Science 9 Chapter 8 Section 1

Electric Potential Energy and
Voltage (pp. 250-259)

Cells and Batteries

- electrochemical cells: **devices that convert chemical energy into electrical energy**;
- Battery: **a combination of electrochemical cells connected together produces a potential difference**
- The battery terminals are the end points where we make a connection. **Extra electrons accumulate** on one of the battery terminals, making it **negatively charged**. The other terminal has **lost these electrons** and is therefore **positively charged**. When the battery is connected to an electronic device, electrons can travel through the wires and into the device.

Electric Potential Difference

- Energy: **the ability to do work**
- electric potential energy: **electric energy stored in a battery**
- The electrical energy stored in a battery is called **electric potential energy** because the electrons have **stored energy** and the ability to do work after they leave the battery.
- In order for the electrons to lose their stored electrical energy, the battery **must be connected to a device.** When you connect a battery to a light bulb, the electric potential energy is "released" as the electrons move through the wire inside the bulb and the electrons' energy is converted into heat and light energy.

Electric Potential Difference

- potential difference (voltage): **the amount of electric potential energy per one coulomb of charge at one point in a circuit compared to the potential energy per coulomb of charge at another point in the circuit**
- Volt (V): **the unit of potential difference**; one volt causes a current of one ampere to flow through a conductor with a resistance of one ohm

Comparing Potential Energy and Potential Difference

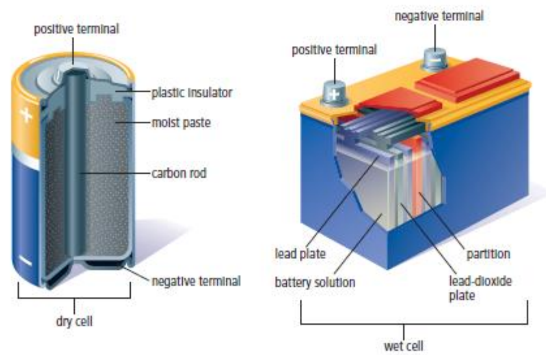
- You might compare potential energy and potential difference with climbing a staircase. When you climb a flight of stairs, your body has done work. The work you have done is now *potential energy. If* you had climbed the same set of stairs with a heavy backpack, you would have done more work. As a result, you and the backpack would have more potential energy. The potential energy thus depends on the height of the stairs and the amount of mass moved to the top.

Comparing Potential Energy and Potential Difference

- You can think of the potential difference in a battery as being like the height of the stairs. The amount of charge separated in a battery is like the mass moved up the stairs. The potential energy in the battery is due to both the potential difference (volts) and the amount of charge that has been separated (coulombs).
- The amount of potential energy a battery can output depends not only on how much voltage the battery has but also on how much charge that battery can separate. Even though C, D, AA, and AAA batteries all have a potential difference of 1.5 V, the battery that can separate the most charge would have the greatest potential energy. The energy that charge possesses is dependent on the amount of charge and the voltage.
- A **voltmeter** is a device that measures the amount of potential difference between two locations of charge separation. When you place the connecting wires of a voltmeter across the + and – terminals of a battery, the voltmeter displays the battery's voltage.

Types of Cells

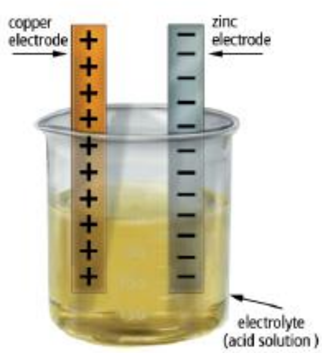
- We can classify batteries into two groups: **dry cells and wet cells.** Dry cells are the batteries in devices like flashlights, portable CD players, and watches. Wet cells are commonly used in cars, motorcycles, and electric wheelchairs. Both types of batteries produce voltage in a similar way.



Parts of Cells

- Cells have 2 electrodes separated by an electrolyte
- Electrodes: **two terminals in a cell or other electricity source; usually made of two different metals or a metal and another material**
- Electrolyte: **substance that conducts an electric current; in a dry cell, the electrolyte is a moist paste; in a wet cell, the electrolyte is a liquid**
- The amount of voltage that is produced in an electrochemical cell depends on the types of metal and the electrolyte used

How a Cell Works



- In a zinc-copper cell, the acidic electrolyte attacks the zinc electrode and pulls atoms off the zinc. But the zinc atoms leave electrons behind on the electrode, and the electrode becomes negatively charged. At the same time, chemical reactions pull electrons off the copper electrode. Therefore, the copper electrode has a positive charge. Because there is an opposite charge on each electrode, there is a potential difference (voltage) between the two electrodes.

Sources of Electrical Energy

- There are several different sources of electrical energy, including:
  - **Friction**
  - **Piezoelectric crystals**
  - **Photoelectric cells**
  - **Thermocouples**
  - **generators**

Friction

- **<u>Rubbing two materials together</u>**, such as acetate and paper, or rubber and wool, can **<u>separate charge</u>**. These separated charges now have electrical energy. Some of the work done by rubbing is converted into the electrical energy stored in the separated charge.

Piezoelectric crystals

- A barbecue lighter has no battery inside to produce the electric spark. The electricity comes from a tiny crystal. When certain types of **<u>crystals, such as quartz, are squeezed, positive and negative charges are separated on either side of the crystal</u>**. A small hammer in the lighter hits the piezoelectric crystal, generating a burst of thousands of volts of electricity. The prefix "piezo-" means pressure or push.

Photo-electrochemical cells

- **Solar panels** and many **calculators** use photo-electrochemical cells or **solar cells** as a source of power. Photo-electrochemical cells are made of **semiconducting material** such as silicon. When light hits the cell, some of the **light energy breaks electrons off the surface of the cell**. These separated electrons now have the electrical energy needed to operate a calculator, a phone booth, or the International Space Station.

Thermocouples

- A thermocouple is a device used **to transform heat energy into electrical energy**. A thermocouple consists of a **loop of two wires of different metals joined at both ends. If one end of the loop is heated or cooled, charge is separated and a voltage is created across the thermocouple**. Individual thermocouples can produce only a small amount of electrical energy. If a larger amount of electricity is needed, several thermocouples must be joined together. We use a thermocouple in a **kitchen oven to control the temperature**

Generators

- The electricity that enters most of our homes is produced by a generator. Generators work on the principle that **when a wire moves close to a magnet or a magnet moves close to a wire, a voltage is created across the wire**. All that is needed is an energy source to provide the wire or the magnet with the necessary motion. In Newfoundland and Labrador, we use hydroelectric energy, the energy of water to generate electrical energy.

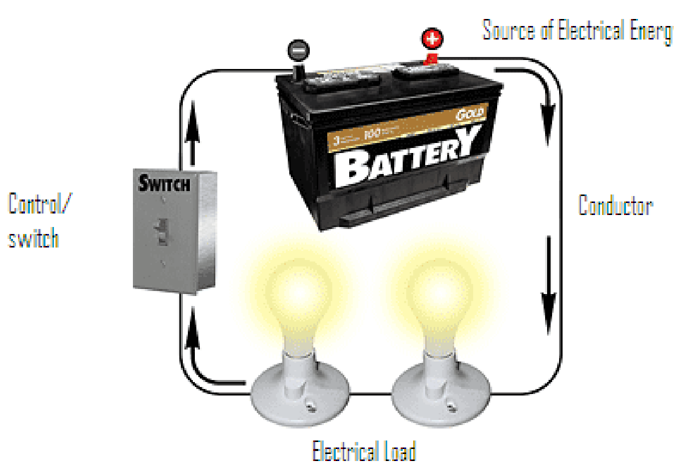
Science 9 Chapter 8 Section 2

Electric Current (pp. 260-269)

Electric Circuit

- electric circuit: **<u>a complete pathway that allows electrons to flow</u>**
- Even the most complex circuits are made of only four basic types of parts or components:
  - **<u>Source: the source of electrical energy</u>**
  - **<u>Conductor: the wire through which electric current flows</u>**
  - **<u>Load: a device that transforms electrical energy into other forms of energy</u>**
  - **<u>Switch: a device that can turn the circuit on or off by closing or opening the circuit</u>**
- An open circuit does not allow electricity to flow (switch is off) while a closed circuit does allow electricity to flow (switch is on)

Parts of an Electric Circuit



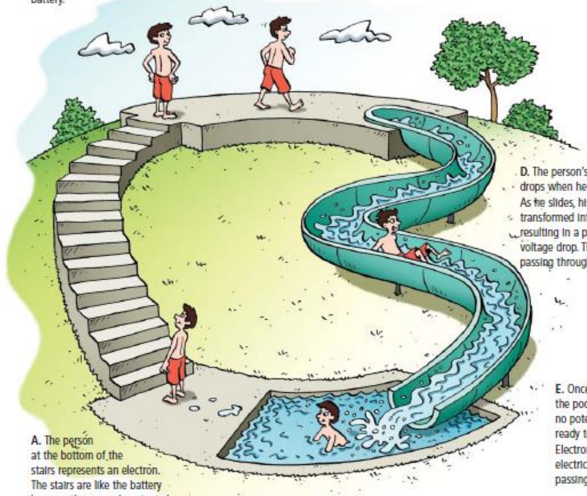
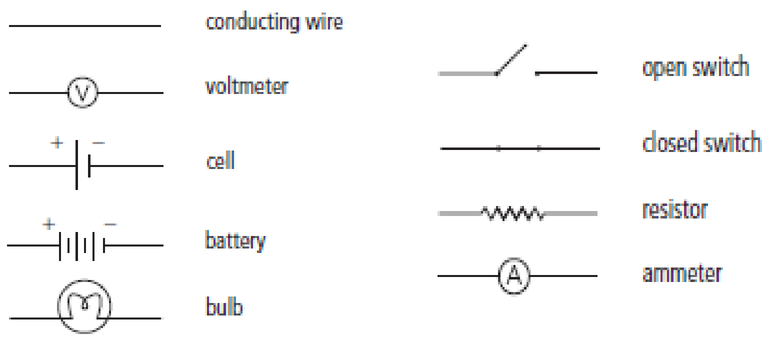


Figure 8.9 One difference between the swimmer and the electron is that a single electron does not keep going around the circuit, whereas the swimmer may make many return trips down the slide!

Circuit Diagrams

- Electric load: **<u>any device that transforms electrical energy into other forms of energy, such as a light bulb, buzzer, heater, or motor</u>**
- Circuit diagram**<u>: a drawing using symbols to represent the different components of a circuit</u>**
- Circuit diagrams give an organized representation of the actual circuit. In order to make your circuit diagrams simple to read, be sure to meet the following criteria.
  - Draw your diagrams using a ruler.
  - Make all connecting wires and leads straight lines with 90° (right-angle) corners.
  - If possible, do not let conductors cross over one another.
  - Your finished drawing should be rectangular or square.

Circuit Diagram Symbols



How Electricity Moves

- In the circuits covered in this section, a battery supplies the energy to push electrons. Electrons are **pushed from the negative terminal of the battery, along conducting wires through a load, such as a light bulb, and end up on the positive terminal of the battery**. As soon as the battery is connected to the circuit, and the circuit is closed, electrons in every part of the circuit are pushing. That is why the light bulb goes on immediately.

How Electricity Moves – an example

- This concept is similar to water in a hose connected to a tap. If the hose is already filled with water, as soon as you turn on the tap, water flows from the other end of the hose. The electrons leaving the negative terminal push the electrons ahead of them, just like water leaving the tap pushes on the water in front. Electrons do not need to touch in order to push other electrons. Electrons apply an action-at-a-distance force.

Current Electricity vs. Static Electricity

- Current electricity: **<u>the continuous flow of charge in a complete circuit</u>**
- Remember that static electricity does not flow; it is stationary
- Electric current: **<u>the amount of charge passing a point in a conductor every second</u>**
- Electric current is measured in **<u>amperes (A).</u>** This unit is named in honour of the French physicist André-Marie Ampère who studied the relationship between electricity and magnetism. Small currents are measured in milliamperes (mA); 1.0 A1000 mA. An ammeter is a device used to measure the current in a circuit
- Ampere: **<u>unit for measuring electric current</u>**;

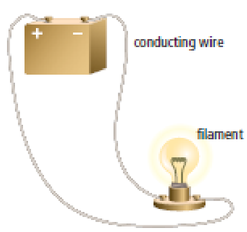
Conventional Current

- In 1747, Benjamin Franklin wrote about charged objects as being electrified "positively" and "negatively," meaning that the positively charged objects contained more electric fluid (a greater, or positive amount) than the negatively charged objects (a lesser, or negative amount). This suggests that whenever electricity flows, it moves from positive to negative.
- Notice that a flow of charge from positive to negative is the opposite of the idea that we use today. For historical reasons, Franklin's idea is named *conventional current. The* concept of conventional current is still used to describe and calculate potential difference in a circuit. The concept of electron flow to describe current was not accepted by scientists until the late 1800s, after the discovery of the electron.

Science 9 Chapter 8 Section 3

Resistance and Ohm's Law (pp. 270-283)

Electrical Resistance



- Resistance: **<u>the property of any material that slows down the flow of electrons and converts electrical energy into other forms of energy</u>**
- Ex. The filament of the light bulb resists the flow of the electrons and therefore slows down the current. The filament's **<u>high resistance</u>** causes the electrons' electrical energy to be converted into **<u>heat and light energy</u>**. The wire that connects the battery to the light bulb has very little resistance, and therefore the electrons travelling through this wire lose almost no electrical energy.

Resistance and Current

- Voltage is the difference in potential energy per unit of charge between one point in the circuit and another point in the circuit. **<u>When you increase the voltage connected to the circuit, the current will also increase</u>**. In other words, voltage is directly proportional to current.
- If a battery is connected to an electric circuit that has a large resistance, **<u>less current will flow than if the same battery is connected to a lower resistance circuit.</u>**

Ohm's Law

- Electrical resistance: **the ratio of voltage to current**
- Ohm's Law: **the mathematical relationship comparing voltage (*V*), current (*I*), *and resistance* (*R*), written as *R* = *V*/*I* or *V* = *IR***
- Ohm (Ω): **the unit of measurement for electrical resistance**

Calculations involving Ohm's law

- What is the resistance of a flashlight bulb if there is a current of 0.75 A through the bulb when connected to a 3.0 V battery?
- R = V/I
- R = 3.0 V/0.75A
- R = 4.0 Ω

Converting units – SI prefixes

- Prefixes are used to indicate the magnitude of a value.
  - *milli (m) represents one-thousandth*
  - *kilo (k) represents one thousand*
  - *mega (M) represents one million*
- When solving a problem where some of the units contain prefixes, first convert the prefixes before you do your calculation.
- Ex. What is the voltage across a 12kΩ load that allows a current of 6.0 mA?
  - **Use the formula:**
  - $V = IR$
  - (6.0 mA)(12 kΩ)
- = (0.0060 A)(12 000 Ω)
- = 72 V

Determining the Resistance – method 1

- Method 1: To experimentally measure the resistance of a device or load, the load must be connected to a source of potential difference, such as a battery. You can use a voltmeter to measure the voltage across the load and an ammeter to measure the current through the load. Then you can use Ohm's law to calculate the resistance.
- To obtain more accurate results, you can place several different voltages across the load. You then measure the current through the load for each voltage. Using Ohm's law, you can calculate the load's resistance for each set of data. These resistances can then be compared.

Determining the Resistance – method 2

- <u>Method 2</u>. Most multimeters also have a setting for measuring resistance. An ohmmeter is a device that measures resistance. When a multimeter is used as an ohmmeter, the meter uses its internal battery to provide a voltage across the load. The meter measures the current leaving the battery and calculates the resistance. This calculated resistance is then shown on the display screen

The Resistor

- Resistor: **<u>an electrical component with a set amount of resistance that slows down current and transforms electrical energy into other forms of energy</u>**
- Resistors can be used to control current or potential difference in a circuit to provide the correct voltage and current to the other components of the circuit.

Resistance and Energy Loss

- When the charge encounters resistance, some of the **electrical energy** stored in the electrons is **transformed** into other forms of energy, **such as heat.** When we say that energy is **lost** in a resistor, it really means that electrical energy has been transformed to other forms of energy. These other forms of energy do not easily get changed back into electrical energy.