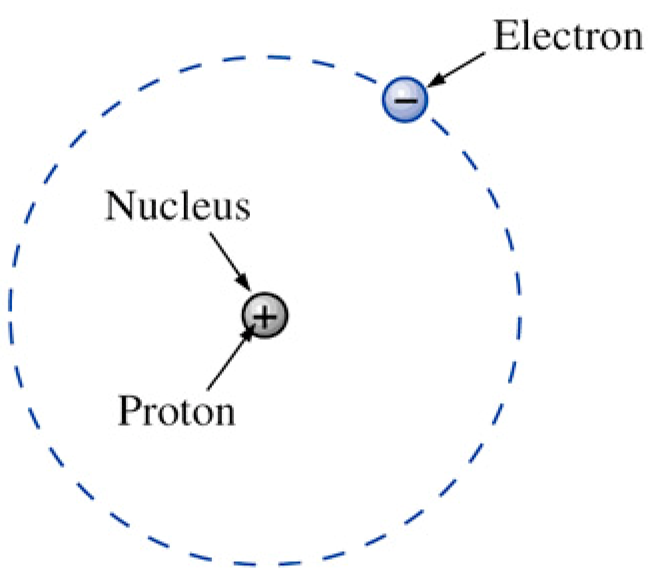
Today’s Lecture

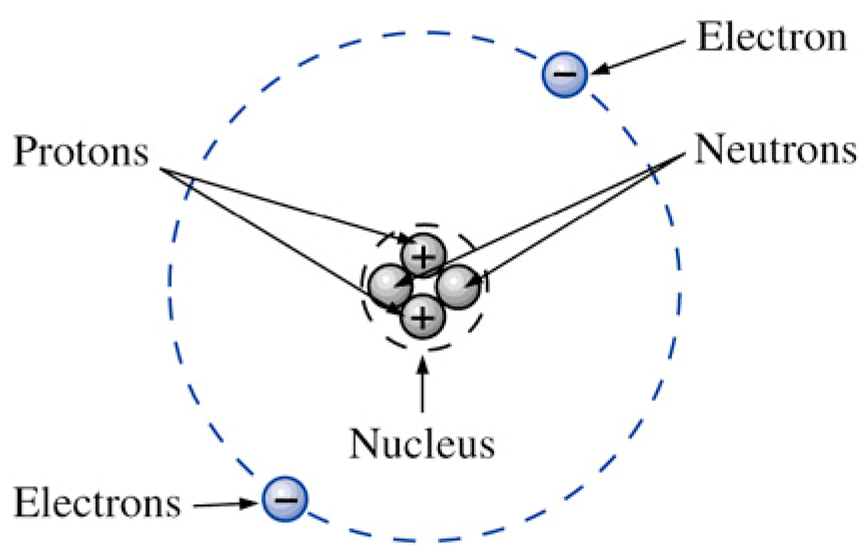
- Atoms & Their Structure (Review)
- Voltage
- Current
- Safety
- Voltage Sources

Atoms & Their Structure

- The orbiting electron carries a negative charge equal in magnitude to the positive charge on the proton.
- The atomic structure of any stable atom has an equal number of electrons and protons

