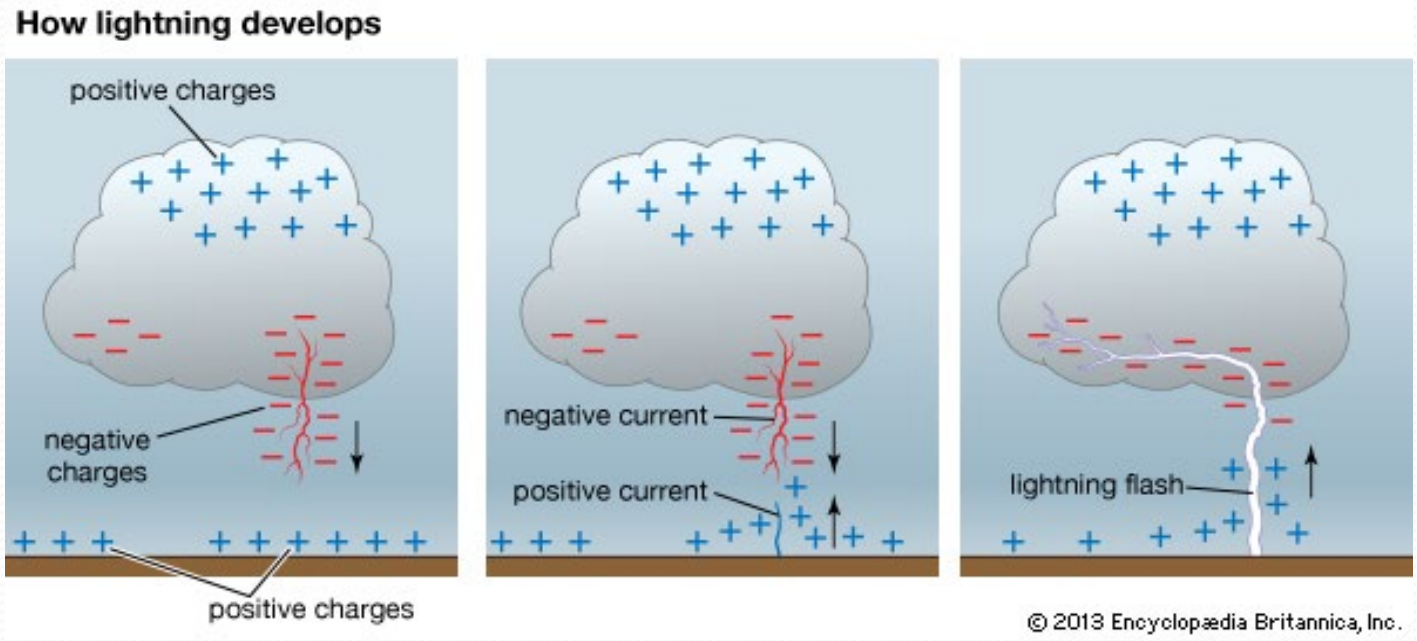
Charge and Voltage

Lightning

- Lightning occurs when warm air floats above cool air; starts to condense and release energy.
- As warm air rises, electrons are transferred to rain drops, creates charge in cloud.
  - Bottom = -
  - Top = +

Lightning



- Electrons move away from cloud, cause charge separation.
- Surface becomes positively charged and below the surface becomes negatively charged.
- Lightning strikes when electrons from the cloud are attracted to the positively charged surface.

Question

- What makes lightning so dangerous?

The current!

