Circuit Lab Test - Summer Exchange

South Brunswick High School Science Olympiad

Section 1. Multiple Choice

1. A given circuit uses 125 watts of power. If the circuit has a total resistance of 5Ω, at what voltage must it be operating
   (a) 5V
   (b) 15V
   (c) 25V
   (d) 45V
   (e) 625V

2. When two identical resistors are connected in series to a battery, the total power dissipated is P. When the same two resistors are connected in parallel to the same battery, the total power dissipated is
   (a) $\frac{1}{4}P$
   (b) $\frac{1}{2}P$
   (c) P
   (d) $2P$
   (e) $4P$

3. The slope of a charge vs. time graph for an RC circuit represents
   (a) the total charge on the capacitor plates
   (b) the potential energy of the capacitor
   (c) the resistance of the circuit
   (d) the instantaneous voltage of the capacitor
   (e) the instantaneous current of the circuit

4. Which of the following combinations of values for total resistance, R, and capacitance, C, would produce an RC circuit that reached its maximum charge (on the capacitor) most quickly?
   (a) $R = 4\Omega$; $C = 20\mu F$
   (b) $R = 6\Omega$; $C = 35\mu F$
   (c) $R = 8\Omega$; $C = 30\mu F$
   (d) $R = 4\Omega$; $C = 35\mu F$
   (e) $R = 8\Omega$; $C = 40\mu F$

5. When two resistors have resistances R_1 and R_2 are connected in parallel, the equivalent resistance of the combination is 10Ω. Which of the following statements about the resistances is true?
   (a) Both R_1 and R_2 are greater than 10Ω.
   (b) Both R_1 and R_2 are equal to 10Ω.
   (c) Both R_1 and R_2 are less than 10Ω.
   (d) The sum of R_1 and R_2 is 10Ω.
   (e) One of the resistances is greater than 10Ω, and the other is less than 10Ω.

6. A battery whose emf is $40V$ has an internal resistance of 5Ω. If the battery is connected to a 15Ω resistor R , what will the voltage drop across R be?
   (a) 10V
   (b) 30V
   (c) 40V
   (d) 50V
   (e) 70V

7. How many windings must a solenoid of length $80cm$ have in order to establish a magnetic field of strength $0.2T$ inside the solenoid, if it carries a current of $20A$
   (a) 1000
   (b) 6400
   (c) 10000
   (d) 32000
   (e) 64000

8. A magnetic field perpendicular to the plane of a wire loop is uniform in space but changes with time t in the region of the loop. If the induced emf in the loop increases linearly with time t, then the magnitude of the magnetic field must be proportional to

   (a) t^3
   (b) t^2
   (c) t
   (d) t^0
   (e) $t^{1/2}$

Section 2. Short Answer

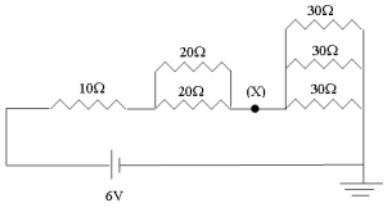
9. Provide formulas for the following: (4pts)
   a. Work (W) as a function of Voltage (V), Current (I), and Time (T)
   b. Energy (E) as a function of Voltage (V), Resistance (R), and Time (T)
   c. Charge (Q) as a function of Current (I) and Time (T)
   d. Current (I) as a function of Power (P) and Resistance (R)

10. What SI unit is V^2F equal to? (V stands for Volts and F for Farad)? (2pts)

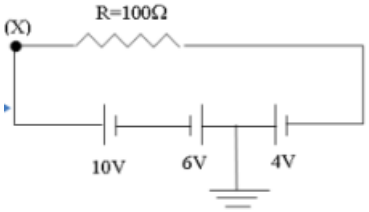
11. What is Kirchoff's Voltage Law? (2pts)

12. What is Kirchoff's Current Law? (2pts)

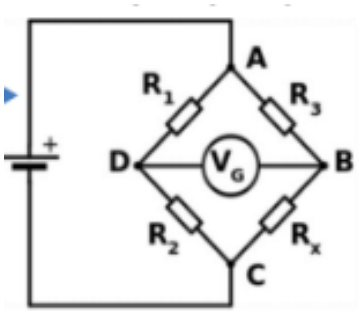
13. How does an inductor work? Explain the theory and concepts behind an inductor. (4 pts)

14. 

