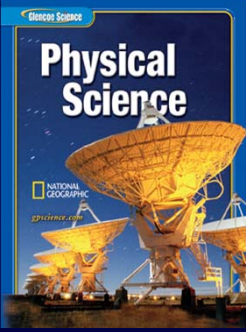


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CHAPTER RESOURCES

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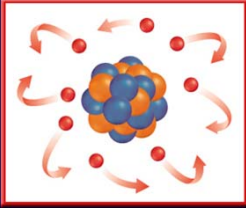
CHAPTER RESOURCES

END

Electric Charge

7.1 **Positive and Negative Charge**

- Atoms contain particles called protons, neutrons, and electrons.



- Protons and electrons have electric charge, and neutrons have no electric charge.

CHAPTER RESOURCES

END

Electric Charge

7.1 **Positive and Negative Charge**

- Protons have positive electric charge and electrons have negative electric charge.
- The amount of positive charge on a proton equals the amount of negative charge on an electron.

CHAPTER RESOURCES

END

Electric Charge

7.1 **Positive and Negative Charge**

- An atom contains equal numbers of protons and electrons, so the positive and negative charges cancel out and an atom has no net electric charge.
- Objects with no net charge are said to be electrically neutral.


CHAPTER RESOURCES

END

Electric Charge

7.1 **Transferring Charge**

- Compared to the electrons in carpet atoms, electrons are bound more tightly to the atoms in the soles of your shoes.



- When you walk on the carpet, electrons are transferred from the carpet to the soles of your shoes.


CHAPTER RESOURCES

END

Electric Charge

7.1 **Transferring Charge**

- The soles of your shoes have an excess of electrons and become negatively charged.
- The carpet has lost electrons and has an excess of positive charge.



- The accumulation of excess electric charge on an object is called **static electricity**.

CHAPTER RESOURCES

Electric Charge

7.1 **Conservation of Charge**

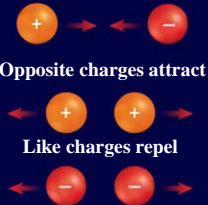
- According to the **law of conservation of charge**, charge can be transferred from object to object, but it cannot be created or destroyed.
- Whenever an object becomes charged, electric charges have moved from one place to another.

CHAPTER RESOURCES

Electric Charge

7.1 **Charges Exert Forces**

- Unlike charges attract each other, and like charges repel each other.



- The force between electric charges also depends on the distance between charges. The force decreases as the charges get farther apart.

CHAPTER RESOURCES

Electric Charge

7.1 **Charges Exert Forces**

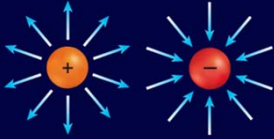
- The force between any two objects that are electrically charged decreases as the objects get farther apart.
- This force also depends on the amount of charge on each object.
- As the amount of charge on either object increases, the electrical force also increases.

CHAPTER RESOURCES

Electric Charge

7.1 **Electric Fields**

- An electric field surrounds every electric charge and exerts the force that causes other electric charges to be attracted or repelled.
- Any charge that is placed in an electric field will be pushed or pulled by the field.



CHAPTER RESOURCES

Electric Charge

7.1 **Comparing Electric and Gravitational Forces**

- The force of gravity between you and Earth seems to be strong. Yet, compared with electric forces, the force of gravity is much weaker.

CHAPTER RESOURCES

Electric Charge

7.1 **Comparing Electric and Gravitational Forces**

- The chemical bonds that form between atoms in molecules also are due to the electric forces between the atoms.
- These electric forces are much larger than the gravitational forces between the atoms.

CHAPTER RESOURCES

END

Electric Charge

7.1 **Comparing Electric and Gravitational Forces**

- The electric forces between the objects around you are much less than the gravitational forces between them.
- Most objects that you see are nearly electrically neutral and have almost no net electric charge.
- As a result, there is usually no noticeable electric force between these objects.

