

# Circuit Lab

## Division B

### Scioly.org Test Exchange

Name (s): \_\_\_\_\_

Team # and Name: \_\_\_\_\_

#### Instructions

- This test was designed to be completed in roughly 50 minutes.
- Recommended materials include one three-ring binder, two stand-alone calculators and writing utensils, which are allowed to be used for this event.
- Include units and appropriate significant answers for any free response questions.
- Good luck and don't forget to have fun!
- This test was written by Scioly.org user *azboy1910*. I have made many mistakes in the past, so do please contact me using the email below if there are mistakes.
- Feel free to email me at [azboy1910@gmail.com](mailto:azboy1910@gmail.com) if you have any questions, concerns, feedback, or notice any mistakes regarding the exam and/or answer key.

**\*NOTE: This test is a re-formatted version of a previous test I have made before. This is also a warning that this test is not very high-quality.**

#### Scoring:

Page	Points	Score
3	7	
4	11	
5	7	
6	11	
7	9	
8	10	
9	13	
10	22	
11	16	
12	12	
13	11	
14	32	
15	21	
16	8	
Total:	190	

## Section I: Matching

Write the last name of the scientist on the answer line provided that best describes a discovery, theory, or invention made by that scientist in the list of statements below. Each question in this section is worth 1 point.

POSSIBLE ANSWERS:

Volta  
Ampere  
Coulomb

Kirchhoff  
Faraday  
Ohm

Tesla

1. (1 point) Wrote a memoir on his experiments using one of his inventions, the torsion balance.

1. \_\_\_\_\_

2. (1 point) Disagreed with Galvani about the concept of electricity.

2. \_\_\_\_\_

3. (1 point) Showed that two parallel wires carrying current in the same direction attract one another.

3. \_\_\_\_\_

4. (1 point) Invented the first electromagnetic generator, also known as a dynamo.

4. \_\_\_\_\_

5. (1 point) Invented the first induction motor.

5. \_\_\_\_\_

6. (1 point) Discovered that the algebraic sum of currents entering a node is equivalent to the sum of currents exiting that same node.

6. \_\_\_\_\_

7. (1 point) The only one in the rules besides Ampere whose name is inscribed on the Eiffel Tower.

7. \_\_\_\_\_

## Section II: Multiple Choice

8. (1 point) According to Ohm's Law, the electric current of a circuit is \_\_\_\_\_ proportional to the electrical potential, and \_\_\_\_\_ proportional to the resistance.
- inversely, directly
  - directly, indirectly
  - inversely, indirectly
  - directly, inversely
9. (1 point) Based on your answer from question 2, how would you solve for the electrical potential, given the electric current and resistance?
- $V = IR$
  - $V = \frac{I}{R}$
  - $V = \frac{R}{I}$
  - $V = \frac{IR}{2}$
10. (1 point) What is the relationship between energy and power?
- They are directly proportional.
  - They are inversely proportional.
  - They are not proportional.
  - None of the above.
11. (1 point) KCL is based off of the law of conservation of \_\_\_\_\_, while KVL is based off of the law of conservation of \_\_\_\_\_.
- mass, energy
  - electric current, energy
  - charge, energy
  - charge, voltage
12. (1 point) 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?
- 0 V
  - 1 V
  - 2 V
  - 3 V
13. (1 point) The formula for drift velocity through any object is \_\_\_\_\_.
- $u = \mu E^2$
  - $u = \mu/E$
  - $u = \mu E$
  - $u = \mu EV$
14. (1 point) Currents of \_\_\_\_\_ or higher can be considered lethal and even cause death.
- 20 mA
  - 100 mA
  - 50 mA
  - 200 mA
15. (1 point) What is the RMS voltage of a wall outlet in a typical home in Algeria?
- 120 V
  - 220 V
  - 230 V
  - 240 V
16. (1 point) Which of the following types of resistors are used for power and high precision applications?
- metal oxide film
  - wirewound
  - carbon composition
  - carbon film
17. (1 point) What is the maximum voltage that a typical carbon film resistor can handle?
- 250 V
  - 200 V
  - 100 V
  - 350-500 V
18. (1 point) Identify the temperature coefficient of a resistor with the bands green, yellow, red, orange, brown, and red.
- 100 ppm/K
  - 10 ppm/K
  - 50 ppm/K
  - 250 ppm/K

19. (1 point) Listed below are some materials. Identify the material with the most resistance out of the following.