    For the circuit above, answer the following. (6pts)
    a. Calculate the value of the voltage at point (X).
    b. What is the total current out of the 6V battery?
    c. What is total work/energy out of the circuit after an hour?

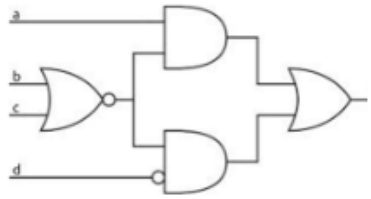
15. 

    For the circuit above, answer the following: (6pts)
    a. What is the value of the potential (voltage) at point (X)?
    b. What is the current across the 100 resistor?
    c. What is the power across the 100 resistor?

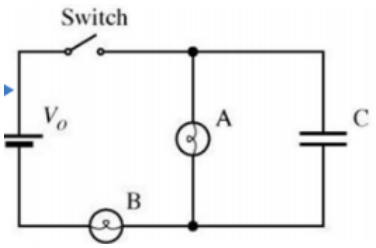
16. 

For the Wheatstone Bridge above, we are searching for an unknown Rx given known values for R_1, R_2, and R_3. (4pts)

a. If R1 = 57 k, R2= 2.2M, and R3= 1, what must Rx equal to make this Wheatstone Bridge circuit balanced?

17. 

Please convert the logic gate circuit into boolean expressions (ex. AB+C,DC,etc.) Answer for the output in terms of A, B, C, D. You do not need to simplify. (4pts)

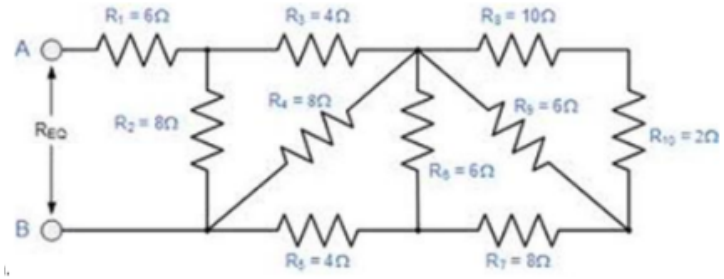
18. 

Please solve for the following with the circuit to the right, assuming that the switch is closed for a very long time, until t=0 and then the switch is opened for a very long time. Vo=12V, each light bulb has 3 resistance and the Capacitor is 200mF. (6pts)

a. What is the voltage across the Capacitor at t=0

b. What is the time constant of the circuit when t is greater than 0 (2 points)

c. What is the complete formula for the voltage of the capacitor for all time, when t is greater than 0 (3 points)

19. 

Solve for the equivalent resistance between nodes a and b. (4pts)

20. Determine the values of the following resistors based upon markings

For help in determining color, use this key

R is Red	Gn is Green	Blu is Blue	O is Orange	W is White	S is Silver
Y is Yellow	Br is Brown	Gy is Gray	Blk is Black	V is Violet	Gd is Gold

a. 

b. 

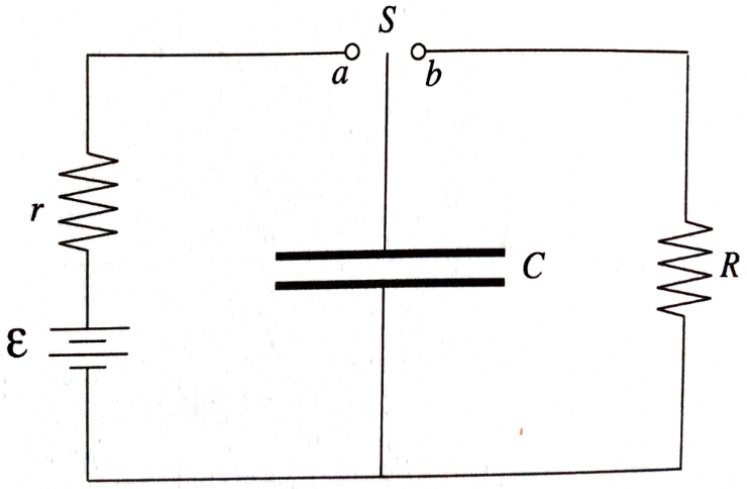
c. 

d. 