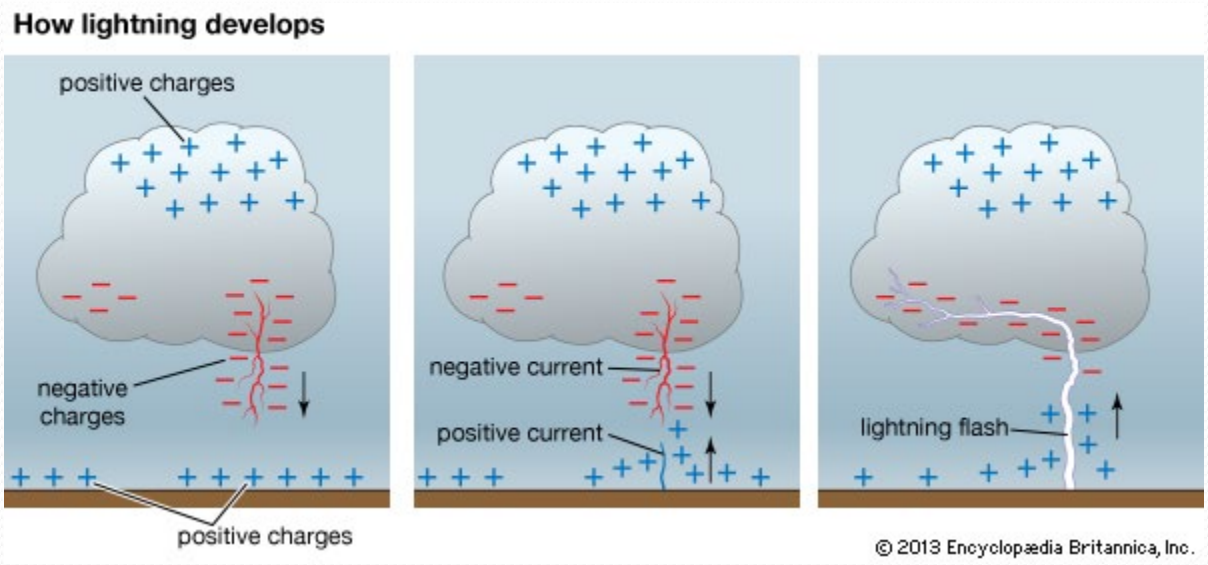
A huge amount of electrons are transferred (10^{18} electrons).

A coulomb of energy = 6.25 x 10^{18} electrons.
If an object transfers electrons, the charge is determined in coulombs.

q = $^{-}1.00$ or $^{+}1.00$

Charge

- Charge is measured in Coulombs, C
- **One electron carries a very small charge of -1.6 x 10^{-19} C** or 0.00000000000000000016 C
- The danger with lightning strikes is a lot of electrons move all at once, which can create a very big charge



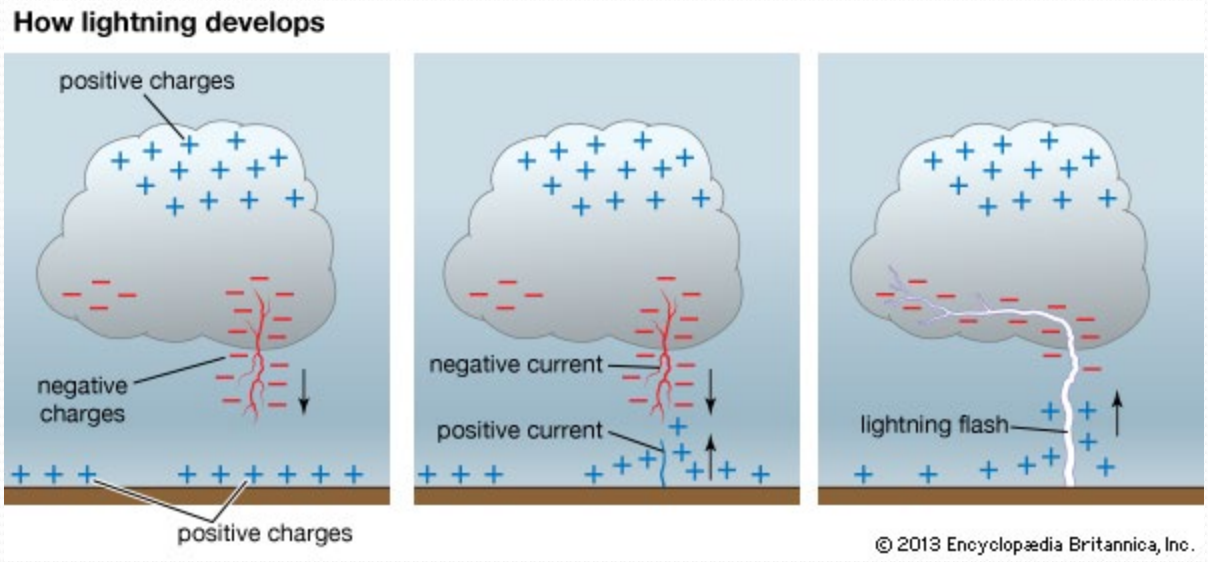
Charging by Friction

rabbit fur	very positive
glass	
human hair	
silk	
aluminium	
steel	neutral
amber	
hard rubber	
copper	
Styrofoam	
Scotch tape	
Teflon	very negative

- Different substance have a different affinity for electrons
- When rubbing two objects together, the object with the greater affinity for electrons will become negative and the other object will become positive

Charge Separation

- When a charged object is brought next to a neutral object, the like charges will be repelled
- This creates an attractive force and can help create lightning



Example

- How many electrons enter your body if you have a −55 μC charge by dragging your feet on the ground?