- A. asphalt
- B. high-temperature glass
- C. dirty water
- D. copper

20. (1 point) 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?

- A. increases by a factor of 2
- B. increases by a factor of  $8/9$
- C. increases by a factor of  $9/8$
- D. increases by a factor of  $7/9$

21. (1 point) What is the mass of a single proton and a single electron in grams, respectively?

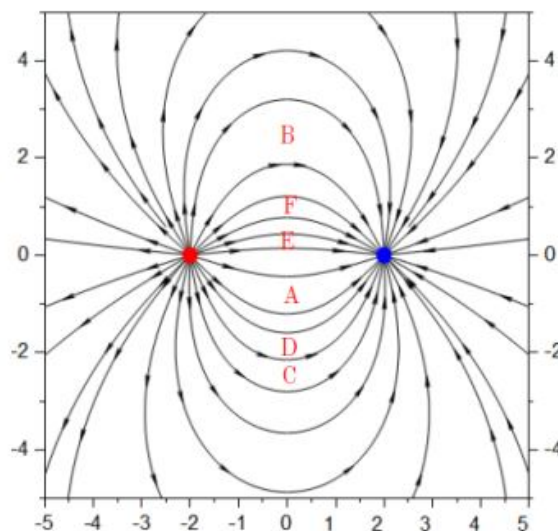
- A.  $1.67 \times 10^{-27}$ ;  $9.11 \times 10^{-28}$
- B.  $9.11 \times 10^{-28}$ ;  $1.67 \times 10^{-24}$
- C.  $1.67 \times 10^{-24}$ ;  $9.11 \times 10^{-28}$
- D.  $1.77 \times 10^{-24}$ ;  $9.11 \times 10^{-28}$

22. (1 point) Protons and neutrons are made up of different quarks. Determine which quarks, and the amount that makes up each.

- A. proton is 2  $u$ , 2  $d$ ; neutron is 1  $u$ , 4  $d$
- B. proton is 2  $c$ , 1  $d$ ; neutron is 1  $u$ , 2  $d$
- C. proton is 2  $b$ , 1  $d$ ; neutron is 1  $u$ , 2  $t$
- D. proton is 2  $u$ , 1  $d$ ; neutron is 1  $u$ , 2  $d$

23. (1 point) Isolines are where the voltage for any particle is \_\_\_\_\_. They are also referred to as \_\_\_\_\_, and are \_\_\_\_\_ to electric field lines.

- A. constant, equipotentials, parallel
- B. varied, equipotentials, perpendicular
- C. constant, equipotentials, perpendicular
- D. varied, equipotentials, parallel



24. (1 point) Using the image shown above, rank the locations A through E in terms of electric field strength, from strongest to weakest.

- 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

25. (1 point) Based on your answer from question 24, the electric field in the diagram to the right is \_\_\_\_\_ and the electric field of a monopole is \_\_\_\_\_. Electric fields are \_\_\_\_\_.

- A. uniform, uniform, scalars
- B. not uniform, uniform, vectors
- C. not uniform, not uniform, vectors
- D. not uniform, uniform, scalars