Determine the values and tolerance of each of the following resistors based upon markings, read from left to right. (8pts, 1pt for resistance, 1pt for tolerance)

Section 3. Free Response

21. The diagram below shows an uncharged capacitor, two resistors, and a battery whose emf is $\mathcal{E}$



The switch S is turned to a point a at time $t = 0$ (Express all answers in terms of C, r, R, $\mathcal{E}$, and fundamental constants)

(a) Determine the current through r at time $t = 0$

(b) Compute the time required for the charge on the capacitor to reach one-half its final value?

(c) When the capacitor is fully charged, which plate is positively charged?

(d) Determine the electrical potential energy stored in the capacitory when the current through r is zero

When the current through r is zero, the switch S is moved to Point b; for the following parts, consider this event time $t = 0$

(a) Determine the current through R as a function of time.

(b) Find the power dissipated in R as a function of time

(c) Determine the total amount of energy dissipated as hear by R.

Answer Key for Exam A

Section 1. Multiple Choice

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   (a) $\frac{1}{4}P$
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   [(e)] $4P$

3. The slope of a charge vs. time graph for an RC circuit represents

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   c. Charge (Q) as a function of Current (I) and Time (T)
   d. Current (I) as a function of Power (P) and Resistance (R)

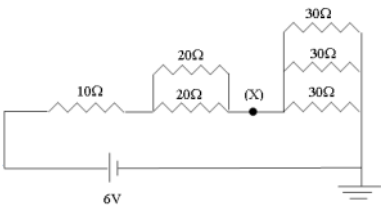
   W=VIT $E = V^2T/R$ Q=IT I=$\sqrt{\frac{P}{R}}$

10. What SI unit is V^2F equal to? (V stands for Volts and F for Farad)? (2pts) Joule (J)

11. What is Kirchoff's Voltage Law? (2pts) for a closed loop series path the algebraic sum of all the voltages around any closed loop in a circuit is equal to zero

12. What is Kirchoff's Current Law? (2pts) At any node (junction) in an electrical circuit, the sum of currents flowing into that node is equal to the sum of currents flowing out of that node

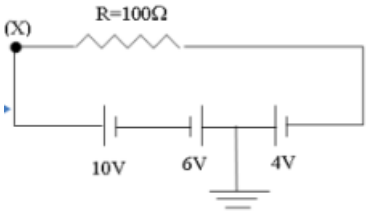
13. How does an inductor work? Explain the theory and concepts behind an inductor. (4 pts)

14. 

    For the circuit above, answer the following. (6pts)

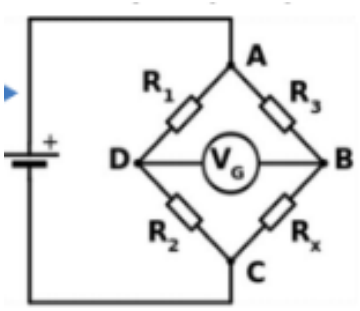
a. Calculate the value of the voltage at point (X).
b. What is the total current out of the 6V battery?
c. What is total work/energy out of the circuit after an hour? a. 2 V b. 0.2 A c. 43.2 kW

15.



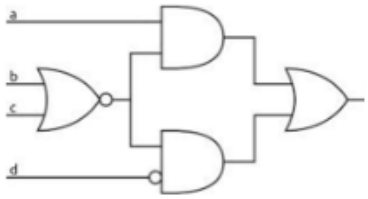
For the circuit above, answer the following: (6pts)
a. What is the value of the potential (voltage) at point (X)?
b. What is the current across the 100 resistor?
c. What is the power across the 100 resistor? a. 4 V b. 0.08 A c. 0.64 W

16.



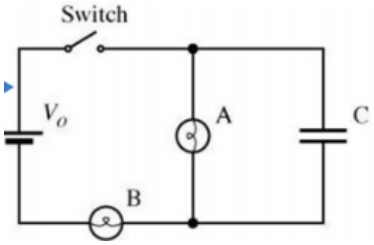
For the Wheatstone Bridge above, we are searching for an unknown Rx given known values for R_1, R_2, and R_3. (4pts)
a. If R1 = 57 k, R2= 2.2M, and R3= 1, what must Rx equal to make this Wheatstone Bridge circuit balanced? 38.6 Ohms

17.



