Chapter 11 Answer Key

11.1 Section Review

1. The formula describes the amount of energy released when a mass is completely converted to energy. It also describes how much mass can be created by a specific amount of energy. The magnitude of the c^2 factor means that a tiny amount of mass is equivalent to a huge amount of energy.
2. $$\left(3\times10^{8}\ \text{m/s}\right)\times\left(60\frac{\text{s}}{\text{min}}\right)\times\left(60\frac{\text{min}}{\text{hour}}\right)\times\left(24\frac{\text{hours}}{\text{day}}\right)$$
$$\times\left(365\frac{\text{days}}{\text{year}}\right)=9.46\times10^{15}\ \text{m}$$
3. $$E=mc^2=(1\ \text{kg})\times(3\times10^{8}\ \text{m/s})^2$$
$$E=9\times10^{16}\ \text{m}^2/\text{s}^2$$
4. Electric charge is reversed.

11.2 Section Review

1. Time moves slower, an object's mass increases, and space gets smaller at speeds close to 3×10^{8} m/s.
2. A person in motion experiences a "longer second."
3. 50 m/s
4. By travelling near the speed of light.

11.3 Section Review

1. According to Einstein's theory of general relativity, gravity is an effect created by the curvature of space and time.
2. My reference frame is how I observe objects around me. Because I am on Earth, my reference frame is moving as Earth moves. It can be moving relative to any other objects such as another person, the center of Earth, or the Sun.
3. A black hole is an object with such strong gravity that its escape velocity equals or exceeds the speed of light.
4. The "big bang" is a theory of the origin of the universe in which the universe was once smaller than an atom and began to expand after a huge explosion.

Connection Answers

1. The theory of special relativity predicts that matter cannot travel faster than the speed of light.
2. The major obstacle to traveling faster than light is that space-time distortions require huge amounts of negative energy that we do not know how to harness.
3. Wormholes can be described as "shortcuts" through the universe. Warp drive is more like an expansion of space-time behind a spaceship and contraction of space-time in front of a spaceship.
4. Warp drive is like a moving sidewalk in that the movement of space-time adds to the movement of the spaceship, just like a moving sidewalk adds to the motion of a person walking on it.

Understanding Vocabulary

1. speed of light
2. antimatter
3. time dilation
4. general relativity
5. hole

Reviewing Concepts

Section 11.1

1. $E = mc^2$, the energy derived from a mass is proportional to the mass multiplied by the speed of light squared.
2. The speed of light, abbreviated with the letter c, has a value of 3×10^8 m/s. According to Einstein's theory of relativity, nothing in the universe can travel faster than light.
3. Antimatter is matter with properties similar to normal matter except that some of its properties, like charge, are opposite to its "matter twin" For example, an electron has a negative charge while its antimatter counterpart, the positron, has a positive charge but behaves like an electron in all other respects. If an electron meets a positron they annihilate one another and release a large quantity of energy.
4. Quarks are small particles from which larger particles such as protons and neutrons are made. There are six different types of quarks; up, down, strange, charm, top and bottom. Protons are made of two up and one down quark while neutrons are made of one up and two down quarks.

Section 11.2

5. Matter cannot exceed the speed of light because the way we measure the universe changes for objects as they approach the speed of light.
6. The speed of light remains constant whether the source is motionless, approaching, or receding. But, the speed of a ball increases as the ball approaches you if thrown from a platform which is moving toward you. Scientists used Einstein's special theory of relativity to reach this conclusion.
7. Observers in different frames of reference do not see light traveling the same distance. In order to maintain a speed of light which is the same for all observers, time dilation must occur for the observer traveling at speeds approaching the speed of light; the second is significantly longer for observers approaching the speed of light.
8. Time dilation is the increase of measured increments of time for observers as they approach the speed of light. Two atomic clocks were precisely synchronized. One of the clocks was flown around the world while the other remained stationary. The clock that moved recorded a smaller amount of time by an amount predicted by the theory of time dilation.
9. According to the "Twin Paradox", two twins are separated, one flying into space at relativistic speeds. The biological clock of the space twin and the spaceship time keeping devices run at a slower rate than those on Earth. The space twin returns significantly younger than the Earth twin.