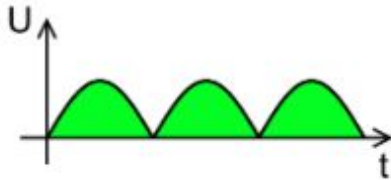
26. (2 points) 5 neutrally conducting spheres are all lined up, but are not in contact with one another, labeled from A to E, as shown in the image above. A rod with  $3.00 \times 10^2$  electrons and 40 protons is brought close, but not touching sphere A. All the spheres are then separated and the rod is removed. Determine the charge of each sphere after this event occurs.
- A- positive, B- negative, C- positive, D- negative, E- negative
  - A- positive, B- negative, C- positive, D- negative, E- positive
  - A- negative, B- positive, C- negative, D- positive, E- negative
  - A- negative, B- negative, C- positive, D- negative, E- positive
27. (1 point) A balloon is rubbed against a piece of cloth. Determine the charge of the balloon and the cloth.
- balloon is negatively charged; cloth is positively charged
  - balloon is positively charged; cloth is negatively charged.
  - both positively charged
  - both negatively charged
28. (1 point) Using the scenario from question 21, identify the name of the interactions between the balloon and cloth.
- grounding
  - triboelectric charging
  - conduction charging
  - induction charging
29. (1 point) Which of the following do not use static electricity?
- printers
  - air filters
  - photocopiers
  - none of the above
30. (1 point) Which of the following is not a hazard of static electricity?
- electric shock
  - explosion
  - toxic gases
  - high current
31. (2 points) 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?
- decreases by a factor of 1
  - increases by a factor of 4
  - increases by a factor of 8
  - increases by a factor of 4
32. (1 point) What is the dielectric constant of teflon? Does this substance have a higher dielectric constant than water?
- 2.25; no
  - 2.1; yes
  - 3.18; no
  - 2.1; no
33. (1 point) When a parallel plate capacitor connected to a battery has a decrease in plate separation, which of the following variables of the capacitor increases?
- charge
  - voltage
  - electric field
  - capacitance
34. (1 point) A geographic south pole is a magnetic \_\_\_\_\_ pole and a geographic north pole is a magnetic \_\_\_\_\_ pole.
- south, north
  - north, south
  - south, south
  - north, north

35. (1 point) Identify which of the following metals have a curie temperature of 1000 K or higher.
- A. nickel
  - B. iron
  - C. cobalt
  - D. gadolinium
36. (1 point) Which of the following is not a property of magnetic field lines?
- 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.
37. (1 point) 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.
- A. clockwise
  - B. counterclockwise
  - C. right
  - D. left
38. (1 point) When a magnetic material is saturated, \_\_\_\_\_.
- 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.
39. (1 point) The magnetic field strength of a white dwarf star in G is
- A.  $10^8$
  - B. 1,000
  - C. 0.01
  - D.  $10^{-12}$
40. (1 point) Which of the following types of steel are not magnetic?
- A. austenitic stainless
  - B. ferritic stainless
  - C. non-stainless
  - D. martensitic stainless
41. (1 point) Which concept explains how transformers work?
- A. magnetic field
  - B. electromagnetic induction
  - C. electromagnetic radiation
  - D. power
42. (1 point) 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?  
**Tiebreaker**
- 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.
43. (1 point) 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.
- A. decreases, decreases
  - B. decreases, increases
  - C. increases, decreases
  - D. increases, increases

44. (1 point) Transformers can function with \_\_\_\_\_.
- A. both AC and DC
  - B. only DC
  - C. neither AC and DC
  - D. only AC
45. (1 point) Which process produces the electrical current in a coil of wire in a DC motor?
- 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.
46. (1 point) A stator is the stationary part of an AC motor. Why is the stator an important part of the motor, despite being stationary?  
**Tiebreaker**
- A. The stator prevents the motor from overheating.
  - B. The stator supplies the electric current necessary to turn a motor.
  - C. There is no purpose for the stator in a motor.
  - D. The stator creates a rotating magnetic field, which allows the motor to function.
47. (1 point) Motors convert \_\_\_\_\_ to \_\_\_\_\_ energy and generators convert \_\_\_\_\_ to \_\_\_\_\_ energy.
- A. potential, kinetic, mechanical, electrical
  - B. electrical, kinetic, mechanical, electrical
  - C. electrical, mechanical, mechanical, electrical
  - D. electrical, mechanical, electrical, mechanical
48. (1 point) Circle the following types of generators which are DC and underline the types of generators which are AC.
- A. induction generator
  - B. MHD generator
  - C. VSCF generator
  - D. linear alternator generator
  - E. homopolar generator
49. (1 point) Which of the following is not a type of diode?
- A. avalanche
  - B. zener
  - C. solar
  - D. laser
50. (1 point) The resistance of an ideal diode in reverse bias is \_\_\_\_\_.
- A.  $5.55 \Omega$
  - B.  $\infty \Omega$
  - C.  $1.75 \Omega$
  - D.  $0 \Omega$
  - E.  $2 \Omega$
  - F.  $3.5 \Omega$
51. (1 point) The resistance of an ideal diode in forward bias is \_\_\_\_\_.
- A.  $5.55 \Omega$
  - B.  $\infty \Omega$
  - C.  $1.75 \Omega$
  - D.  $0 \Omega$
  - E.  $2 \Omega$
  - F.  $3.5 \Omega$
52. (1 point) An LED with a wavelength of 676 nm most likely is the color \_\_\_\_\_.
- A. orange
  - B. green
  - C. red
  - D. blue
53. (1 point) What color LED uses the semiconductor aluminum nitride to give it its color?
- A. pink
  - B. red
  - C. ultraviolet
  - D. infrared

