

## Circuit Lab B

### Division B Captains' Summer Exchange

Written by: Jay M. Robinson Middle School (Nicholas Susanto)

Competitor Names: \_\_\_\_\_  
\_\_\_\_\_

Team Name: \_\_\_\_\_

Team Number: \_\_\_\_\_ Score: \_\_\_\_\_/305 Rank: \_\_\_\_\_

#### Directions:

- Each team has 50 minutes to complete this test.
- One binder of any size, two stand-alone calculators, and writing utensils are allowed to be brought to this event. Scrap paper will be provided as needed.
- This test packet may be taken apart, but it is kindly asked of you that you put it back together in the correct order.
- For calculations, significant figures and metric units are both required.
- Stop writing when time is up. Failure to do so will result in a penalty or disqualification.
- Good luck and don't forget to have fun!
- Feel free to email me at [azboy1910@gmail.com](mailto:azboy1910@gmail.com) if you have any questions, concerns, comments, or feedback regarding the exam and/or answer key.

### Section I: Matching - 28 points

Each of the following questions are worth 2 points each. Match each scientist to each corresponding statement by writing the letter of the scientist on the line provided. Not every letter may be used.

- |                       |                          |                         |
|-----------------------|--------------------------|-------------------------|
| A. Alessandro Volta   | E. Charles Coulomb       | I. Carl Friedrich Gauss |
| B. Andre-Marie Ampere | F. Heinrich Hertz        | J. James Watt           |
| C. Georg Ohm          | G. Michael Faraday       | K. Charles Wheatstone   |
| D. Gustav Kirchoff    | H. Hans Christian Ørsted | L. Nikola Tesla         |
- 
- |   |   |
|---|---|
| 1. _____ Wrote a memoir on his experiments using one of his inventions, the torsion balance.        | 8. _____ The only one in this list besides Ampere whose name is inscribed on the Eiffel Tower.                  |
| 2. _____ Disagreed with Galvani about the concept of electricity.                                   | 9. _____ Contributed to the large scale generation of electricity with his invention of the power steam engine. |
| 3. _____ Showed that two parallel wires carrying current in the same direction attract one another. | 10. _____ Discovered the “electrodynamic molecule.”   |
| 4. _____ Invented the first electromagnetic generator, also known as a dynamo.                      | 11. _____ The first to discover aluminum.   |
| 5. _____ Invented the first induction motor.  | 12. _____ Wrote a book about galvanic electricity.  |
| 6. _____ Discovered and isolated the gas methane.   | 13. _____ Found that most substances have a magnetic ordering of diamagnetism.                                  |
| 7. _____ Showed that the sum of currents entering a node is equivalent to zero.                     | 14. _____ Invented the magnetometer to measure Earth’s magnetic field.  |

### Section II: Multiple Choice - 94 points

Circle or highlight your answer for each question. For simple calculations, significant figures and metric units are required.

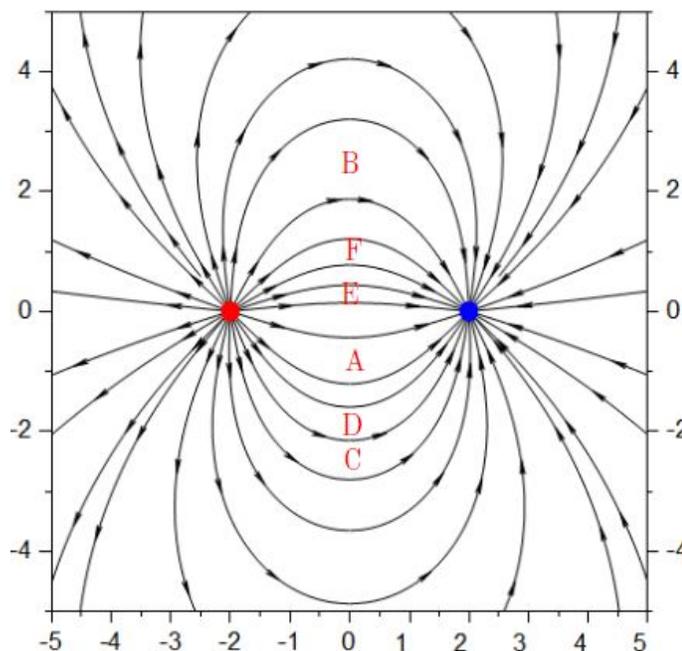
#### Part I: Voltage, Current, Resistance, Power, Energy and Ohm’s and Kirchoff’s Laws