Section 11.3

10. Classically, objects are caused to move together because of the gravitational attraction between objects. Consequently we describe the motion of a small satellite as moving in a circular path around a larger mass. According the theory of general relativity, space is curved by mass causing the satellite to travel in the straight line in a space which has been curved by the large mass.
11. Large masses like stars curve the space around them. The curvature of space by large masses causes light to curve.
12. A black hole would result from the compression of a large mass into an extremely small space.
13. It is thought that the universe was initially small in size (possibly smaller than an atom) and, as the result of a "big bang" explosion, has been expanding for more than 13 billion years ago. It continues to expand today.

Solving Problems

Section 11.1

1. $E = mc^2$
   $E = (0.1 \text{ kg})(3 \times 10^8 \text{ m/s})^2$
   $E = 9 \times 10^{15}$ joules
2. $E = mc^2$
   $38 \times 10^{26} \text{ J} = (m)(3 \times 10^8 \text{ m/s})^2$
   $m = 4.2 \times 10^9$ kg

3. $t = d \div v$
   $t = (2.28 \times 10^{11}\ \text{m}) \div (3 \times 10^{8}\ \text{m/s})$
   $t = 7.6 \times 10^{2}\ \text{s}$ or 12.7 minutes
4. $t = d \div v$
   $t = (3.844 \times 10^{8}\ \text{m}) \div (3 \times 10^{8}\ \text{m/s})$
   $t = 1.28\ \text{s}$

Section 11.2

5. $v_r = v_{bk} + v_{ba}$
   $v_r = 5\ \text{m/s} + 10\ \text{m/s}$
   $v_r = 15\ \text{m/s}$
6. The clock that was traveling at 460 miles per hour would have recorded slightly less time than the stationary clock.
7. The nearest galaxy, Andromeda, is 2 million light years away, so if you were traveling near the speed of light and time progressed slowly for you, millions of years will have passed on Earth before you returned.

Section 11.3

8. The diagram should show the ray of light curving as it approaches the star. The mass of the star curves the space around the star causing the light to travel in this curved space. The path appears curved.

Test Practice

Section 11.1

1. c
2. c
3. b
4. d

Section 11.2

5. c
6. a
7. a

Section 11.3

8. d
9. b
10. c
11. d

Applying Your Knowledge

Section 11.1

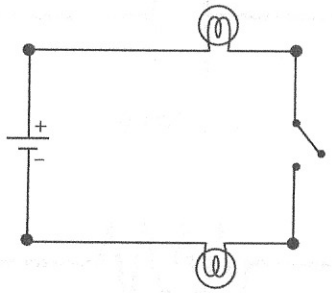
1. $t = d \times v$
   $t = (4.0 \times 10^{12}\ \text{m}) \div (3 \times 10^{8}\ \text{m/s})$
   $t = 1.3 \times 10^{4}\ \text{s}$ or 220 minutes
2. Descriptions of the history of our ideas about matter have been included in the student text. A great deal of supplemental information can be found by doing an internet search. Time lines will most likely start with the Greek philosopher of the 5th century BC, Leucippus, the tutor of Democritus. Dalton is the next to make a significant contribution, in 1803. Individuals who might be included are Marie Curie, Millikan, Thomson, Rutherford, Bohr, Crookes, Chadwick, Einstein, Avogadro, Faraday, Perrin, deBroglie, Schrodinger, Pauli, Heisenberg as well more contemporary researchers involved with the development of string theory and dark matter.

   Encourage your students to be creative and imaginative in their posters and stories. You may wish to limit the number of significant names and/or dates to include in the time line.

   Some possible made up future events could be: (1) black holes acting as time portals, (2) discovering one fundamental particle, or (3) reversing time.