54. (1 point) The first LED was created in \_\_\_\_\_ and was the color \_\_\_\_\_.
- 1953, green
  - 1887, red
  - 1975, ultraviolet
  - 1962, red
55. (1 point) What is the similarity between a diode and a rectifier?
- 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.
58. (2 points) 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?
- A:  $-0.025$  W, B:  $0.025$  W
  - A:  $-25$  W, B:  $-25$  W
  - A:  $-0.25$  W, B:  $0.025$  W
  - A:  $-0.025$  W, B:  $-0.025$  W

59. (2 points) A cylinder-shaped wire has a resistivity of  $0.00605$   $\Omega$ -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  $m\Omega$ ?
- $25200$   $m\Omega$
  - $56250$   $m\Omega$
  - $26205$   $m\Omega$
  - $26200$   $m\Omega$



56. (1 point) The graph above represents the voltage output for a \_\_\_\_\_ rectifier.
- single phase half-wave
  - three phase full-wave
  - single phase full-wave
  - three phase half-wave
57. (2 points) 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.
- $0.008$
  - $0.004$
  - $4$
  - $0.007$
60. (2 points) 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? **Tiebreaker**
- $0.432$   $\Omega$
  - $0.43$   $\Omega$
  - $0.47$   $\Omega$
  - $1.34$   $\Omega$
61. (2 points) 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? **Tiebreaker**
- $0.110$  T
  - $2.07 \times 10^{-6}$  T
  - $11.0 \times 10^{-5}$  T
  - $2.83 \times 10^{-4}$  T



## Section III: Short Response

62. (12 points) Fill out the following table below. Each blank is worth 0.5 points.

Unit	Expressed in Base SI	Quantity Measured
Volt		
Ampere		
Siemen		
Ohm		
Farad		
Watt		
Joule		
Coulomb		
Newton		
Tesla		
Weber		
Henry		

63. (5 points) A table showing different elements is shown below. On the blank to the right of each element, write the type of magnetism that each element exhibits without the influence of a magnetic field. Each blank is worth 0.5 points.

Element	Magnetic Property	Element	Magnetic Property
Rubidium		Nickel	
Aluminum		Osmium	
Antimony		Flourine	
Copper		Hydrogen	
Chromium		Potassium	

64. (3 points) List out three ways to increase the inductance of an inductor.