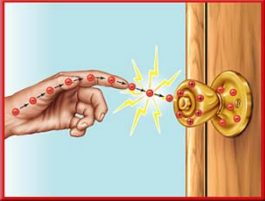
CHAPTER RESOURCES

END

Electric Charge

7.1 **Conductors and Insulators**

- If you reach for a metal doorknob after walking across a carpet, you might see a spark.



- The spark is caused by electrons moving from your hand to the doorknob.

CHAPTER RESOURCES

END

Electric Charge

7.1 **Conductors**

- A material in which electrons are able to move easily is a **conductor**.
- The best electrical conductors are metals.
- The atoms in metals have electrons that are able to move easily through the material.


CHAPTER RESOURCES

END

Electric Charge

7.1 **Insulators**

- A material in which electrons are not able to move easily is an **insulator**.
- Electrons are held tightly to atoms in insulators.
- Most plastics are insulators.
- The plastic coating around electric wires prevents a dangerous electric shock when you touch the wire.



CHAPTER RESOURCES

END

Electric Charge

7.1 **Charging Objects**

- Rubbing two materials together can result in a transfer of electrons.
- Then one material is left with a positive charge and the other with an equal amount of negative charge.
- The process of transferring charge by touching or rubbing is called **charging by contact**.

CHAPTER RESOURCES

END

Electric Charge

7.1 **Charging at a Distance**

- Because electrical forces act at a distance, charged objects brought near a neutral object will cause electrons to rearrange their positions on the neutral object.


CHAPTER RESOURCES

END

Electric Charge

7.1 **Charging at a Distance**

- The balloon on the left is neutral. The balloon on the right is negatively charged. It produces a positively charged area on the sleeve by repelling electrons.
- The rearrangement of electrons on a neutral object caused by a nearby charged object is called **charging by induction**.



CHAPTER RESOURCES

END

Electric Charge

7.1 **Lightning**

- Lightning is a large static discharge.
- A static discharge is a transfer of charge between two objects because of a buildup of static electricity.
- A thundercloud is a mighty generator of static electricity. As air masses move and swirl in the cloud, areas of positive and negative charge build up.


CHAPTER RESOURCES

END

Electric Charge

7.1 **Lightning**

- Eventually, enough charge builds up to cause a static discharge between the cloud and the ground.
- As the electric charges move through the air, they collide with atoms and molecules. These collisions cause the atoms and molecules in air to emit light.



CHAPTER RESOURCES

END

Electric Charge

7.1 **Thunder**

- Lightning also generates powerful sound waves.
- The electrical energy in a lightning bolt rips electrons off atoms in the atmosphere and produces great amounts of heat.
- The heat causes air in the bolt's path to expand rapidly, producing sound waves that you hear as thunder.

CHAPTER RESOURCES

END

Electric Charge

7.1 **Grounding**

- A discharge can occur any time that charge builds up in one area.
- Providing a path for charge to reach Earth prevents any charge from building up.
- Earth is a large, neutral object that is also a conductor of charge.


CHAPTER RESOURCES

END

Electric Charge

7.1 **Grounding**

- Any object connected to Earth by a good conductor will transfer any excess electric charge to Earth.
- Connecting an object to Earth with a conductor is called grounding.



? CHAPTER RESOURCES ⏪ 📄 ⏩ END

Electric Charge

7.1 **Detecting Electric Charge**

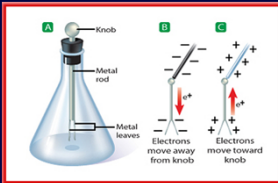
- The presence of electric charges can be detected by an electroscope.
- One kind of electroscope is made of two thin, metal leaves attached to a metal rod with a knob at the top.
- The leaves are allowed to hang freely from the metal rod.

? CHAPTER RESOURCES ⏪ 📄 ⏩ END

Electric Charge

7.1 **Detecting Electric Charge**

- When the device is not charged, the leaves hang straight down.
- Notice the position of the leaves on the electroscope when they are A uncharged, B negatively charged, and C positively charged.



