Lecture Outline

Chapter 22: Electrostatics

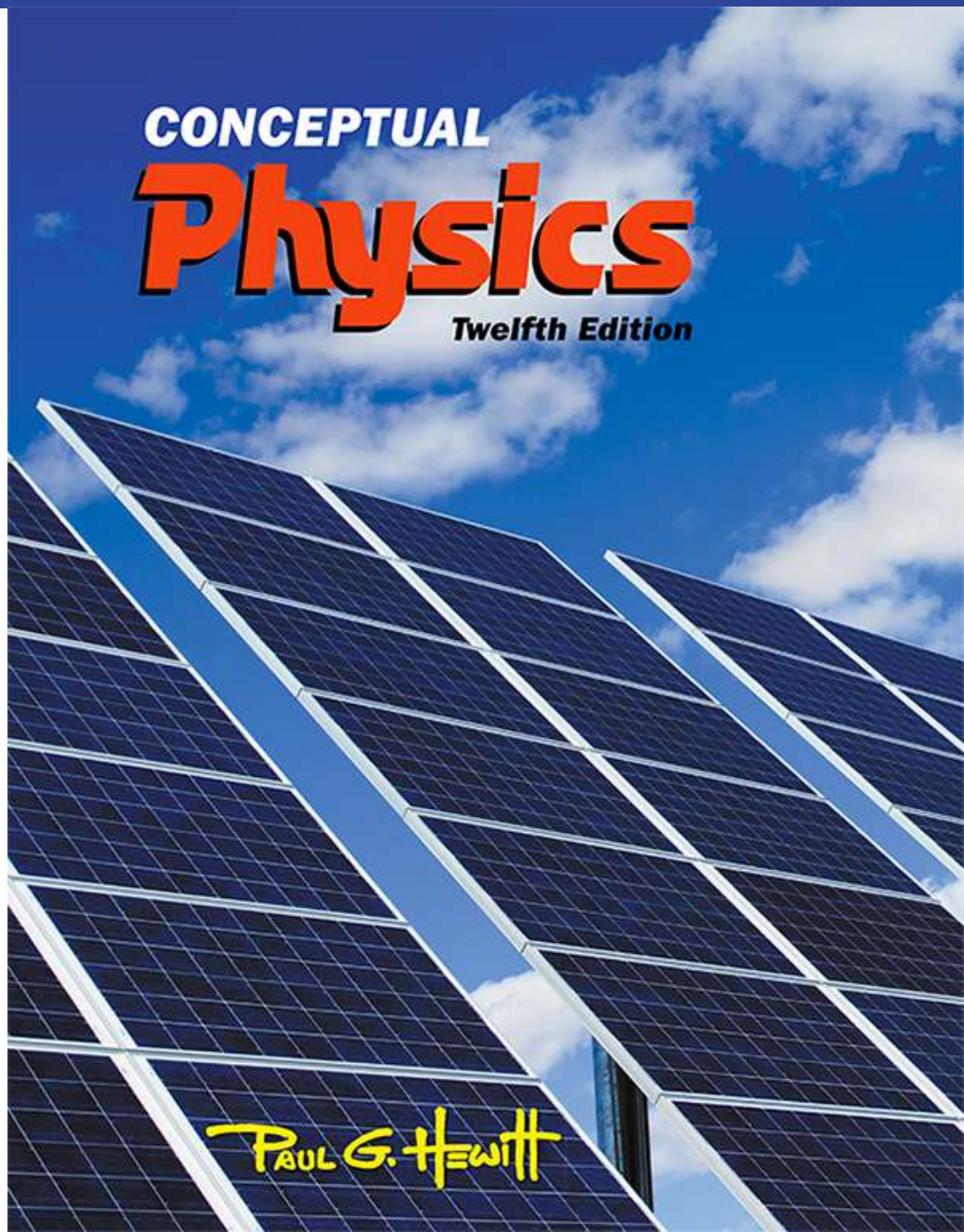
Sections 1-3:

Electricity

Electrical Forces

Electrical Charges

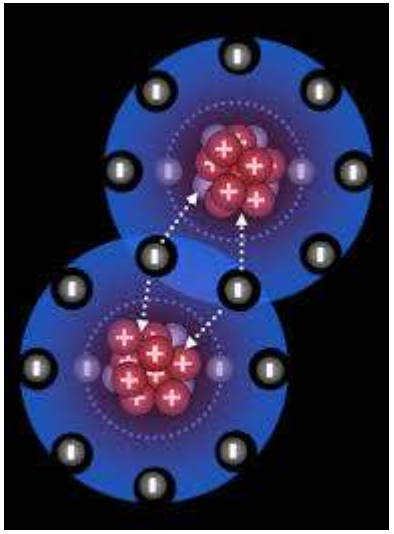
Conservation of Charge



Section 22.1 Electricity

- *Electricity* is the name given to a wide range of electrical phenomena, such as
  - lightning.
  - spark when we strike a match.
  - what holds atoms together.