---

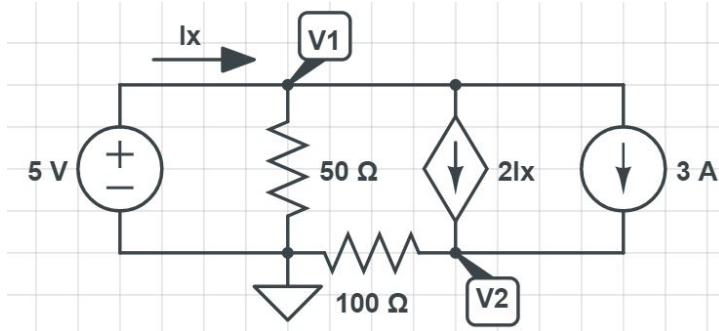


---

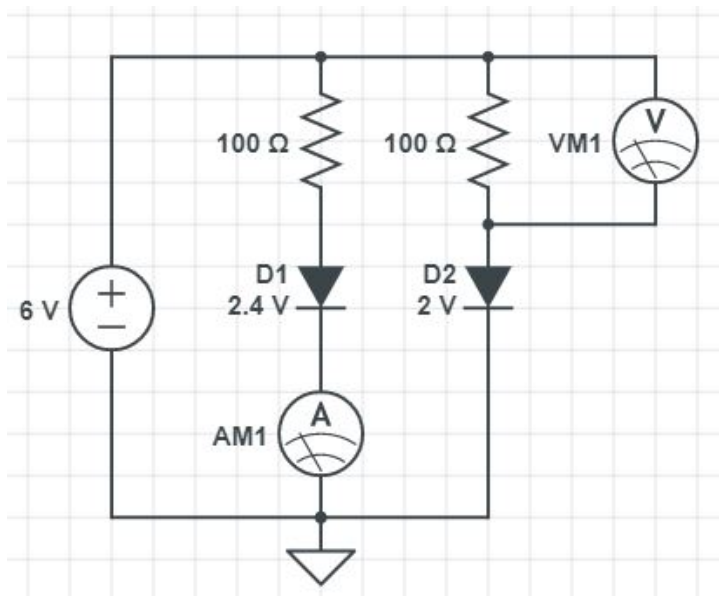
65. (2 points) Inductors store \_\_\_\_\_ in the form of \_\_\_\_\_.

### Section IV: Free Response

66. (5 points) Find the magnitude of  $V_1$  and  $V_2$  in V shown in the circuit shown below. Do not give units and round your answer to 3 significant figures.



67. (11 points) Use the following circuit to answer parts (a) through (c). Assume both diodes are ideal, along with the voltmeter and ammeter. Each part is 2 points each, except for part (c), which is worth 5 points.



- (a) Find the reading of the ammeter in mA. Round to 2 significant figures.

- (b) Find the reading of the voltmeter in V. Round to 4 significant figures.

- (c) What is the forward current flowing through  $D_1$  and  $D_2$ ? Why does the forward current through each diode differ?

- (d) Find the total power used by the circuit in mW. Round to 3 significant figures.

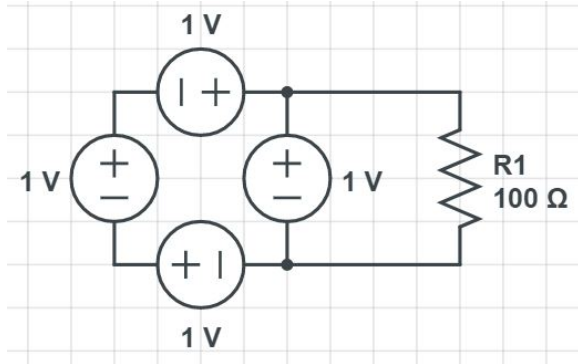
68. (3 points) Why might it not be best to use thin, superconductive wires in high current applications?

69. (3 points) Find the potential energy between two electrons separated by a distance of 1 m. Round your answer to 2 significant figures.

70. (3 points) After how many time constants is an ideal capacitor in an RC circuit fully charged? How is this different from an actual capacitor in the same setting?

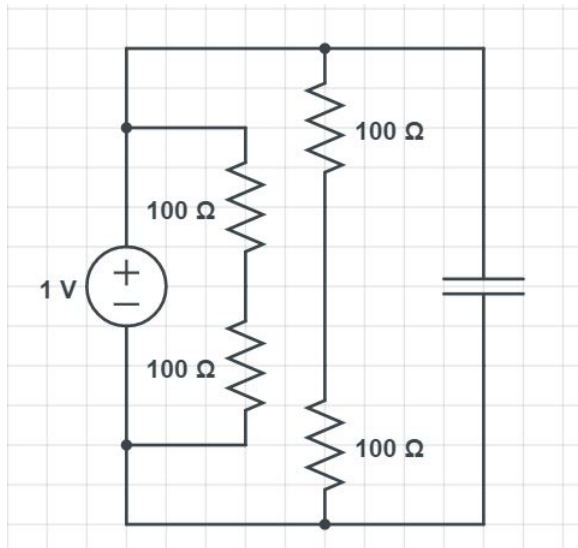
71. (3 points) I touch a live wire in midair, but not much happens. Why is it safer for me to touch a live wire in midair than if I was standing on the ground?

72. (4 points) Why is it impossible for the circuit shown below to exist? **Tiebreaker**

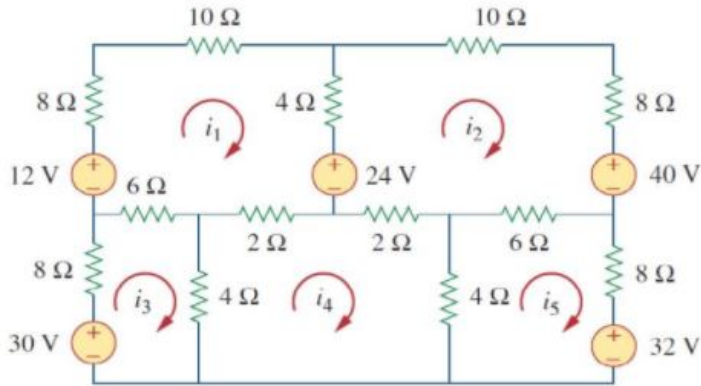


73. (3 points) Depending on its resistance, a component can have a voltage across it even if no current is flowing through it. Explain how an ideal voltmeter demonstrates this.

74. (4 points) Is it possible to determine the RC time constant of the circuit below? If so, explain how. **Tiebreaker**



75. (28 points) Use the following circuit shown below for parts (a) and (b). Part (a) is worth 15 points and part (b) is worth 10 points, and part (c) is worth 3 points.



(a) Calculate the magnitude of current in loops  $i_1$ ,  $i_2$ ,  $i_3$ ,  $i_4$  and  $i_5$  in A. Round to 2 significant figures.

(b) Calculate the thevenin voltage and resistance of this circuit with respect to the 30 V battery. Round to 3 significant figures.

(c) Why is it best to use mesh current analysis for part (a) instead of superposition or nodal analysis?

76. (4 points) A cylindrical wire with a current  $I$  passing through it and a volume  $V$  is suspended in a magnetic field with a flux density  $B$ . Express the magnetic force exerted on the wire in terms of  $\pi$ ,  $r$ ,  $B$ ,  $I$ , and  $V$ .

77. (2 points) Now replace that wire with an electron moving from west to east. If the magnetic field is pointing outwards, what direction will the electron be deflected?

78. (3 points) For the previous question, if the electron was moving outwards in the direction of the magnetic field, then how does this affect the magnetic force exerted on it?

79. (3 points) Briefly describe what reluctance is in the context of magnetic circuits.

80. (6 points) What is Faraday's Law of Induction? How is this applied in transformers and generators?

81. (4 points) Let's go back to question 77. If the electron is moving at a velocity  $v$  and has a charge of  $q$  and the magnetic field has a flux density  $B$ , what is the magnetic force on the electron in terms of  $v$ ,  $B$  and  $q$ ? What law/formula is used to determine this magnetic force?

82. (3 points) Pablo connects a battery in series with an LED. He finds that the LED burns out, but he isn't sure what is going on. Explain why the LED has burned out.

83. (3 points) Explain why it is important to put a multimeter on voltage mode when measuring voltage, current mode when measuring current, etc.

84. (5 points) A student connects a battery, resistor and LED in series on a breadboard. The LED is not lighting up. Explain at least two possible reasons for why this could be happening. **Tiebreaker**