15. According to Ohm’s Law, the electric current of a circuit is \_\_\_\_\_ proportional to the electrical potential, and \_\_\_\_\_ proportional to the resistance. (1 pt)
- |                         |                          |
|-------------------------|--------------------------|
| A. Inversely, directly  | C. Inversely, indirectly |
| B. Directly, indirectly | D. Directly, inversely   |
16. Based on your answer from question 15, how would you solve for the electrical potential, given the electric current and resistance? (1 pt)
- |              |               |
|--------------|---------------|
| A. $V = IR$  | C. $V = R/I$  |
| B. $V = I/R$ | D. $V = IR/2$ |
17. What is the relationship between energy and power? (1 pt)
- |                                     |  |
|-------------------------------------|--|
| A. They are directly proportional.  | C. They are not proportional to one another. |
| B. They are inversely proportional. | D. None of the above.                        |
18. KCL is based off of the law of conservation of \_\_\_\_\_, while KVL is based off of the law of conservation of \_\_\_\_\_. (2 pts)
- |                             |                    |
|-----------------------------|--------------------|
| A. Mass, energy             | C. Charge, energy  |
| B. Electric current, energy | D. Charge, voltage |
19. A battery is connected in series with three resistors. If the voltage drop of the combined three resistors is subtracted from the voltage of the battery, what is the value of the resulting voltage? (1 pt)
- |        |        |
|--------|--------|
| A. 0 V | C. 2 V |
| B. 1 V | D. 3 V |
20. The formula for drift velocity through any object is \_\_\_\_\_. (2 pts)
- |                  |                 |
|------------------|-----------------|
| A. $u = \mu E^2$ | C. $u = \mu E$  |
| B. $u = \mu/E$   | D. $u = \mu EV$ |
21. Currents of \_\_\_\_\_ or higher can be considered lethal and even cause death. (2 pts)
- |           |           |
|-----------|-----------|
| A. 20 mA  | C. 50 mA  |
| B. 100 mA | D. 200 mA |
22. In Algeria, what is the  $V_{RMS}$  of a typical home? (2 pts)
- |          |          |
|----------|----------|
| A. 120 V | C. 230 V |
| B. 220 V | D. 240 V |

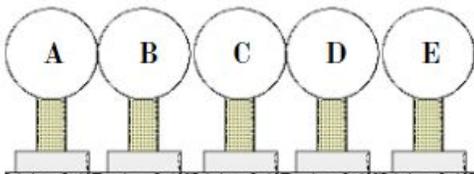
23. Which of the following types of resistors are used for power and high precision applications? (2 pts)
- |                               |                                 |
|-------------------------------|---------------------------------|
| A. Metal Oxide Film Resistors | C. Carbon Composition Resistors |
| B. Wirewound Resistors        | D. Carbon Film Resistors        |
24. What is the maximum voltage that a typical carbon film resistor can handle? (2 pts)
- |          |              |
|----------|--------------|
| A. 250 V | C. 100 V     |
| B. 200 V | D. 350-500 V |
25. Identify the temperature coefficient of a resistor with the bands green, yellow, red, orange, brown, and red. (2 pts)
- |              |              |
|--------------|--------------|
| A. 100 ppm/K | C. 50 ppm/K  |
| B. 10 ppm/K  | D. 250 ppm/K |
26. Listed below are some materials. Identify the material with the most resistance out of the following. (2 pts)
- |                           |                |
|---------------------------|----------------|
| A. Asphalt                | C. Dirty water |
| B. High-temperature glass | D. Copper      |

### Part II: Electric Charges/Fields, Static Electricity, Capacitance

27. Two charges,  $q_1$  and  $q_2$  respectively, have a charge  $+Q$ . If the distance between them triples, the charge of  $q_1$  is doubled, and the charge of  $q_2$  is quadrupled, by what factor does the electrostatic force between the two charges increase? (2 pts)
- |  |  |
|--|--|
| A. It increases by a factor of 2.      | C. It increases by a factor of $9/8$ . |
| B. It increases by a factor of $8/9$ . | D. It increases by a factor of $7/9$ . |
28. What is the mass of a single proton and a single electron in grams? (2 pts)
- |   |
|---|
| A. The mass of a proton is $1.67 \times 10^{-27}$ grams, the mass of an electron is $9.11 \times 10^{-28}$ grams. |
| B. The mass of a proton is $9.11 \times 10^{-28}$ grams, the mass of an electron is $1.67 \times 10^{-24}$ grams. |
| C. The mass of a proton is $1.67 \times 10^{-24}$ grams, the mass of an electron is $9.11 \times 10^{-28}$ grams. |
| D. The mass of a proton is $1.77 \times 10^{-24}$ grams, the mass of an electron is $9.11 \times 10^{-28}$ grams. |
29. Protons and neutrons are made up of different quarks. Determine which quarks, and the amount that makes up each. (2 pts)
- |  |
|--|
| A. A proton is made up of 2 $u$ quarks and 2 $d$ quarks. A neutron is made up of 1 $u$ quark and 4 $d$ quarks. |
| B. A proton is made up of 2 $c$ quarks and 1 $d$ quark. A neutron is made up of 1 $u$ quark and 2 $d$ quarks.  |
| C. A proton is made up of 2 $b$ quarks and 1 $d$ quark. A neutron is made up of 1 $u$ quark and 2 $t$ quarks.  |
| D. A proton is made up of 2 $u$ quarks and 1 $d$ quark. A neutron is made up of 1 $u$ quark and 2 $d$ quarks.  |
30. Isolines are where the voltage for any particle is \_\_\_\_\_. They are also referred to as \_\_\_\_\_, and are \_\_\_\_\_ to electric field lines. (2 pts)
- |  |  |
|--|--|
| A. Constant, equipotentials, parallel    | C. Constant, equipotentials, perpendicular |
| B. Varied, equipotentials, perpendicular | D. Varied, equipotentials, parallel        |
31. Using the image on the right, rank the locations A through E in terms of electric field strength, from strongest to weakest. (2 pts)
- |                     |
|---------------------|
| A. B, A, C, D, F, E |
| B. B, A, C, D, E, F |
| C. A, B, C, D, F, E |
| D. E, F, D, C, A, B |
32. Based on your answer from question 30, the electric field in the diagram to the right is \_\_\_\_\_ and the electric field of a monopole is \_\_\_\_\_. Electric fields are \_\_\_\_\_. (2 pts)
- |                                      |
|--------------------------------------|
| A. Uniform, uniform, scalars         |
| B. Not uniform, uniform, vectors     |
| C. Not uniform, not uniform, vectors |
| D. Not uniform, uniform, scalars     |