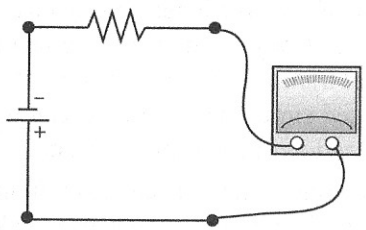
Chapter 12 Answer Key

12.1 Section Review

1. Similarities: Both carry energy, do work, and can be used to run machines. Differences: Electric current is not visible, while water currents are. If a wire is broken, the electric current stops immediately, but a broken pipe does not stop the flow of water. Current does not leave a wire as current can leave a pipe.
2. 

3. A closed circuit has electric current flowing through it with no breaks. An open circuit has a break (from an open switch, disconnected wire, etc.) and no electric current flow.

12.2 Section Review

1. Current is measured in amperes, abbreviated A.
   Voltage is measured in volts, abbreviated V.
2. The meter is reading voltage difference between its probes. If both probes are connected to the same place, the difference between the probes is zero.
3. A 1.5-V battery gives 1.5 watts of power per ampere of current.
4. Electric current flows and does work. A voltage difference is a form of electrical potential energy that provides the energy that causes current to flow.
5. 

12.3 Section Review

1. According to Ohm's law, resistance and current are inversely related, so if resistance increases, current decreases. Current and voltage are directly related, so if voltage increases, current also increases.
2. Resistance is measured in ohms, abbreviated Ω.
   Voltage is measured in volts, abbreviated V.
   Current is measured in amperes, abbreviated A.
3. $R = V \div I$
   $= 120\ V \div 10\ A$
   $= 12\ \Omega$
4. Answers are:

air	Insulator
gold	Conductor
silicon	Semiconductor
rubber	Insulator
aluminum	Conductor

Connection Answers

1. Similarities: Both involve a flow of charged material; Both rely on certain conductors to carry the current from one place to another. Differences: Battery circuits have a flow of negative electrons; body circuits have a flow of positive ions; Battery circuits have to have all components touching; Body circuits can conduct the impulse across gaps using chemical transmitters; Battery circuits must have a source of energy and a closed circuit; body circuits can work when a stimulus begins the depolarization of a sensory neuron.
2. When someone's sino-atrial node needs extra help to send regular electrical impulses to the heart muscle, a pacemaker can be installed. The pacemaker sends regular electrical impulses to the heart muscle, stimulating the muscle to contract regularly. The rhythmic contraction/relaxation of your heart allows blood to be circulated throughout the body.
3. A defibrillator sends an electric current to your heart to stimulate it to begin beating after a heart attack or other trauma. This electric shock will also help an irregularly beating heart regain a natural rhythm.
4. Answers will vary. Two animals that use electricity are: Electric Ray - can deliver 8 - 220 volts, depending on the species, to stun or kill prey. Electric Fish - a large group of weakly electric fish generate electric current to attract the opposite sex or intimidate predators - they don't have enough current to stun or kill prey.

Understanding Vocabulary

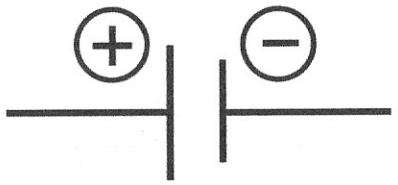
1. electric current
2. open circuit
3. Ohm's law
4. voltage
5. conductor, insulator

Reviewing Concepts

Section 12.1

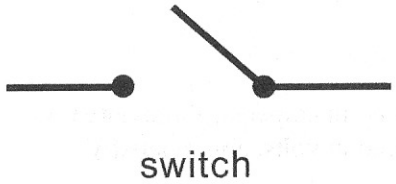
1. The symbols are standard way of describing circuit connections so that anyone trained in electrical circuits can understand the design and operation of the circuit.
2. Answers are:

a.

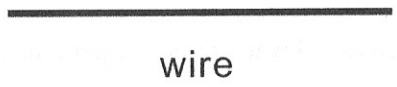


b.

c.



d.



3. Resistors may represent many different loads in a circuit. Examples include a toaster, a light bulb, a motor, a heater, or a speaker.
4. Sources of electrical energy include: batteries which may power mp3 players and flashlights; solar cells which may power calculators, landscape lighting, satellites, and Mars rovers; and generating plants which may power toasters and lamps.
5. No. When a circuit is open, current will not flow in the circuit.
6. A switch is a desirable way to open a circuit, but some other ways to break a circuit are: breaks in the wire, or a broken filament in a light bulb.