- What does the negative signify?

You gained the electrons!

Step 1: write out the conversion factor from electrons to coulombs

From the previous slide we know that **1e = 1.6 x 10-19C**

We can place this information into a fraction like below

- 1e = 1.6 x 10 -19 C

$$\frac{1e}{1.6 \times 10^{-19}\ C}$$

Step 2 Convert μC to C… How do we do this? Multiple by 10^{-6}

Prefix	Symbol	Factor by Which Base Unit Is Multiplied	
tera	T	1 000 000 000 000	$= 10^{12}$
giga	G	1 000 000 000	$= 10^{9}$
mega	M	1 000 000	$= 10^{6}$
kilo	k	1 000	$= 10^{3}$
hecto	h	100	$= 10^{2}$
deca	da	10	$= 10^{1}$
Common Base Units*		1	$= 10^{0}$
deci	d	0.1	$= 10^{-1}$
centi	c	0.01	$= 10^{-2}$
milli	m	0.001	$= 10^{-3}$
micro	μ	0.000 001	$= 10^{-6}$
nano	n	0.000 000 001	$= 10^{-9}$
pico	p	0.000 000 000 001	$= 10^{-12}$

$1\mu c = 10^{-6}$ C

-55×10^{-6} C

Step 3:

- What did the question give us?
- 55 x 10 -6C

- What are we looking for?
- Electrons

- **Place into fraction beside step 1: ensure same units are on the top (ex: electrons) and same units are on the bottom (ex: coulombs)**

Given: 55×10^{-6} C looking for: e

$$\frac{1.6 \times 10^{-19}\ \text{C}}{1\ \text{e}} = \frac{55 \times 10^{-6}\ \text{C}}{x}$$

Step 4: **Cross multiply and divide!**

3.4×10^{14} electrons …. you will gain 3.4×10^{14} electrons

Board Question

- A student rubbed an ebonite rod with fur, transferring about 1.4 x 10^{10} electrons from the fur to the ebonite rod. Determine the charge on the rod

Cross multiply and divide!

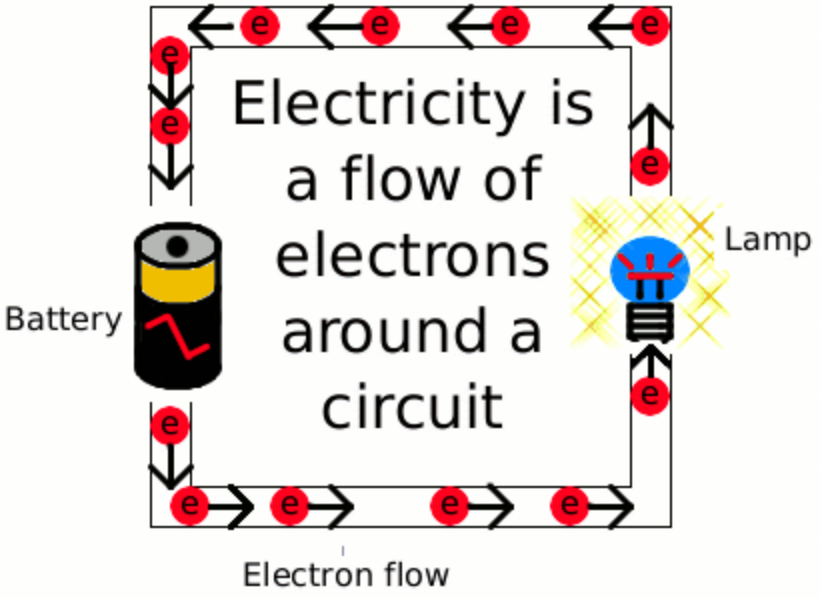
$$\frac{1.6 \times 10^{-19}\ C}{1\ \text{electrons}} = \frac{x}{1.4 \times 10^{10}\ \text{electrons}}$$