33. 5 neutrally conducting spheres are all lined up and are in contact with one another, labeled from A to E, as shown in the image below. A rod with  $3 \times 10^2$  electrons and  $4 \times 10^{1.5}$  protons is brought close, but not touching sphere A. Determine the charge of each sphere after this event occurs. (2 pts)



- A. A- positive, B- negative, C- positive, D- negative, E- negative  
 B. A- positive, B- negative, C- positive, D- negative, E- positive  
 C. A- negative, B- positive, C- negative, D- positive, E- negative  
 D. A- negative, B- negative, C- positive, D- negative, E- positive
34. A balloon is rubbed against a piece of cloth. Determine the charge of the balloon and the cloth. (2 pts)  
 A. The balloon is negatively charged, the cloth is positively charged.  
 B. The balloon is positively charged, the cloth is negatively charged.  
 C. They are both positively charged.  
 D. They are both negatively charged.
35. Using the scenario from question 31, identify the name of the interactions between the balloon and cloth. (2 pts)  
 A. Grounding  
 B. Triboelectric Charging  
 C. Charging through Conduction  
 D. Charging through Induction
36. Which of the following do not use static electricity? (2 pts)  
 A. Printers  
 B. Air Filters  
 C. Photocopiers  
 D. None of the above
37. Which of the following is not a hazard of static electricity? (2 pts)  
 A. Electric Shock  
 B. Explosion  
 C. Toxic Gases  
 D. High Current
38. Two parallel plates make up a capacitor with an area A and a distance D. If the distance between the two plates decreases by a factor of two, and the area of each plate is increased by a factor of 2, by what factor does the capacitance of this capacitor increase or decrease? (2 pts)  
 A. It decreases by a factor of 1.  
 B. It increases by a factor of 4.  
 C. It increases by a factor of 8.  
 D. It increases by a factor of 4.
39. What is the purpose of inserting an insulator between two parallel plates in a capacitor? (2 pts)  
 A. To increase the resistance of the capacitor.  
 B. To increase the maximum temperature the capacitor can handle.  
 C. To increase the amount of charge the capacitor can hold.  
 D. To increase the amount of voltage the capacitor can hold.
40. What is the dielectric constant of teflon? Does this substance have a higher dielectric constant than water? (2 pts)  
 A. 2.25, it does have a higher dielectric constant than water  
 B. 2.1, it does have a higher dielectric constant than water  
 C. 3.18, it does not have a higher dielectric constant than water  
 D. 2.1, it does not have a higher dielectric constant than water
41. When a parallel plate capacitor connected to a battery has a decrease in plate separation, which of the following variables of the capacitor increases? (2 pts)  
 A. Charge  
 B. Voltage  
 C. Electric Field  
 D. Capacitance

### Part III: Magnetism, Transformers, Motors, Generators

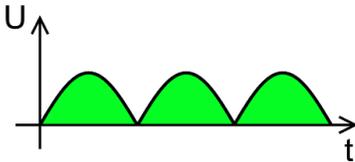
42. A geographic south pole is a magnetic \_\_\_\_\_ pole and a geographic north pole is a magnetic \_\_\_\_\_ pole. (2 pts)  
 A. South, north  
 B. North, south  
 C. South, south  
 D. North, north
43. Identify which of the following metals have a curie temperature of 1000 K or higher, (2 pts)  
 A. Nickel  
 B. Iron  
 C. Cobalt  
 D. Gadolinium