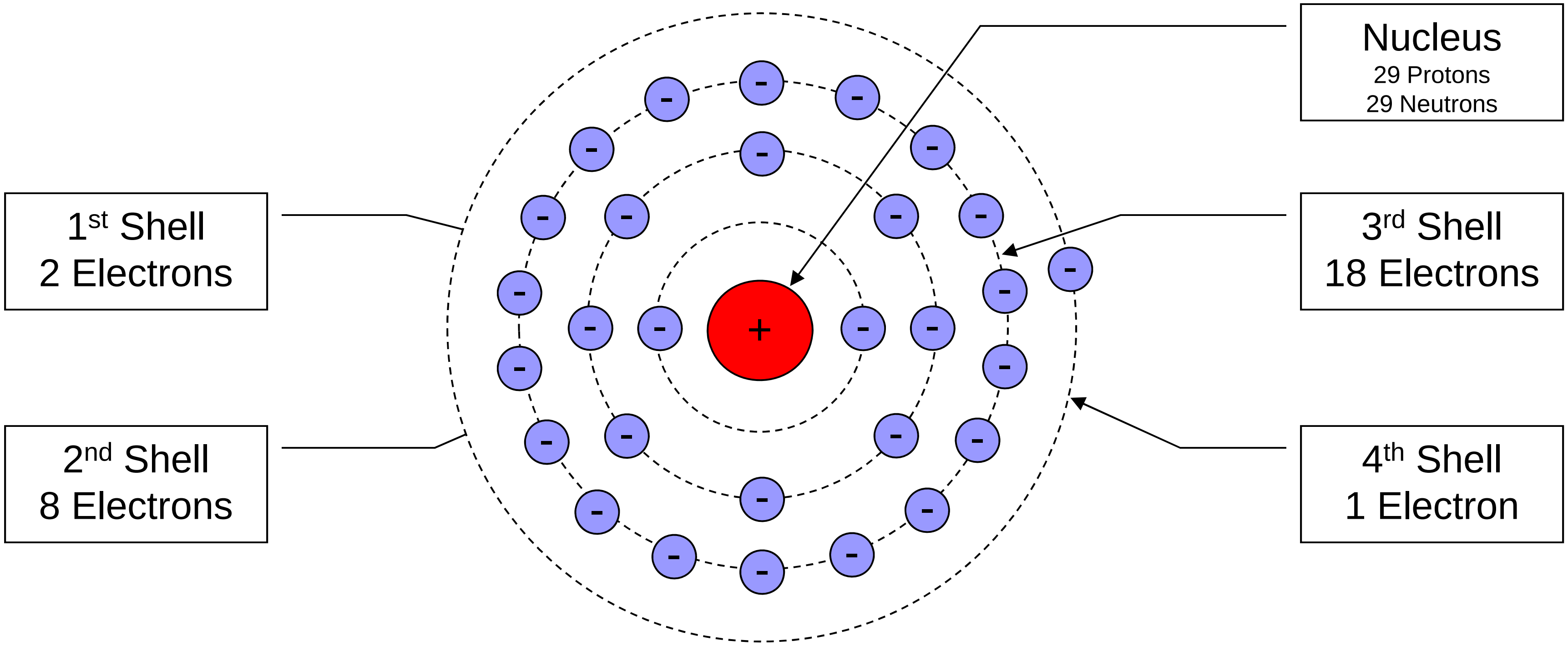


Hydrogen atom



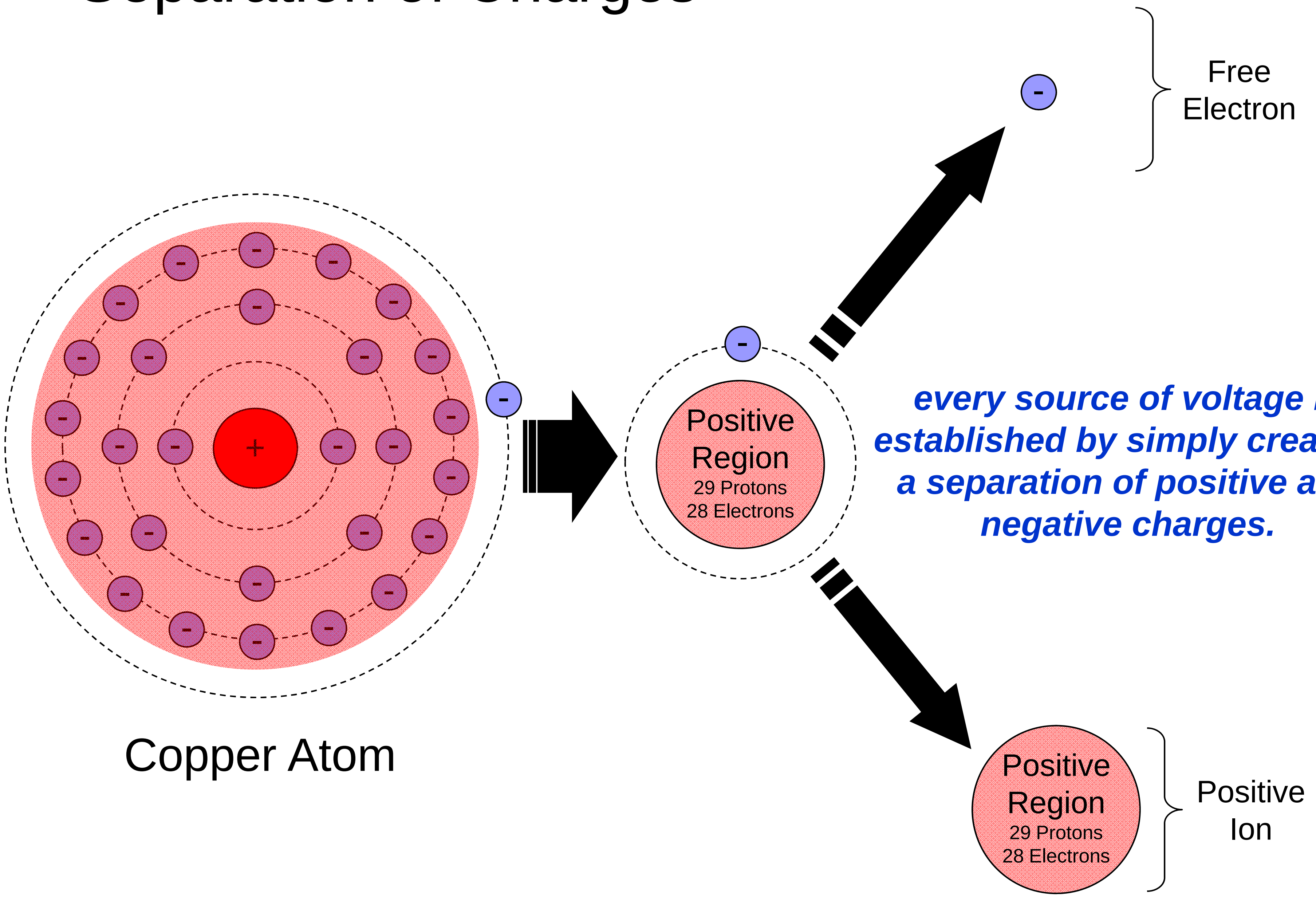
Helium atom

Atomic Structure of Copper



- Shells ($2n^2$: 2, 8, 18, 32, etc)
- The outer shell of copper is incomplete (only 1 of 32 slots occupied).
- This outer-most electron is loosely bound to the atom and could be separated from the parent atom with minimal outside force.