Section 12.2

7. positive; negative
8. Voltage is a measure of the electrical potential energy.
9. ampere; current; joule
10. A battery is like a water pump because the battery supplies electrical potential energy to a circuit and a pump provides potential energy to water.
11. Multimeters can measure both voltage and current for AC and DC while ammeters measure only current and voltmeters only voltage (potential difference).
12. To measure current, the current must pass through the meter.

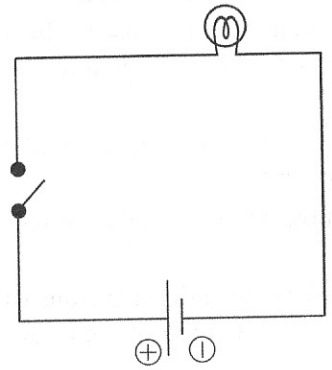
Section 12.3

13. current
14. The amount of total resistance increases because you have more resistive devices in the circuit.
15. If the resistance is doubled, the current will be reduced to ½. The product of the current in a circuit and the resistance in the circuit is a constant. A graph of current as a function of resistance in a circuit produces a hyperbolic curve.
16. The current in a circuit is dependent upon the voltage. Doubling the voltage in a circuit doubles the current.
17. voltage; resistance
18. Answers are:
    a. The current will decrease and the bulb will not glow as brightly.
    b. More current will flow in the circuit and bulb will glow more brightly.
    c. More current will flow in the circuit.
19. The resistance in a circuit will increase as the temperature of a conductor increases. The bulb's temperature increases when it is left on for some time.
20. The resistance of dry skin is very high. It will not allow enough current to flow to be harmful.
21. Conductors allow current to flow while insulators block the flow of current.
22. Water reduces the resistance of the skin from 100,000 ohms to a lower level which might allow dangerous current levels to flow through your body.
23. Copper is a very good conductor. The covering material acts an insulator to the wire from making contact with objects that should not be exposed to the current and voltage of the conducting copper wire.
24. Semiconductors are materials that have less conducting ability than a conductor but more ability than an insulator.
25. Answers are:
    a. Insulator
    b. Insulator
    c. Semiconductor
    d. Conductor
    e. Insulator
    f. Conductor
26. Fixed resistors have a resistance that cannot be changed. Variable resistors can be adjusted to have a resistance within a certain range.
27. potentiometer

Solving Problems

Section 12.1

1.



Section 12.2

2. Answers are:
   a. 1.5 V
   b. 0 V
3. Diagram B
4. Since each AA battery supplies 1.5 volts of potential, combining four batteries in series (stacking them on top of each other) would supply 6 volts.

Section 12.3

5. The current is doubled; the current is tripled.
6. $R = V/I = (120\ \text{V})/(10\ \text{A}) = 12\ \Omega$
7. $I = V/R = (120\ \text{V})/(60\ \Omega) = 2\ \text{A}$
8. $I = V/R = (6\ \text{V})/(3\ \Omega) = 2\ \text{A}$
9. Answers are:
   a. $V = IR = (1.5\ \text{A})(3\ \Omega) = 4.5\ \text{V}$
   b. 3-1.5 volt cells
10. Answers are:
    a. $I = V/R = (6\ \text{V})/(2\ \Omega) = 3\ \text{A}$
    b. $I = V/R = (12\ \text{V})/(3\ \Omega) = 4\ \text{A}$
    c. $I = V/R = (9\ \text{V})/(2\ \Omega) = 4.5\ \text{A}$
11. $R = V/I = (120\ \text{V})/(15\ \text{A}) = 8\ \Omega$
12. Each battery supplies 1.5 volts of potential, for a total of 3 volts with 2 batteries combined.
    $I = V/R = (3\ \text{V})/(6\ \Omega) = 0.5\ \text{A}$

Test Practice

Section 12.1

1. a
2. a
3. c

Section 12.2

4. a
5. d
6. a

Section 12.3

7. c
8. b
9. d
10. c
11. c