44. Which of the following is not a property of magnetic field lines? (2 pts)
- A. Magnetic field lines have closed loops.
  - B. The density of magnetic field lines are proportional to its strength.
  - C. Magnetic field lines terminate at magnetic materials.
  - D. The magnetic field lines of a magnet start from the north pole and end at the south pole.
45. Determine the direction of an opposing magnetic field created by a current flowing through a wire which is induced by a magnetic field rotating counterclockwise. (2 pts)
- A. Clockwise
  - B. Counterclockwise
  - C. Right
  - D. Left
46. When a magnetic material is saturated, \_\_\_\_\_. (2 pts)
- A. External fields can no longer increase their magnetization.
  - B. Any applied external fields now decrease their magnetization.
  - C. External fields increase their magnetization very significantly.
  - D. The curie temperature of the material can now increase.
47. The magnetic field strength of a white dwarf star in G is... (2 pts)
- A.  $10^8$  G
  - B. 1000 G
  - C. 0.01 G
  - D.  $10^{-12}$  G
48. Which of the following types of steel are not magnetic? (2 pts)
- A. austenitic stainless
  - B. ferritic stainless
  - C. non stainless
  - D. martensitic stainless
49. Which concept explains how transformers work? (2 pts)
- A. Magnetic field
  - B. Electromagnetic induction
  - C. Electromagnetic radiation
  - D. Power
50. Why is it important for a transformer to have a core made up of a metal such as iron instead of a metal such as copper instead? (2 pts)
- A. The malleability of any metal allows more voltage to be increased or decreased across the primary and secondary coils.
  - B. A build-up of electrons in an iron core links the primary and secondary coil together, inducing a voltage in the secondary.
  - C. A magnetic field links the primary and secondary coil together, inducing a voltage in the secondary. Therefore, a stronger magnetic field would link the two coils together more efficiently and induces a voltage in the secondary also more efficiently.
  - D. The equipotential lines around any electrons prevent any interruptions when a voltage is being changed from a primary to secondary coil.
51. In a step-down transformer, the voltage \_\_\_\_\_ from primary to secondary coil. In a step-up transformer, the electric current \_\_\_\_\_ from primary to secondary coil. (2 pts)
- A. Decreases, decreases
  - B. Decreases, increases
  - C. Increases, decreases
  - D. Increases, increases
52. Transformers can function with \_\_\_\_\_. (1 pt)
- A. Both AC and DC
  - B. Only DC
  - C. Neither AC or DC
  - D. Only AC
53. Which process produces the electrical current in a coil of wire in a DC motor? (2 pts)
- A. The brushes make moving contact with a split ring.
  - B. The rotor of a DC motor turns, creating electric current in the process.
  - C. The magnet of the motor creates magnetic fields, which create electrical current in the coil.
  - D. The brushes make moving contact with the commutator.
54. Write out the formula for the magnetic force created in a DC motor and determine what each letter represents in the equation. (2 pts)
- A.  $F = IL/B \rightarrow F = \text{magnetic force}, I = \text{current}, L = \text{length of motor}, B = \text{magnetic flux density}$
  - B.  $F = ILB \rightarrow F = \text{magnetic force}, I = \text{current}, L = \text{inductance of motor}, B = \text{magnetic flux}$
  - C.  $F = ILB \rightarrow F = \text{magnetic force}, I = \text{current}, L = \text{length of motor}, B = \text{magnetic flux}$
  - D.  $F = ILB \rightarrow F = \text{magnetic force}, I = \text{current}, L = \text{length of motor}, B = \text{magnetic flux density}$

55. A stator is the stationary part of an AC motor. Why is the stator an important part of the motor, despite being stationary? (2 pts)
- The stator prevents the motor from overheating.
  - The stator supplies the electric current necessary to turn a motor.
  - There is no purpose for the stator in a motor.
  - The stator creates a rotating magnetic field, which makes the motor work.
56. Motors convert \_\_\_\_\_ to \_\_\_\_\_ energy and generators convert \_\_\_\_\_ to \_\_\_\_\_ energy. (2 pts)
- Potential, kinetic, mechanical, electrical
  - Electrical, kinetic, mechanical, electrical
  - Electrical, mechanical, mechanical, electrical
  - Electrical, mechanical, electrical, mechanical
57. Circle the following types of generators which are DC and underline the types of generators which are AC. (2 pts)
- Induction generator
  - MHD generator
  - VSCF generator
  - Linear alternator generator
  - Homopolar generator

#### Part IV: Diodes, Rectifiers

58. Which of the following is not a type of diode? (2 pts)
- Avalanche
  - Zener
  - Solar
  - Laser
59. The resistance of an ideal diode with a wide depletion layer is \_\_\_\_\_. (2 pts)
- $5.55 \Omega$
  - $\infty \Omega$
  - $1.75 \Omega$
  - $0 \Omega$
  - $2 \Omega$
  - $3.5 \Omega$
60. The resistance of an ideal diode with a narrow depletion layer is \_\_\_\_\_. (2 pts)
- $5.55 \Omega$
  - $\infty \Omega$
  - $1.75 \Omega$
  - $0 \Omega$
  - $2 \Omega$
  - $3.5 \Omega$
61. An LED with a wavelength of 676 nm most likely has the color \_\_\_\_\_. (2 pts)
- Orange
  - Green
  - Red
  - Blue
62. What color LED uses the semiconductor aluminum nitride to give it its color? (2 pts)
- Pink
  - Red
  - Ultraviolet
  - Infrared
63. The first LED was created in \_\_\_\_\_ and was the color \_\_\_\_\_. (2 pts)
- 1953, green
  - 1887, red
  - 1975, ultraviolet
  - 1962, red
64. What is the similarity between a diode and a rectifier? (2 pts)
- They both are circuits.
  - The photoelectric effect explains how they both work.
  - They both are singular electrical components.
  - They both convert DC to AC.
  - They both convert AC to DC.
65. The following graph represents the voltage output for a \_\_\_\_\_ rectifier. (2 pts)



- Single phase half-wave
- Three phase full-wave
- Single phase full-wave
- Three phase half-wave

