 pF

(E) 748 pF

(F) 234 pF

(G) 833 pF

(H) 465 pF

Points Per Response:

A: 8
B: 4
C: 4
D: 5
E:
F:
G:
H:

15. (4 points) A parallel plate capacitor is connected in series to a battery. The capacitor is fully charged and then while staying connected to the battery, the plate separation is doubled. What happens to the energy stored in the capacitor?

(A) The energy decreases by a factor of 4

(B) The energy decreases by a factor of 2

(C) The energy stays constant

(D) The energy increases by a factor of 2

(E) The energy increases by a factor of 4

Points Per Response:

A:
B: 4
C:
D:
E:

16. (4 points) What happens to the magnitude of the electric field between the plates of the capacitor when the plate separation was doubled in the previous problem?

(A) The electric field decreases by a factor of 4

(B) The electric field decreases by a factor of 2

(C) The electric field stays constant

(D) The electric field increases by a factor of 2

(E) The electric field increases by a factor of 4

Points Per Response:

A:
B: 4
C:
D:
E: