CHAPTER

50 Principles of Electrical Systems

At the start of each chapter you'll find the NATEF tasks, Knowledge Objectives, and Skills Objectives from the textbook. These are your objectives as you make your way through the exercises in this workbook and the chapter in your textbook. The following activities have been designed to help you refresh your knowledge of the material in this chapter.

NATEF Tasks

- N50001 Demonstrate knowledge of the causes and effects from shorts, grounds, opens, and resistance problems in electrical/electronic circuits. (MLR/AST/MAST)
- N50002 Demonstrate knowledge of electrical/electronic series, parallel, and series-parallel circuits using principles of electricity (Ohm's law). (MLR/AST/MAST)

Knowledge Objectives

After reading this chapter, you will be able to:

- K50001 Explain the basic fundamentals of electricity.
- K50002 Define units of electrical measurement.
- K50003 Define electrical circuit terminology.
- K50004 Explain the sources and effects of electricity.
- K50005 Explain the application of basic electrical laws.

Skills Objectives

There are no Skills Objectives for this chapter.

Matching

Match the following terms with the correct description or example.

A. Alternating current (AC)
B. Amp
C. Relay
D. Current flow
E. Ammeter
F. Electromagnet
G. Energy
H. Ground
I. Insulator
J. Sine wave
K. Ohm
L. Hole theory
M. Polarity
N. Semiconductor
O. Short
P. Silicon
Q. Electron theory
R. Voltage drop
S. Hot junction
T. Volt

_____ 1. The theory that as electrons flow from negative to positive, holes flow from positive to negative.

_____ 2. A material that has properties that prevent the easy flow of electricity. These materials are made up of atoms with five to eight electrons in the valance ring.

_____ 3. The theory that electrons, being negatively charged, repel other electrons and are attracted to positively charged objects; thus electrons flow from negative to positive.

_____ 4. A conductor wound in a coil that produces a magnetic field when current flows through it.

_____ 5. The state of charge, positive or negative.

_____ **6.** A device used to measure current flow.
_____ **7.** A material commonly used to make semiconductors.
_____ **8.** A type of current flow that flows back and forth.
_____ **9.** The heating point of a thermocouple.
_____ **10.** The ability to do work.
_____ **11.** Also called a short circuit, the flow of current along an unintended route.
_____ **12.** An electromechanical switching device whereby the magnetism from a coil winding acts on a lever that switches a set of contacts.
_____ **13.** The amount of potential difference between two points in a circuit.
_____ **14.** A mathematical function that describes a repetitive waveform such as an alternating current signal.
_____ **15.** An abbreviation for amperes, the unit for current measurement.
_____ **16.** The unit for measuring electrical resistance.
_____ **17.** The unit used to measure potential difference or electrical pressure.
_____ **18.** A material used to make microchips, transistors, and diodes.
_____ **19.** The flow of electrons, typically within a circuit or component.
_____ **20.** The return path for electrical current in a vehicle chassis, other metal of the vehicle, or dedicated wire.

Multiple Choice

Read each item carefully, and then select the best response.

_____ **1.** Electromotive force is also referred to as _____.
A. voltage
B. resistance
C. amperage
D. electrons

_____ 2. The electrical resistance of a circuit is measured in _____.
A. A
B. Ω
C. V
D. W

_____ **3.** What materials make a good insulator?
A. Copper and aluminum
B. Ceramic and plastic
C. Copper and silicon
D. Argon and silicon

_____ **4.** If a 15-volt circuit with a single light has a current flow of 2 amps, then what is the power in watts in the circuit?
A. 17
B. 30
C. 7.5
D. 13

_____ **5.** Which type of current flow is produced by a battery?
A. Alternating current
B. Three phase
C. Direct current
D. Sine wave

_____ **6.** What is meant by the term "continuity"?
A. A low-voltage circuit that does not have a complete circuit and therefore cannot conduct current
B. A circuit fault in which current takes a shorter path, in terms of resistance, through an accidental or unintended route
C. An electrical circuit that has a continuous and uninterrupted connection
D. An electric circuit that has a break, and current cannot flow past the break

_____ **7.** The term _____ describes a low-voltage circuit that does not have a complete circuit and therefore cannot conduct current.
- **A.** closed
- **B.** open
- **C.** short
- **D.** grounded

_____ **8.** When two dissimilar metals are immersed in an electrolyte, the breakdown of chemicals into charged particles that results in a flow of electricity is called _____.
- **A.** photovoltaic effect
- **B.** induction
- **C.** electrolysis
- **D.** electrostatic energy

_____ **9.** All of the following are effects of the flow of electricity, except:
- **A.** Chemical reactions
- **B.** Mechanical action
- **C.** Heat
- **D.** Magnetism

_____ **10.** Which of the following Ohm's law formulas is correct?
- **A.** A = V/R
- **B.** V = A × R
- **C.** R = V ÷ A
- **D.** All of the above

_____ **11.** The rate of transforming energy is also known as _____.
- **A.** power
- **B.** voltage
- **C.** work
- **D.** magnetism

_____ **12.** In a(n) _____ circuit, all components are connected directly to the voltage supply.
- **A.** series
- **B.** parallel
- **C.** series/ parallel
- **D.** all of the above

_____ **13.** Which law states that current entering any junction is equal to the sum of the current flowing out of the junction?
- **A.** Ohm's law
- **B.** Kirchhoff's current law
- **C.** The law of conservation of energy
- **D.** Newton's first law of energy

_____ **14.** A _____ is an electromechanical switching device whereby the magnetism from a coil winding acts on a lever that switches a set of contacts.
- **A.** thermocouple
- **B.** solenoid
- **C.** diode
- **D.** relay

_____ **15.** Electrochemical energy is produced when _____.
- **A.** sunlight falls on photocells
- **B.** steam builds up
- **C.** when two dissimilar metals are heated
- **D.** two dissimilar metals are immersed in an acidic liquid

_____ **16.** What of these is a by-product of the flow of electricity?
- **A.** Heat
- **B.** Water
- **C.** Oil
- **D.** Steam

_____ **17.** If a person has a 4 ohm resistor and the battery is charged to 12 volts, how many amps will flow in the circuit?
- **A.** 1 amp
- **B.** 2 amps
- **C.** 3 amps
- **D.** 4 amps

_____ **18.** How many paths are there in a series circuit?
- **A.** One
- **B.** Two
- **C.** Three
- **D.** Four

_____ **19.** Which of these cannot conduct electrons easily?
- **A.** Conductors
- **B.** Superconductors
- **C.** Insulators
- **D.** Semi-conductors

_____ **20.** What can be the number of valence ring electrons of conductors?
- **A.** Two
- **B.** Four
- **C.** Six
- **D.** Eight

True/False

If you believe the statement to be more true than false, write the letter "T" in the space provided. If you believe the statement to be more false than true, write the letter "F."

_____ **1.** A deficiency of electrons gives an atom an overall positive charge.

_____ **2.** Most wiring diagrams are written from the conventional theory perspective, while electronic circuits are typically designed and operate on the electron theory perspective.

_____ **3.** Volts, amps, and ohms are three basic units of electrical measurement.

_____ **4.** Hertz is the measurement of frequency and indicates the number of cycles per second.

_____ **5.** If voltage stays the same and resistance doubles, half as much amperage can be pushed through the resistance.

_____ **6.** A potential electrical difference across a crystal that will physically distort the crystal is called electromagnetic induction.

_____ **7.** When negative ions in a solution are attracted to the negative plate and positive ions to the positive plate, a chemical reaction can occur.

_____ **8.** Ohm's law is a relationship between volts, amps, and ohms, and because they must always balance out, if we know any two of the values, then we can calculate the third.

_____ **9.** A light bulb uses a certain amount of electrical power, but the power used is not an indication of brightness.

_____ **10.** A typical incandescent light bulb creates light, but only about 10% of the electricity is converted to light; about 90% is wasted as heat.

Fill in the Blank

Read each item carefully, and then complete the statement by filling in the missing word(s).