### Part V: Simple Calculations

66. A charge of 4 C passes through a wire with an energy value of 8 J in 2 seconds. Calculate the power loss through this wire in kilowatts. (2 pts)
- A. 0.008 kW  
B. 0.004 kW  
C. 4 kW  
D. 0.007 kW
67. A circuit comprises two subcircuits, labeled A and B, respectively. A voltage of -5.0 mV is applied across both subcircuits, along with an electric current of 5.0 C/s flowing from subcircuit B to A. What is the power consumption by each subcircuit? (2 pts)
- A. A: -0.025 W, B: 0.025 W  
B. A: -25 W, B: -25 W  
C. A: -0.25 W, B: 0.025 W  
D. A: -0.025 W, B: -0.025 W
68. A circular-shaped wire has a resistivity of  $0.00605 \Omega\text{-m}$ , the radius of the cross-section of the wire is 1.05 cm and a length of 1.50 m. What is the resistance of the wire in  $\text{m}\Omega$ ? (2 pts)
- A. 25,200  $\text{m}\Omega$   
B. 56,250  $\text{m}\Omega$   
C. 26,201  $\text{m}\Omega$   
D. 26,200  $\text{m}\Omega$
69. One AA battery is connected in series with a  $15 \Omega$  resistor and a  $35 \Omega$  resistor. This branch of the circuit is connected in parallel with a resistor labeled X with an unknown resistance. If the total current generated by this circuit is 3.50 A, then what is the value of the resistance of resistor X? (2.5 pts) **Tiebreaker**
- A. 0.432  $\Omega$   
B. 0.43  $\Omega$   
C. 0.47  $\Omega$   
D. 1.34  $\Omega$
70. A solenoid has a current of 5.30 A passing through it and has a length of 40.0 cm with 30.0 turns. If the relative permeability of the core of the solenoid is 220.0 H/m, what is the magnetic flux of the center of the solenoid? (2.5 pts) **Tiebreaker**
- A.  $1.95 \times 10^{-6} \text{ T}$   
B.  $3.37 \times 10^{-6} \text{ T}$   
C.  $1.954 \times 10^{-5} \text{ T}$   
D.  $2.54 \times 10^{-4} \text{ T}$

### Section III: Short Response - 78 points

The following questions for this section are like the free response section, but shorter. For Part I, each question has a value of 2 points.

#### Part I: Units

- |   |  |
|---|--|
| <p>71. <b>Unit 1:</b> Volt<br/>Unit in Base SI units: _____<br/>Quantity it Measures: _____</p>   | <p>77. <b>Unit 7:</b> Joule<br/>Unit in Base SI units: _____<br/>Quantity it Measures: _____</p>   |
| <p>72. <b>Unit 2:</b> Ampere<br/>Unit in Base SI units: _____<br/>Quantity it Measures: _____</p> | <p>78. <b>Unit 8:</b> Coulomb<br/>Unit in Base SI units: _____<br/>Quantity it Measures: _____</p> |
| <p>73. <b>Unit 3:</b> Siemen<br/>Unit in Base SI units: _____<br/>Quantity it Measures: _____</p> | <p>79. <b>Unit 9:</b> Newton<br/>Unit in Base SI units: _____<br/>Quantity it Measures: _____</p>  |
| <p>74. <b>Unit 4:</b> Ohm<br/>Unit in Base SI units: _____<br/>Quantity it Measures: _____</p>    | <p>80. <b>Unit 10:</b> Tesla<br/>Unit in Base SI units: _____<br/>Quantity it Measures: _____</p>  |
| <p>75. <b>Unit 5:</b> Farad<br/>Unit in Base SI units: _____<br/>Quantity it Measures: _____</p>  | <p>81. <b>Unit 11:</b> Weber<br/>Unit in Base SI units: _____<br/>Quantity it Measures: _____</p>  |
| <p>76. <b>Unit 6:</b> Watt<br/>Unit in Base SI units: _____<br/>Quantity it Measures: _____</p>   | <p>82. <b>Unit 12:</b> Henry<br/>Unit in Base SI units: _____<br/>Quantity it Measures: _____</p>  |

**Part II: Fleming's Right-Hand Rule**

83. Use Fleming's Right-Hand Rule to fill the empty blanks with the correct direction in the table below for a charged particle. (15 pts)

Direction of Motion	Direction of Force	Direction of Field
Up		Right
Into the Page	Down	
	Right	Out of the Page
Out of the Page	Right	
Left		Down
	Down	Into the Page
Into the Page		Left
	Into the Page	Left
Into the Page	Right	
Out of the page		Down
Up	Right	
	Left	Down
Into the Page		Up
	Up	Into the Page
	Into the Page	Left

**Part III: Magnetism, Induction**

84. A table showing different elements is shown below. On the box to the right of each element, write the type of magnetism that each element exhibits (without the influence of a magnetic field). (10 pts)

<b>Rubidium</b>		<b>Nickel</b>	
<b>Aluminum</b>		<b>Osmium</b>	
<b>Antimony</b>		<b>Fluorine</b>	
<b>Copper</b>		<b>Hydrogen</b>	
<b>Chromium</b>		<b>Potassium</b>	