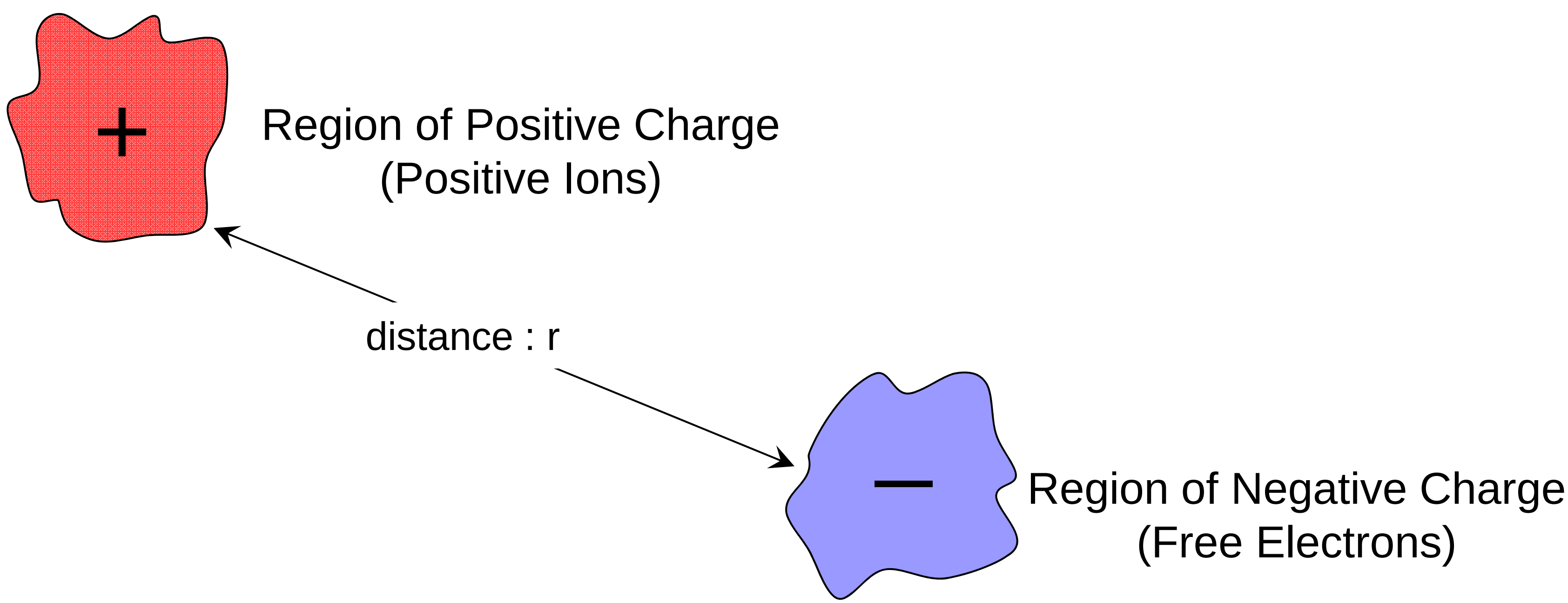
Separation of Charges



every source of voltage is established by simply creating a separation of positive and negative charges.

Voltage Potential

- To create a voltage level of any magnitude establish a region of positive and negative charge.
- The greater the quantity of charge, the more voltage potential.