? CHAPTER RESOURCES ⏪ 📄 ⏩ END

Section Check

7.1

Question 1

The law of conservation of charge states that _____.

? CHAPTER RESOURCES ⏪ 📄 ⏩ END

Section Check

7.1

Answer

Charge can be transferred from object to object, but it cannot be created or destroyed.

? CHAPTER RESOURCES ⏪ 📄 ⏩ END

Section Check

7.1

Question 2

Which of the following is the best conductor of electricity?

- A. copper
- B. rubber
- C. wood
- D. water

? CHAPTER RESOURCES ⏪ 📄 ⏩ END

Section Check

7.1

Answer

The answer is A. The best electrical conductors are metals.

CHAPTER RESOURCES

END

Section Check

7.1

Question 3

The accumulation of excess electric charge on an object is called _____.

A. lightning
B. static electricity
C. static discharge
D. thunder

CHAPTER RESOURCES

END

Section Check

7.1

Answer

The answer is B. Lightning is a large static discharge that emits light.

CHAPTER RESOURCES

END

Electric Current

7.2

Current and Voltage Difference

- The net movement of electric charges in a single direction is an **electric current**.
- In a metal wire, or any material, electrons are in constant motion in all directions. As a result, there is no net movement of electrons in one direction.

CHAPTER RESOURCES

END

Electric Current

7.2

Current and Voltage Difference

- When an electric current flows in the wire, electrons continue their random movement, but they also drift in the direction that the current flows.
- Electric current is measured in amperes.

CHAPTER RESOURCES

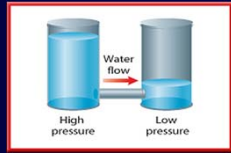
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Electric Current

7.2

Voltage Difference

- In some ways, the electric force that causes charges to flow is similar to the force acting on the water in a pipe.
- Water flows from higher pressure to lower pressure.



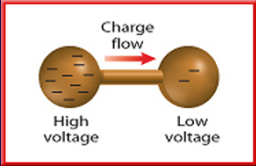
CHAPTER RESOURCES

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Electric Current

7.2 **Voltage Difference**

- In a similar way, electric charge flows from higher voltage to lower voltage.



A **voltage difference** is related to the force that causes electric charges to flow. Voltage difference is measured in volts.

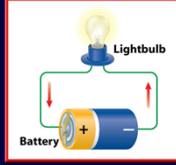
CHAPTER RESOURCES

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Electric Current

7.2 **Electric Circuits**

- This figure shows an electric current doing work by lighting a lightbulb.
- A closed path that electric current follows is a **circuit**.
- If the circuit is broken by removing the battery, or the lightbulb, or one of the wires, current will not flow.



CHAPTER RESOURCES

END

Electric Current

7.2 **Batteries**

- To keep an electric current continually flowing in the electric circuit a voltage difference needs to be maintained in the circuit.
- A battery can provide the voltage difference that is needed to keep current flowing in a circuit.
- Current flows as long as there is a closed path that connects one battery terminal to the other battery terminal.

CHAPTER RESOURCES

END

Electric Current

7.2 **Dry-Cell Batteries**

- A cell consists of two electrodes surrounded by a material called an electrolyte.
- The electrolyte enables charges to move from one electrode to the other.

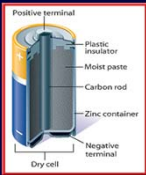
CHAPTER RESOURCES

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Electric Current

7.2 **Dry-Cell Batteries**

- One electrode is the carbon rod, and the other is the zinc container.
- The electrolyte is a moist paste containing several chemicals.
- The cell is called a dry cell because the electrolyte is a moist paste, and not a liquid solution.