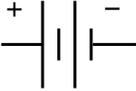
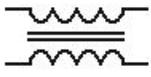
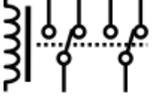
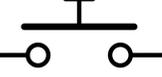
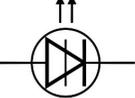
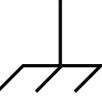
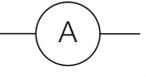
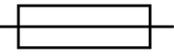
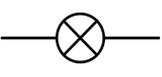
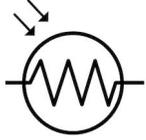
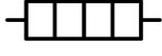
85. List out three ways to increase the inductance of an inductor. (6 pts)

- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_

86. Inductors store \_\_\_\_\_ in the form of \_\_\_\_\_. (2 pts)

**Part IV: Symbols**

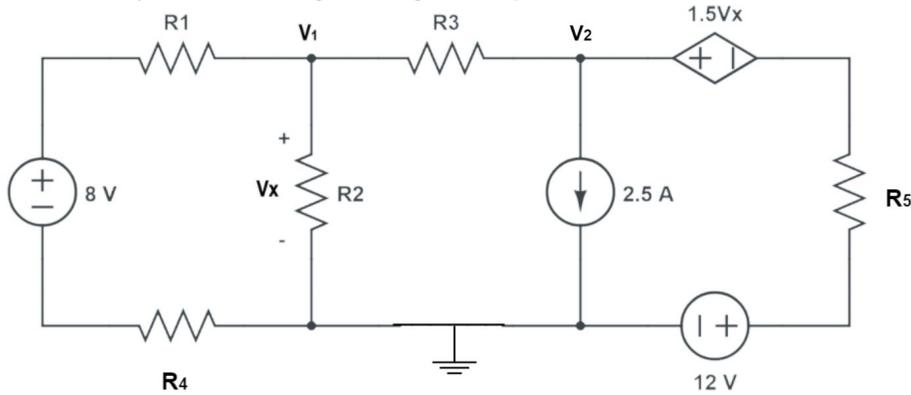
87. Write the name of each of the following symbols on the box to the right. For symbols with multiple names, any of the names used for those symbols will be accepted as an answer, although only one of them is listed on the key. (21 pts)

Symbol	Name	Symbol	Name	Symbol	Name
					
					
					
					
					
					
					

**Section IV: Free Response - 105 points**

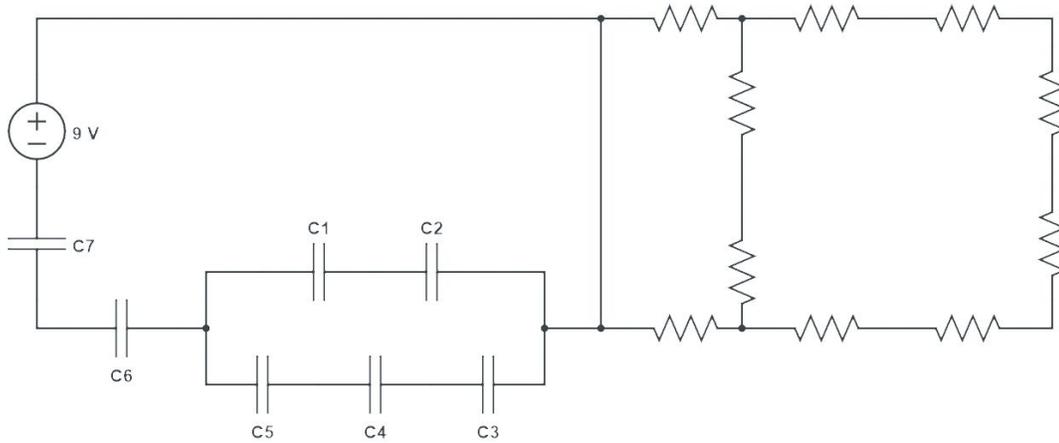
*Reminder: Use the appropriate significant figures and metric units.*

88. In the circuit shown below, solve for the electric potential at nodes  $V_1$  and  $V_2$  when resistors  $R_1$ ,  $R_2$ , and  $R_3$  have a resistance of  $8 \Omega$ . Round your answer to 3 significant figures. (10 pts)



Answers:	Work:
$V_1 =$ _____ $V_2 =$ _____	

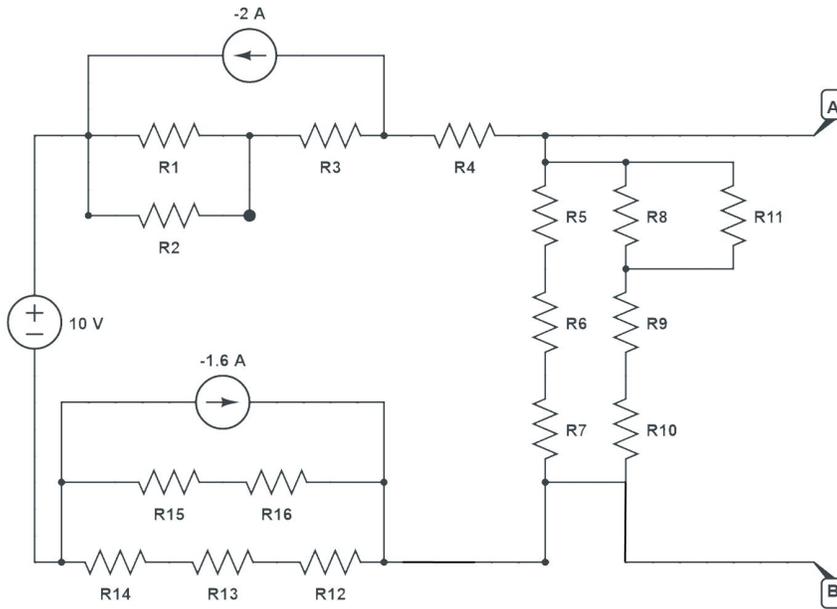
89. The table below the circuit below displays the distance between the plates and plate area of each of the 7 parallel plate capacitors in the circuit. Each of the resistors have a resistance of  $20 \Omega$ . Solve for the following in the circuit:  $C_{total}$ ,  $R_{total}$ ,  $Q_{total}$ , and RC Time Constant. Round your answers to 4 significant figures. (12.5 pts)



	C1	C2	C3	C4	C5	C6	C7
<b>Distance between Plates</b>	1.9 m	710 cm	8,300 mm	6.3 m	6.6 m	3.0 m	100 cm
<b>Plate Area</b>	$0.7 \text{ m}^2$	$5 \text{ m}^2$	$4 \text{ m}^2$	$1.9 \text{ m}^2$	$4.1 \text{ m}^2$	$3.5 \text{ m}^2$	$10 \text{ m}^2$

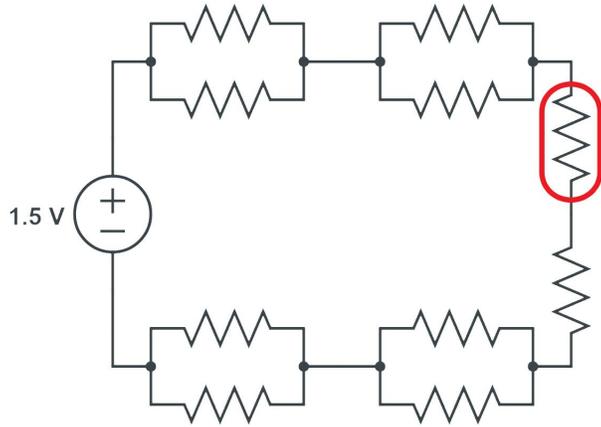
Answers:	Work:
$C_{total} = \underline{\hspace{2cm}}$ $R_{total} = \underline{\hspace{2cm}}$ $Q_{total} = \underline{\hspace{2cm}}$ <b>RC Time Constant</b> = $\underline{\hspace{2cm}}$	

90. Draw the Norton equivalent circuit with respect to terminals A and B. Resistors  $R_1$  thru  $R_4$  have a resistance of  $70 \Omega$ , resistors  $R_5$  thru  $R_8$  have a resistance of  $10 \Omega$ , resistors  $R_9$  thru  $R_{12}$  have a resistance of  $50 \Omega$ , and resistors  $R_{13}$  through  $R_{16}$  have a resistance of  $40 \Omega$ . Round your answers to 3 significant figures. (13.5 points) **(Tiebreaker #1)**



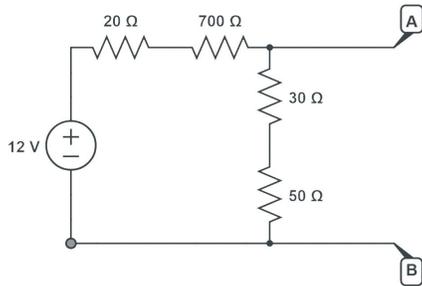
Answer:	Work:
<b>Draw your Norton equivalent circuit below:</b>	

91. Find the voltage, current, and power of the resistor circled in the circuit below. Each of the resistors have a resistance of  $4 \Omega$ . Round your answers to 2 significant figures. (7 pts)



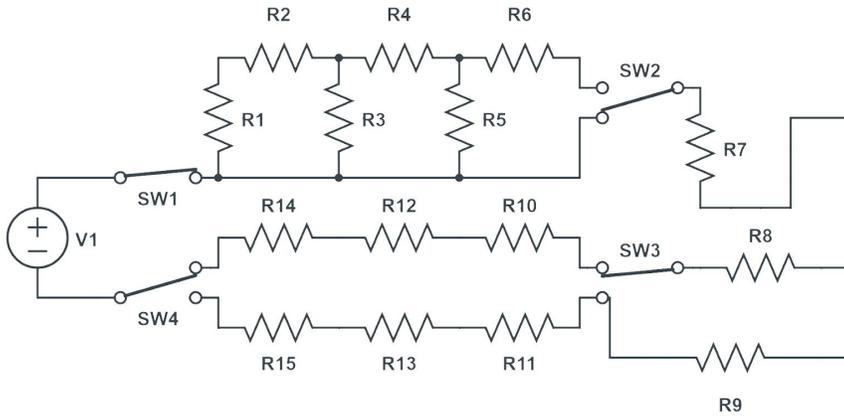
Answers:	Work:
<p><b>Voltage</b> = _____</p> <p><b>Current</b> = _____</p> <p><b>Power</b> = _____</p> <p><small>s</small></p>	

92. Modify the following circuit using only the components included to make a circuit with a voltage of 10.95 V between terminals A and B. Draw your circuit in the answer box. (4.5 points)



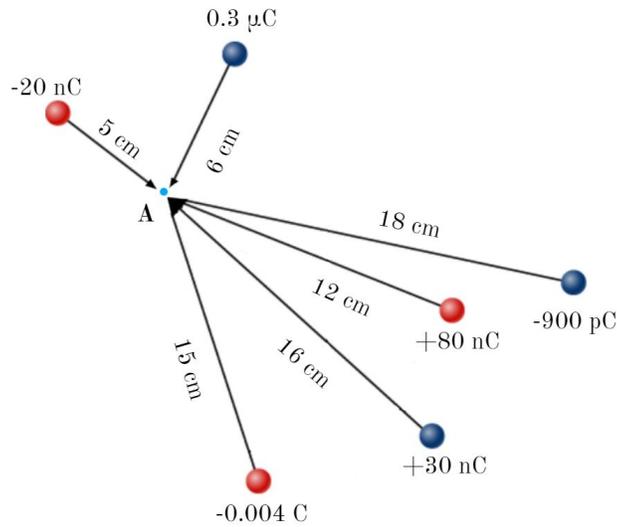
Answer:	Work:
<p><b>Draw your circuit below:</b></p>	

93. If switches 2, 3, and 4 are switched “off” in the following circuit, determine which resistors will have current flowing through them. Explain the reason for current not flowing through specific resistors. (4 pts)



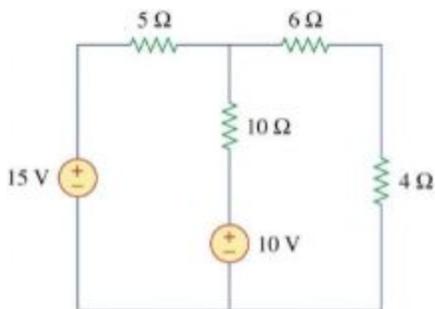
Answers:	Work:
<p><b>Yes, current flows through:</b></p> <p>_____</p>	
<p><b>No, current does not flow through:</b></p> <p>_____</p>	

94. Find the net electric potential and electric field at point A. Round your answers to 3 significant figures. (13 pts) **(Tiebreaker #2)**



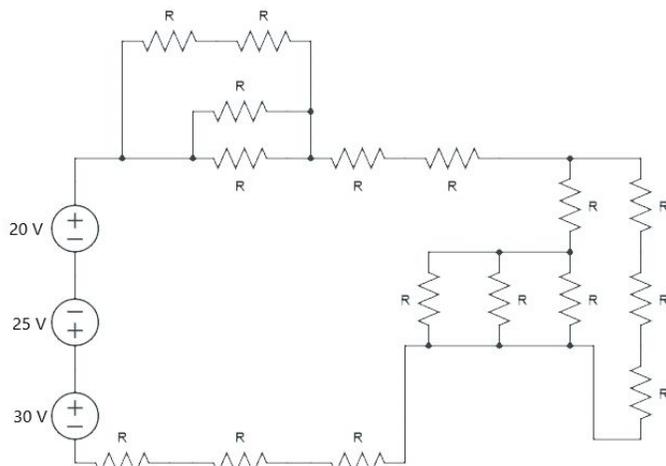
Answers:	Work:
<p>Net Electric Field = _____</p> <p>Net Electric Potential = _____</p>	

95. In the circuit below,  $t = 0$  s. Determine the energy dissipated by each resistor after  $5.50 \times 10^{28} \mu\text{s}$  of time has gone by, Round your answers to 3 significant figures. (10 pts)



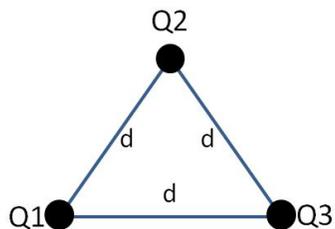
Answers:	Work:
<p>Energy of 5 Ω = _____</p> <p>Energy of 10 Ω = _____</p> <p>Energy of 6 Ω = _____</p> <p>Energy of 4 Ω = _____</p>	

96. If the total power across the circuit is 35.5 W, then what is the value of R? (6.5 pts)





99. Determine the net force on Q1, Q2 and Q3, using the image below.  $Q1 = +5 \mu\text{C}$ ,  $Q2 = +6,000 \text{ nC}$ ,  $Q3 = -3.50 \mu\text{C}$ , and  $d = 2.5 \text{ m}$ . Round your answers to 4 significant figures. (8.5 pts)



Answers:	Work:
Net Force on Q1 = _____	
Net Force on Q2 = _____	
Net Force on Q3 = _____	

100. What is the magnitude and direction of the force on a proton moving west at a velocity of 5.50 m/s towards a magnetic field pointing into the page with a magnetic flux of 20.0 T? (2.5 pts)