Coulomb & Joule Definitions

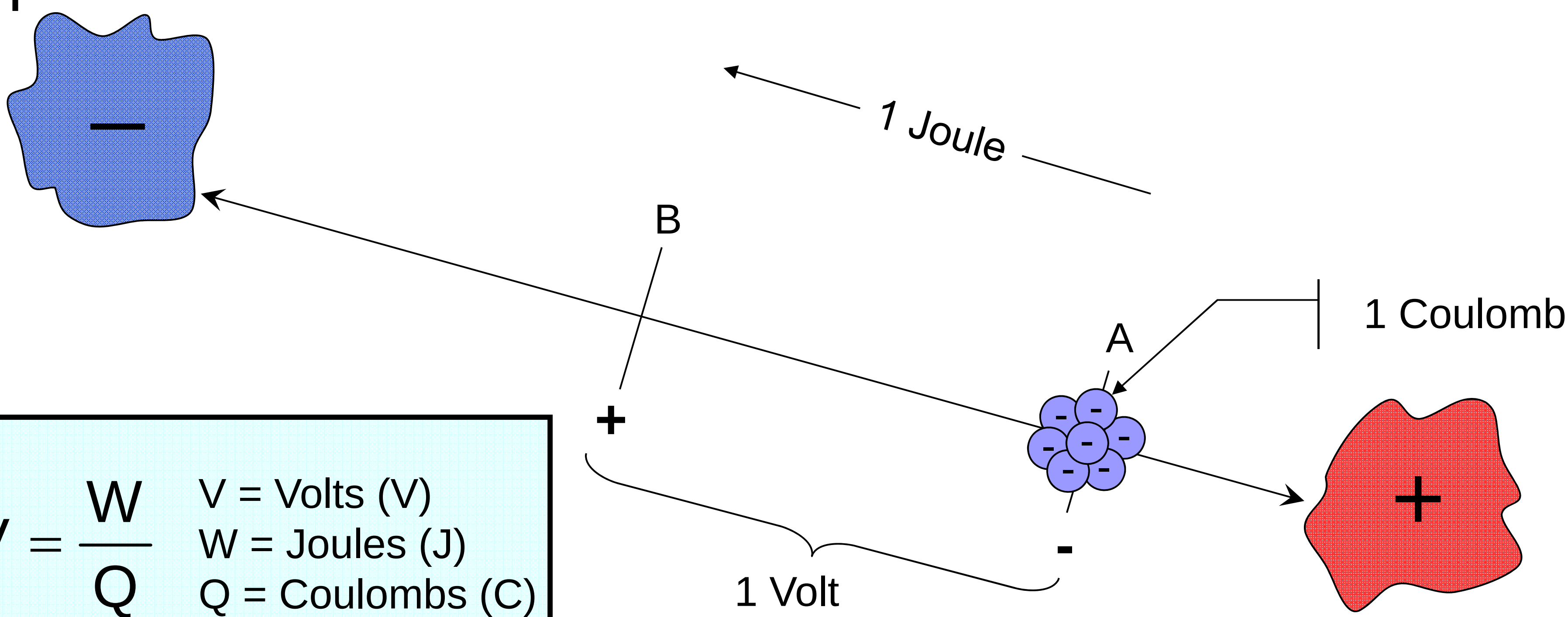
- Since the voltage potential created by the separation of a single electron is insignificant, we group the electrons into a package called a ***Coulomb***.

  1 Coulomb (C): The total charge associated with 6.242×10^{18} Electrons

- *One **Joule*** (J) is the unit of energy equal to the work done when a force of one Newton (N) acts through a distance of one meter .

Voltage Definition

If a total of 1 joule (W) of energy is used to move 1 Coulomb (C) of charge between points A and B, there is a difference of 1 volt (V) between the two points.



$$V = \frac{W}{Q}$$

V = Volts (V)
W = Joules (J)
Q = Coulombs (C)

Other Forms….

Volts (V)

$$V = \frac{W}{Q}$$

V = Volts (V)
W = Joules (J)
Q = Coulombs (C)

Joules (W)

$$W = QV$$

V = Volts (V)
W = Joules (J)
Q = Coulombs (C)

Coulombs (Q)

$$Q = \frac{W}{V}$$

V = Volts (V)
W = Joules (J)
Q = Coulombs (C)