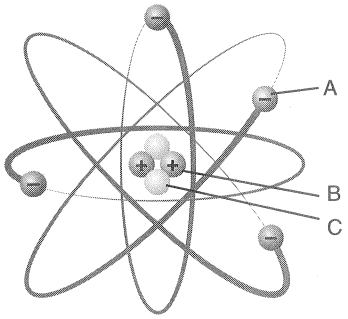
1. _____ _____ are only loosely held by the nucleus and are free to move from one atom to another when an electrical potential (pressure) is applied.
2. Electrical _____, measured in ohms, affects the current flow in a circuit.
3. _____ _____ tells us that if we increase current flow through a resistance, the voltage used by that resistance will increase.
4. The PN junction of a semiconductor is located in the _____ layer.
5. The unit of _____ _____ is the watt.

6. A(n) _____ is constructed by winding a conductor wire, many hundreds or thousands of times, around a soft iron or metal core and passing a current through the coil.
7. The transfer of electrical energy from one coil to another through induction in a transformer is known as _____ _____.
8. _____ is achieved when an electrical circuit has a continuous and uninterrupted electrical connection and is thereby capable of conducting current and working as designed.
9. In its purest definition, the term _____ describes a circuit fault in which current takes a shorter path, resistance-wise, through an accidental or unintended route.
10. One _____ is produced when 1 volt causes 1 amp of current to flow.

Labeling

Label the following diagrams with the correct terms.

1. Parts of an atom (including charge):

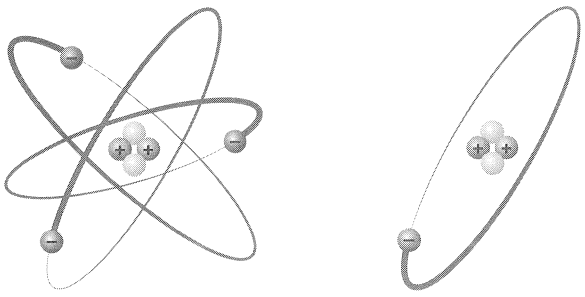


A. _____ Charge _____

B. _____ Charge _____

C. _____ Charge _____

2. Ions:

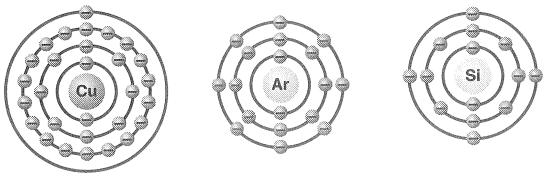


A B

A. _____

B. _____

3. Insulators:



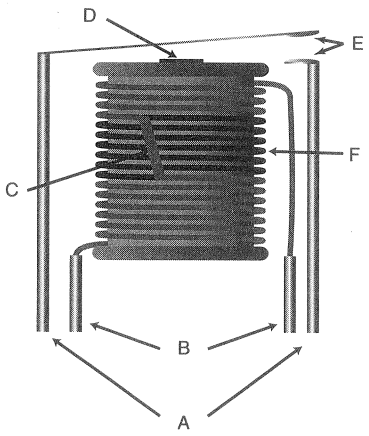
A B C

A. _____

B. _____

C. _____

4. Short circuit:



A. _____

B. _____

C. _____

D. _____

E. _____

F. _____

Review Questions

_____ **1.** All of the following statements describing the basic principles of electricity are true *except*:
- **A.** An atom with less/deficiency of electrons than protons has an overall positive charge and is called a positive ion.
- **B.** An atom with more electrons than protons has an overall negative charge and is called a negative ion.
- **C.** A positive ion exerts a repelling force on the extra electron.
- **D.** The flow of electrons from atom to atom is called current flow.

_____ **2.** Which of the following materials is typically used in the construction of semiconductors?
- **A.** Silicon
- **B.** Copper
- **C.** Plastic
- **D.** Ceramic

_____ **3.** Electromotive force can be best described as the:
- **A.** force of electrons repelling each other.
- **B.** repelling force of the negative terminal.
- **C.** attracting force of the positive terminal.
- **D.** force of attraction/repelling which drives the electrons to move along.