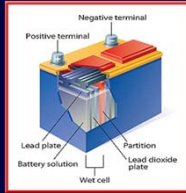
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Electric Current

7.2 **Wet-Cell Batteries**

- A wet cell contains two connected plates made of different metals or metallic compounds in a conducting solution.
- A wet-cell battery contains several wet cells connected together.



CHAPTER RESOURCES

END

Electric Current

7.2 **Lead-Acid Batteries**

- Most car batteries are lead-acid batteries.
- A lead-acid battery contains a series of six wet cells made up of lead and lead dioxide plates in a sulfuric acid solution.
- The chemical reaction in each cell provides a voltage difference of about 2 V, giving a total voltage difference of 12 V.

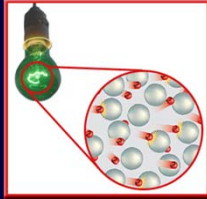
CHAPTER RESOURCES

END

Electric Current

7.2 **Resistance**

- As the electrons flow through the filament in a lightbulb, they bump into the metal atoms that make up the filament.



- In these collisions, some of the electrical energy of the electrons is converted into thermal energy.

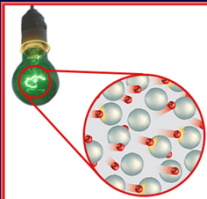
CHAPTER RESOURCES

END

Electric Current

7.2 **Resistance**

- Eventually, the metal filament becomes hot enough to glow, producing radiant energy that can light up a dark room.



CHAPTER RESOURCES

END

Electric Current

7.2 **Resisting the Flow of Current**

- **Resistance** is the tendency for a material to oppose the flow of electrons, changing electrical energy into thermal energy and light.
- With the exception of some substances that become superconductors at low temperatures, all materials have some electrical resistance.
- Resistance is measured in ohms (Ω).

CHAPTER RESOURCES

END

Electric Current

7.2 **Temperature, Length, and Thickness**

- The electric resistance of most materials usually increases as the temperature of the material increases.
- The resistance of an object such as a wire also depends on the length and diameter of the wire.

CHAPTER RESOURCES

END

Electric Current

7.2 **Temperature, Length, and Thickness**

- The resistance of a wire, or any conductor, increases as the wire becomes longer.
- The resistance also increases as the wire becomes thinner.

CHAPTER RESOURCES

END

Electric Current

7.2 **The Current in a Simple Circuit**


- A simple electric circuit contains a source of voltage difference, such as a battery, a device, such as a lightbulb, that has resistance, and conductors that connect the device to the battery terminals.
- When the wires are connected to the battery terminals, current flows in the closed path.

CHAPTER RESOURCES

Electric Current

7.2 **The Current in a Simple Circuit**

- The voltage difference, current, and resistance in a circuit are related.
- If the voltage difference doesn't change, decreasing the resistance increases the current in the circuit.
- If the resistance doesn't change, increasing the voltage difference increases the current.



CHAPTER RESOURCES

Electric Current

7.2 **Ohm's Law**

- According to **Ohm's law**, the current in a circuit equals the voltage difference divided by the resistance.
- If I stands for the electric current, Ohm's law can be written as the following equation.

Ohm's Law

$$\text{current (in amperes)} = \frac{\text{voltage difference (in volts)}}{\text{resistance (in ohms)}}$$

$$I = \frac{V}{R}$$

CHAPTER RESOURCES

Electric Current

7.2 **Ohm's Law**

- Ohm's law provides a way to measure the resistance of objects and materials. First the equation above is written as:

$$R = \frac{V}{I}$$

- An object is connected to a source of voltage difference and the current flowing in the circuit is measured.
- The object's resistance then equals the voltage difference divided by the measured current.

CHAPTER RESOURCES

Section Check

7.2 **Question 1**

_____ is the net movement of electric charges in a single direction.

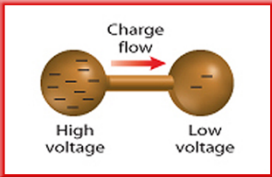
A. An open circuit
B. Electric current
C. Proton flow
D. Voltage

CHAPTER RESOURCES

Section Check

7.2 **Answer**

The answer is B. Electric forces in a material cause electric current to flow.