$= 2.24 \times 10^{-9}$

Current

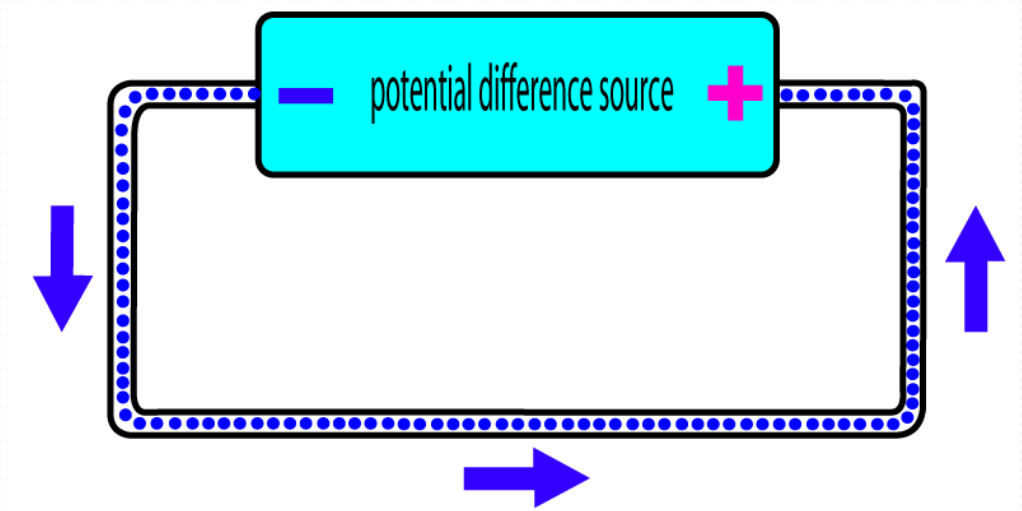
- Current is the movement of charge
- Current is measured in Amp (A) which is how many coulombs of charge move past a point every second

1 e = 1.6 x 10-19C



Voltage

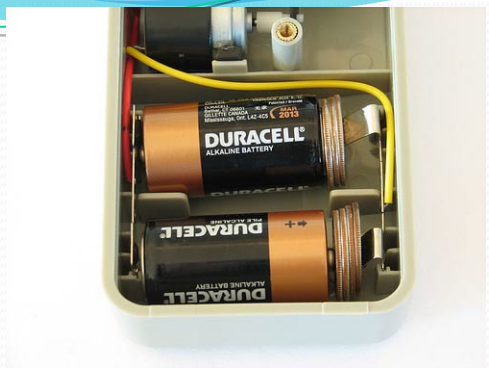
- A voltage is caused by one side of an object being positive and the other side being negative (e.g. A static shock when you walk on carpet).



Voltage

- A voltage is sometimes called a potential difference because there's a difference in charge between sides.
- Potential energy stored in your finger is converted to light, sound and energy (why it hurts).
- Determined by:
  - $V = \Delta E/q$
    - Where V = voltage. (V)
    - ΔE = change in energy (J)
    - q = charge (C)

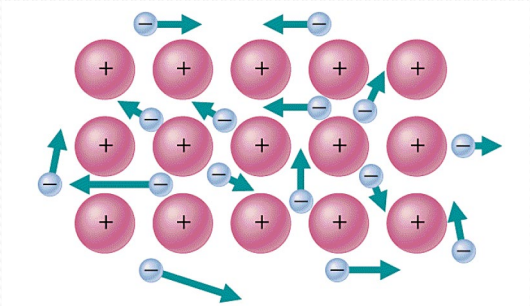
Energy and charge



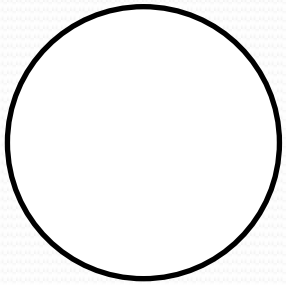
- What does 1.5V mean?
  - 1.5J of energy per coulomb.
- Voltage is related to energy transferred per coulomb; if there is a lot of energy, the voltage is high.
- Lightning is dangerous because voltage and charge (coulombs) are large values.

Insulators vs. Conductors

- Conductors are objects that allow charge to flow throughout (Able to move)
- Ex. Metals



- Insulators are objects that do not allow charge to flow very well (stay there)
- Ex. Wood or Plastic



- Only electrons move. Protons do not.