_____ **4.** The degree to which a material opposes the passage of electrical current through it is called:
- **A.** voltage.
- **B.** resistance.
- **C.** discharge.
- **D.** insulation.

_____ **5.** Which of the following is a measure of the number of electrons flowing past a given point in 1 second?
- **A.** Volt
- **B.** Watt
- **C.** Ohm
- **D.** Amp

_____ **6.** The device which is used to measure the amount of resistance in a component or a circuit is a(n):
- **A.** ohmmeter.
- **B.** ammeter.
- **C.** voltmeter.
- **D.** multimeter.

_____ **7.** The force with which the positive terminal pulls the free electrons toward it in a circuit is measured in:
- **A.** volts.
- **B.** amperage.

C. current.
D. ohms.

_____ **8.** All of the following statements describing an electrical circuit are true *except*:
A. An open circuit does not have continuity.
B. Current flows through the fuse into the circuit wires.
C. Electrical circuits consist of a power source, a fuse, a switch, a component that performs work, and wires connecting them all together.
D. When the switch is moved to closed position, the current path is broken and current flow stops.

_____ **9.** Which side of a circuit starts at the negative post of the battery and ends at either a load or a switch?
A. Positive side
B. Ground side
C. Supply side
D. Power side

_____ **10.** When two dissimilar metals are immersed in an acidic liquid, the breakdown of chemicals into charged particles results in a flow of electricity. This principle is used in a(n):
A. HVAC system.
B. battery.
C. sensor.
D. LED.

ASE Technician A/Technician B Style Questions

_____ **1.** Tech A says that a pure short circuit is the only type of short circuit. Tech B says that a short causes abnormally high current flow in the circuit and may cause the circuit protection devices to open the circuit. Who is correct?
A. Tech A
B. Tech B
C. Both A and B
D. Neither A nor B

_____ **2.** Tech A says that the movement of electrons in a circuit is called current flow. Tech B says that the movement of electrons in a circuit is measured in amps. Who is correct?
A. Tech A
B. Tech B
C. Both A and B
D. Neither A nor B

_____ **3.** Tech A says that electromotive force is also known as voltage. Tech B says that when electrons flow in one direction only, this is DC. Who is correct?
A. Tech A
B. Tech B
C. Both A and B
D. Neither A nor B

_____ **4.** Tech A says that an unintended resistance results in a voltage drop. Tech B says that one of the factors that determines the level of electrical resistance is the weight of the conductor. Who is correct?
A. Tech A
B. Tech B
C. Both A and B
D. Neither A nor B

_____ **5.** Tech A says that if resistance stays the same and voltage goes up, then amperage goes down. Tech B says that if voltage stays the same and resistance goes down, then amperage goes down. Who is correct?
A. Tech A
B. Tech B
C. Both A and B
D. Neither A nor B

_____ **6.** Tech A says that a series circuit has only one path for current to flow. Tech B says that a parallel circuit current flows through one resistor before getting to the next resistor. Who is correct?

A. Tech A
B. Tech B
C. Both A and B
D. Neither A nor B

_____ **7.** Two technicians are discussing a series circuit with four resistors of various resistances. Tech A says that current flow is different in each resistor. Tech B says that current flow is the same in each resistor. Who is correct?

A. Tech A
B. Tech B
C. Both A and B
D. Neither A nor B

_____ **8.** Tech A says that an ohm is a unit of measurement of resistance. Tech B says that high resistance creates heat at the point of resistance in the circuit. Who is correct?

A. Tech A
B. Tech B
C. Both A and B
D. Neither A nor B

_____ **9.** Tech A says that in a series circuit with two resistors of 120 ohms each, the total circuit resistance is 240 ohms. Tech B says that in a parallel circuit with two resistors of 120 ohms each, the total circuit resistance is 240 ohms. Who is correct?

A. Tech A
B. Tech B
C. Both A and B
D. Neither A nor B

_____ **10.** Tech A says that if a 12-volt light has 10 amps flowing through it, it is using 22 watts of electricity. Tech B says that watts are units of electrical power. Who is correct?

A. Tech A
B. Tech B
C. Both A and B
D. Neither A nor B