CHAPTER RESOURCES

Section Check

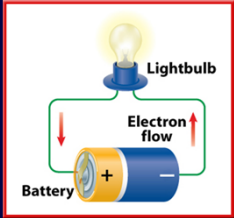
7.2

Question 2

What is a volt?

Answer

A volt is the unit of measurement for voltage difference, which is related to the force that causes electric charges to flow.



END

Section Check

7.2

Question 3

What is the tendency for a material to oppose the flow of electrons called?

Answer

The tendency for a material to oppose the flow of electrons is called resistance, and is measured in ohms.

END

Electrical Energy

7.3

Series and Parallel Circuits

- Circuits usually include three components. One is a source of voltage difference that can be provided by a battery or an electrical outlet.
- Another is one or more devices that use electrical energy.
- Circuits also include conductors such as wires that connect the devices to the source of voltage difference to form a closed path.

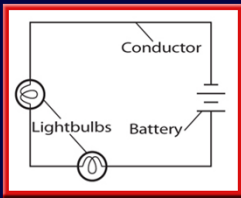
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Electrical Energy

7.3

Series Circuits

- One kind of circuit is called a series circuit.
- In a **series circuit**, the current has only one loop to flow through.
- Series circuits are used in flashlights and some holiday lights.



END

Electrical Energy

7.3

Open Circuit

- How can one faulty bulb cause a whole string of lights to go out?
- When any part of a series circuit is disconnected, no current flows through the circuit.
- This is called an open circuit. The burned-out bulb causes an open circuit in the string of lights.

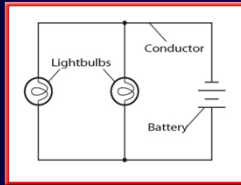
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Electrical Energy

7.3

Parallel Circuits

- Houses are wired with parallel circuits.
- **Parallel circuits** contain two or more branches for current to move through.
- The current can flow through both or either of the branches.




END

Electrical Energy

7.3 Parallel Circuits

- Parallel circuits have several advantages.
- When one branch of the circuit is opened, such as when you turn a light off, the current continues to flow through the other branches.



Click box to play movie

CHAPTER RESOURCES

END

Electrical Energy

7.3 Household Circuits

- The wiring in a house must allow for the individual use of various appliances and fixtures.
- This wiring is mostly a combination of parallel circuits connected in an organized and logical network.

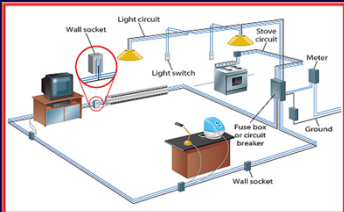
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Electrical Energy

7.3 Household Circuits

- The main switch and circuit breaker or fuse box serve as an electrical headquarters for your home.



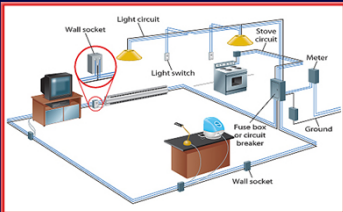
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Electrical Energy

7.3 Household Circuits

- Parallel circuits branch out from the breaker or fuse box to wall sockets, major appliances, and lights.



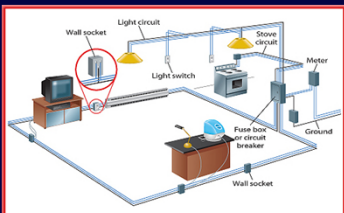
CHAPTER RESOURCES

END

Electrical Energy

7.3 Household Circuits

- To protect against overheating of the wires, all household circuits contain either a fuse or a circuit breaker.