Please convert the logic gate circuit into boolean expressions (ex. AB+C,DC,etc.) Answer for the output in terms of A, B, C, D. You do not need to simplify. (4pts)
a. A $\overline{b}\overline{c} + \overline{b} + \overline{c} + \overline{d}$

18.



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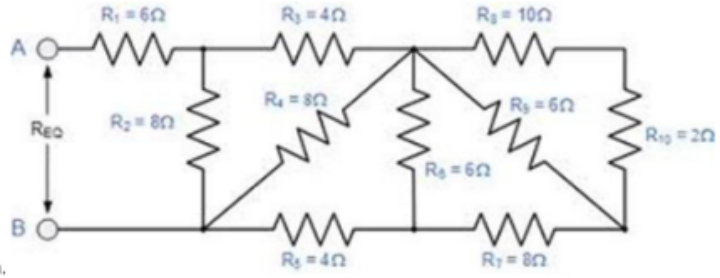
a. What is the voltage across the Capacitor at t=0
b. What is the time constant of the circuit when t is greater than 0 (2 points)

c. What is the complete formula for the voltage of the capacitor for all time, when t is greater than 0 (3 points) a. 6 V b. 0.6 sec c. $6V \times e^{\frac{-t}{0.6sec}}$

19. 

Solve for the equivalent resistance between nodes a and b. (4pts) 10 Ohms

20. Determine the values of the following resistors based upon markings
For help in determining color, use this key

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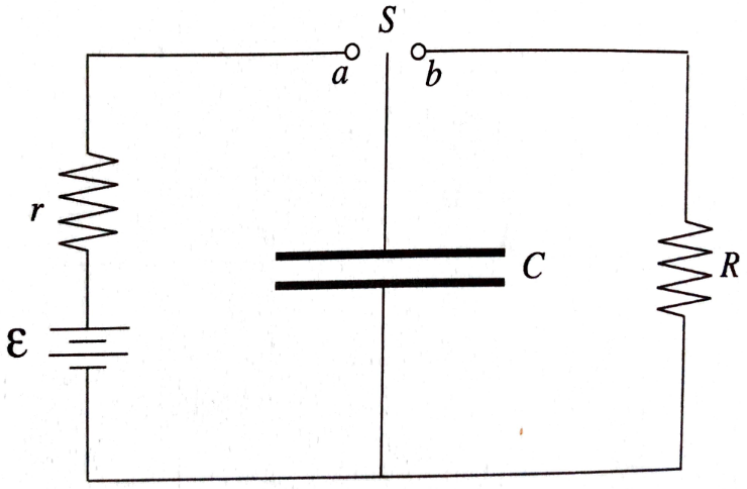
Y is Yellow	Br is Brown	Gy is Gray	Blk is Black	V is Violet	Gd is Gold

Determine the values and tolerance of each of the following resistors based upon markings, read from left to right. (8pts, 1pt for resistance, 1pt for tolerance) a. 820 Ohms, 10 percent b. 56,000 Ohms, 10 percent c. 2,200 Ohms, 10 percent d. 3,900 Ohms, 10 percent

Section 3. Free Response

21. The diagram below shows an uncharged capacitor, two resistors, and a battery whose emf is $\mathcal{E}$



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(a) Determine the current through r at time $t = 0$

(b) Compute the time required for the charge on the capacitor to reach one-half its final value?

(c) When the capacitor is fully charged, which plate is positively charged?

(d) Determine the electrical potential energy stored in the capacitory when the current through r is zero

When the current through r is zero, the switch S is moved to Point b; for the following parts, consider this event time $t = 0$

(a) Determine the current through R as a function of time.

(b) Find the power dissipated in R as a function of time

(c) Determine the total amount of energy dissipated as hear by R.

ANSWER

(a) $I_0 = \mathcal{E}/r$

(b) $t = (\ln 2)rC$

(c) Top plate will be positively charged

(d) $U_E = \dfrac{1}{2}CV^2 = \dfrac{1}{2}C\mathcal{E}^2$

Second Part

(a) $I(t) = (\mathcal{E}/R)e^{-t/RC}$

(b) $P(t) = \dfrac{\mathcal{E}^2}{R}e^{-2t/RC}$

(c) $E = \dfrac{C\mathcal{E}^2}{2}$