Breakout Exercise #1

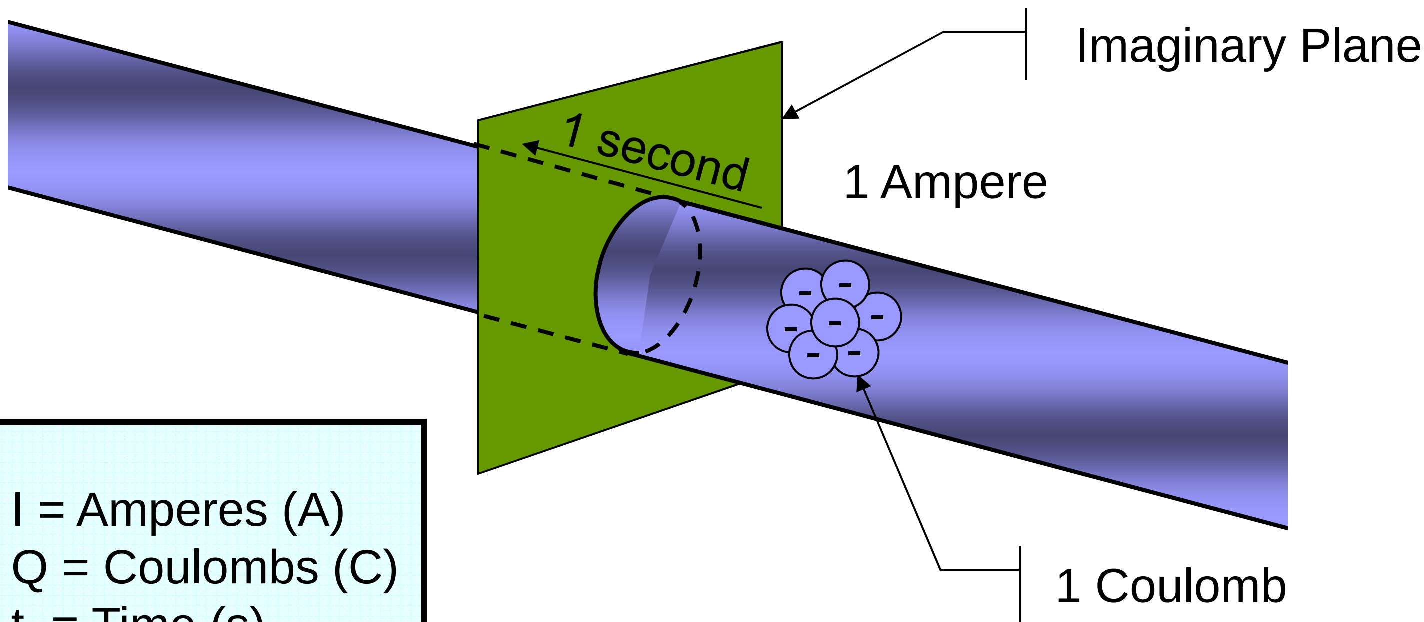
What is the voltage between two points if 1.2 J (joules) of energy are required to move 0.4 mC (coulombs) between the two points?

Breakout Exercise #2

Find the charge Q that requires 96 J of energy to be moved through a potential difference of 16 V.

Current Definition

If 1 coulomb (C) passes through an imaginary plane of wire in 1 second (s), the flow of charge, or current, is 1 ampere (A).



$$I = \frac{Q}{t}$$

I = Amperes (A)
Q = Coulombs (C)
t = Time (s)

Other Forms….

Amperes (I)

$$I = \frac{Q}{t}$$

I = Amperes (A)
Q = Coulombs (C)
t = Time (s)

Coulombs (Q)

$$Q = I \times t$$

I = Amperes (A)
Q = Coulombs (C)
t = Time (s)

Time (t)

$$t = \frac{Q}{I}$$

I = Amperes (A)
Q = Coulombs (C)
t = Time (s)

Breakout Exercise #3

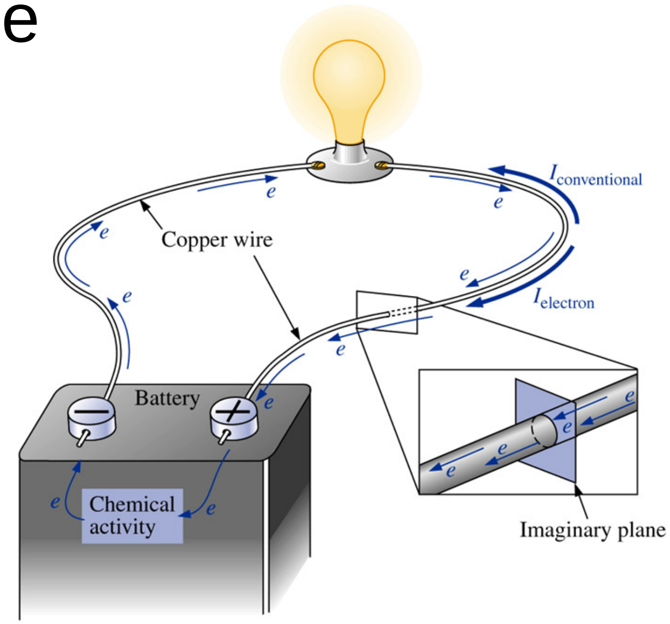
Find the current in amperes if 12 mC of charge pass through a wire in 2.8 seconds.

Breakout Exercise #4

If a current flow of 40 mA exists in a wire for 0.8 minutes, how many coulombs of charge have passed through the wire?

Voltage & Current : Chicken & The Egg

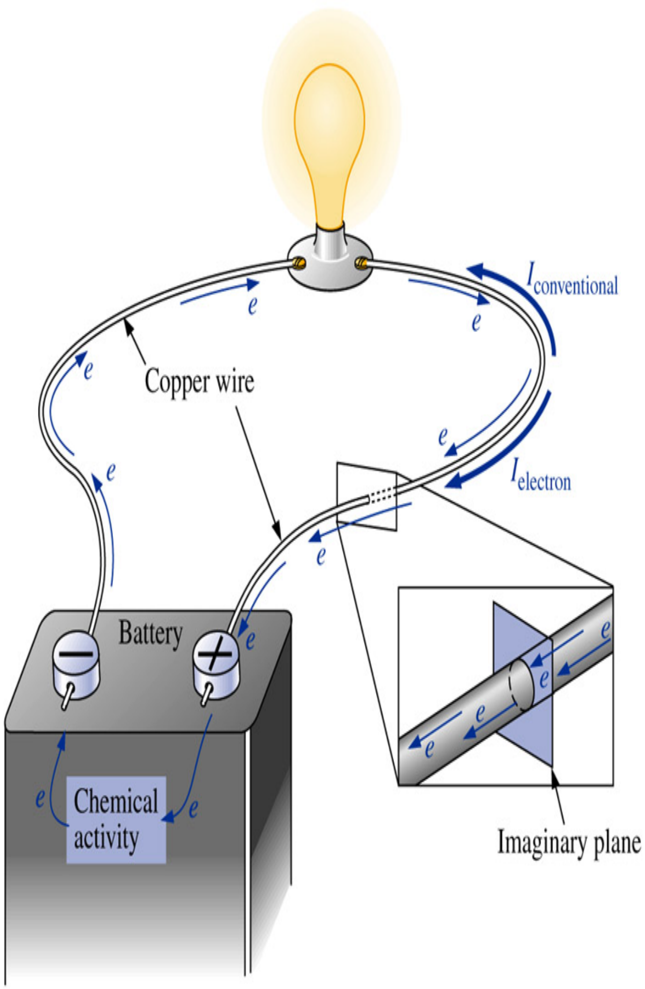
- The applied potential of a voltage source is the "pressure" to set the system in motion and "cause" the flow of current through the electrical system.
- You can have voltage without current, but you can't have current without a voltage
- For example, a battery in a flashlight has a voltage potential regardless of whether the flashlight is on (current flow) or off (no current flow).



- Without the battery, there can not be current flow.

Electron Flow vs Conventional Current Flow

- **Electron Flow** is what actually happens. Electrons flow out of the negative terminal, through the circuit and into the positive terminal of the voltage source.
- **Conventional Current** assumes that current flows out of the positive terminal, through the circuit and into the negative terminal of the source. This was the convention chosen during the discovery of electricity. *They were wrong!*
- Both **Conventional Current** and **Electron Flow** are used by industry. In fact, it makes no difference which way current is flowing as long as it is used *consistently*. The direction of current flow does not affect what the current does.
- Throughout this course, **Conventional Current** is used.



Safety
Voltage Doesn't Kill – Current Kills

- Contrary to popular belief, you cannot feel high voltage directly and it will not kill you. Voltage is simply the amount of stored energy.
- Current is the motion of that charge and can have lethal effects.
- As we will see later, there is a relationship between voltage and current (Ohm's Law) that can make high voltage significant.
- Several factors determine how dangerous electricity can be. These factors will determine whether you will feel a little buzz, are hospitalized, or worse.

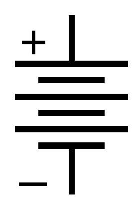
Effect of Current on the Body

Current	Reaction
1 mA	Just a faint tingle.
5 mA	Slight shock felt. Disturbing, but not painful. Most people can “let go.” However, strong involuntary movements can cause injuries.
6-25 mA (women)	Painful shock. Muscular control is lost. This is the range where “freezing currents” start. It may not be possible to “let go.”
9-30 mA (men)	
50-150 mA	Extremely painful shock, respiratory arrest (breathing stops), severe muscle contractions. Flexor muscles may cause holding on; extensor muscles may cause intense pushing away. Death is possible.
1.0 – 4.3 Amps	Ventricular fibrillation (heart pumping action not rhythmic) occurs. Muscles contract; nerve damage occurs. Death is likely.
> 10 Amps	Cardiac arrest and severe burns occur. Death is probable.

Voltage Sources

- There are a variety of ways to establish a desired direct current (dc) voltage
  - Battery : Chemical Action or Solar Energy
  - Generator : Mechanical Action
  - Rectification/Conversion : Power Supplies
- DC voltage supplies are ones that produce a unidirectional (one direction) flow of charge. 

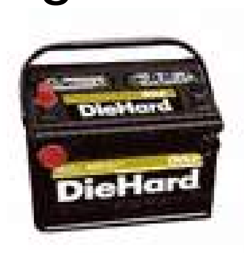
- AC (Alternating Current) will be discussed later.
- Regardless of method, all dc voltage sources have the same schematic symbol…



Voltage Sources

- Batteries
  - Primary Cells / Non-Rechargeable
    - Alkaline
    - Lithium

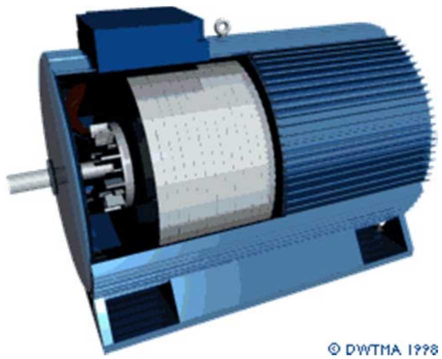
  - Secondary Cells / Rechargeable
    - Lead-Acid (car batteries)



    - NiMH (Nickel-Metal Hydride)
    - NiCd (Nickel-Cadmium)

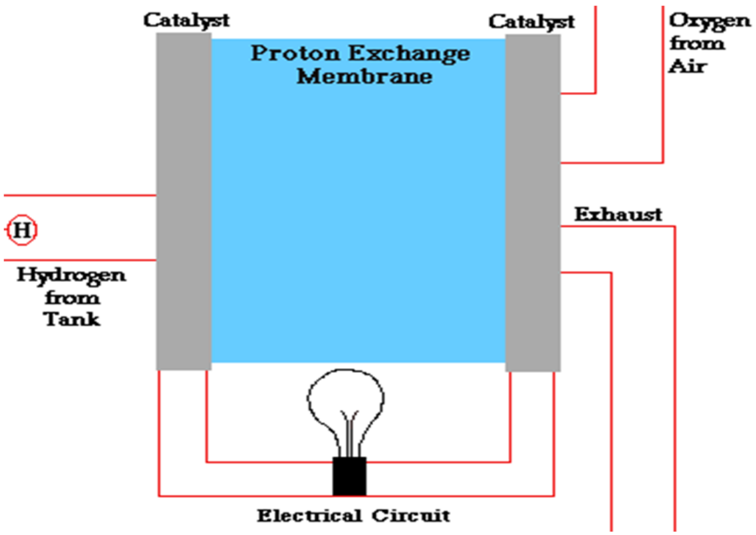
Voltage Sources

- Generators



- Power Supplies

- Fuel Cells



Breakout Exercise #5

Which would you prefer?

a) A penny for every electron that passes through a wire in 0.01 μSec at a current of 2 mA

OR

b) A dollar for every electron that passes through a wire in 1.5 nSec if the current is 100 μA.