CHAPTER RESOURCES

END

Electrical Energy

7.3 Fuses

- An electrical fuse contains a small piece of metal that melts if the current becomes too high.
- When it melts, it causes a break in the circuit, stopping the flow of current through the overloaded circuit.

CHAPTER RESOURCES

END

Electrical Energy

7.3 **Fuses**


- To enable current to flow again in the circuit, you must replace the blown fuse with a new one.
- Too many appliances in use at the same time is the most likely cause for the overheating of the circuit.

CHAPTER RESOURCES

Electrical Energy

7.3 **Circuit Breaker**

- A circuit breaker contains a piece of metal that bends when the current in it is so large that it gets hot.
- The bending causes a switch to flip and open the circuit, stopping the flow of current.
- Circuit breakers usually can be reset by pushing the switch to its "on" position.



CHAPTER RESOURCES

Electrical Energy

7.3 **Electric Power**

- The reason that electricity is so useful is that electrical energy is converted easily to other types of energy.
- The rate at which electrical energy is converted to another form of energy is the **electric power**.

CHAPTER RESOURCES

Electrical Energy

7.3 **Calculating Electric Power**

- Electric power can be calculated from the following equation.

Electric Power Equation

electric power (in watts) = current (in amperes) × voltage difference (in volts)

$$P = IV$$

- The unit for power is the watt (W). Because the watt is a small unit of power, electric power is often expressed in kilowatts (kW).
- One kilowatt equals 1,000 watts.

CHAPTER RESOURCES

Electrical Energy

7.3 **Electrical Energy**

- Electric companies charge by the amount of electrical energy used, rather than by the electric power used.
- Electrical energy usually is measured in units of kilowatt hours (kWh) and can be calculated from this equation:

Electric Energy Equation

electric energy (in kWh) = electric power (in kW) × time (in hours)

$$E = Pt$$

CHAPTER RESOURCES

Electrical Energy

7.3 **The Cost of Using Electrical Energy**

- The cost of using the appliance can be computed by multiplying the electrical energy used by the amount the power company charges for each kWh.
- For example, if a 100-W lightbulb is left on for 5 h, the amount of electrical energy used is

$$E = Pt = (0.1 \text{ kW}) (5 \text{ h}) = 0.5 \text{ kWh}$$

CHAPTER RESOURCES

Electrical Energy

7.3

The Cost of Using Electrical Energy

Power and Energy Used by Home Appliances			
Appliance	Time of Usage (hr/day)	Power Rating (W)	Energy Usage (kWh/day)
Hair dryer	0.25	1,000	0.25
Microwave oven	0.5	700	0.35
Stereo	2.5	100	0.27
Range (oven)	1	2,600	2.60
Refrigerator/freezer (15 ft ³ , frostless)	10	615	6.15
Television (color)	3.25	200	0.80
100-W lightbulb	6	100	0.60
40-W fluorescent lightbulb	1	40	0.04

- The cost of using some household appliances is given in this table, where the cost per kWh is assumed to be \$0.09/kWh.

CHAPTER RESOURCES

END

Section Check

7.3

Question 1

What is an open circuit?

Answer

An open circuit is a series circuit in which one part is disconnected. This prevents current from flowing through the circuit.

CHAPTER RESOURCES

END

Section Check

7.3

Question 2

The rate at which electrical energy is converted to another form of energy is called _____.

A. electrical fuse
B. electrical switching
C. electric power
D. thermal energy

CHAPTER RESOURCES

END

Section Check

7.3

Answer

The answer is C. Electric power is the rate of energy conversion and is measured in watts.

CHAPTER RESOURCES

END

Section Check

7.3

Question 3

Which of the following equations is used to calculate electric power?

A. $P = IV$
B. $P = I/V$
C. $P = V/I$
D. $P = AV$

CHAPTER RESOURCES

END

Section Check

7.3

Answer




The answer is A. Electric power is equal to the current, I , multiplied by the voltage difference, V .

CHAPTER RESOURCES

END





7 **Help**


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