- Electrostatics involves electric charges,
  - the forces between them,
  - the aura (field) that surrounds them,
  - and their behavior in materials.



The word *electro-* comes from Greek for *amber* = fossilized tree sap

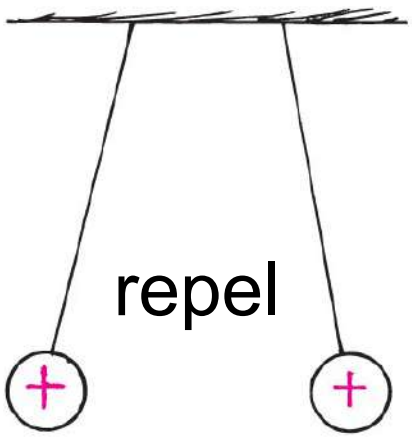
The word –*statics* comes from Greek: *to stand*

So ***electrostatics*** = electrons that “stand at rest”

Electric *currents* are always moving….we study them later.

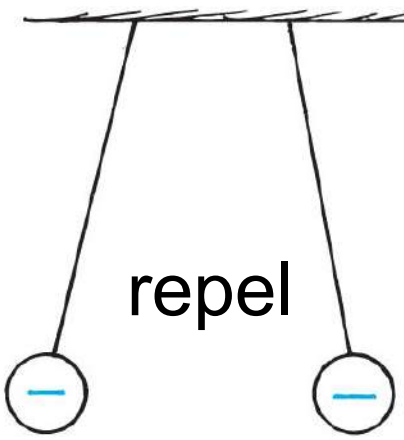
Section 22.2 There are 2 types of charges

- Central rule of electricity:
  - **Opposite** charges **attract** one another;
  - **Like** (*like* = same kind of) charges **repel**.



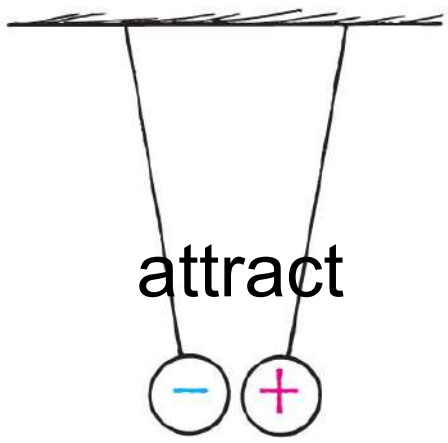
Like charges:

2 positive (+)



Like charges:

2 negative (-)

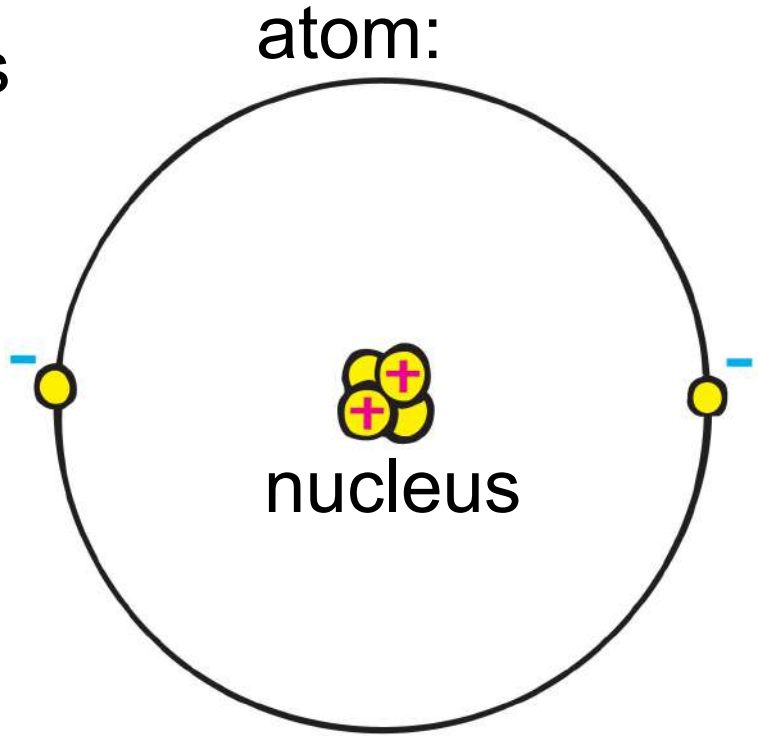


Opposite charges:

negative (-) & positive (+)

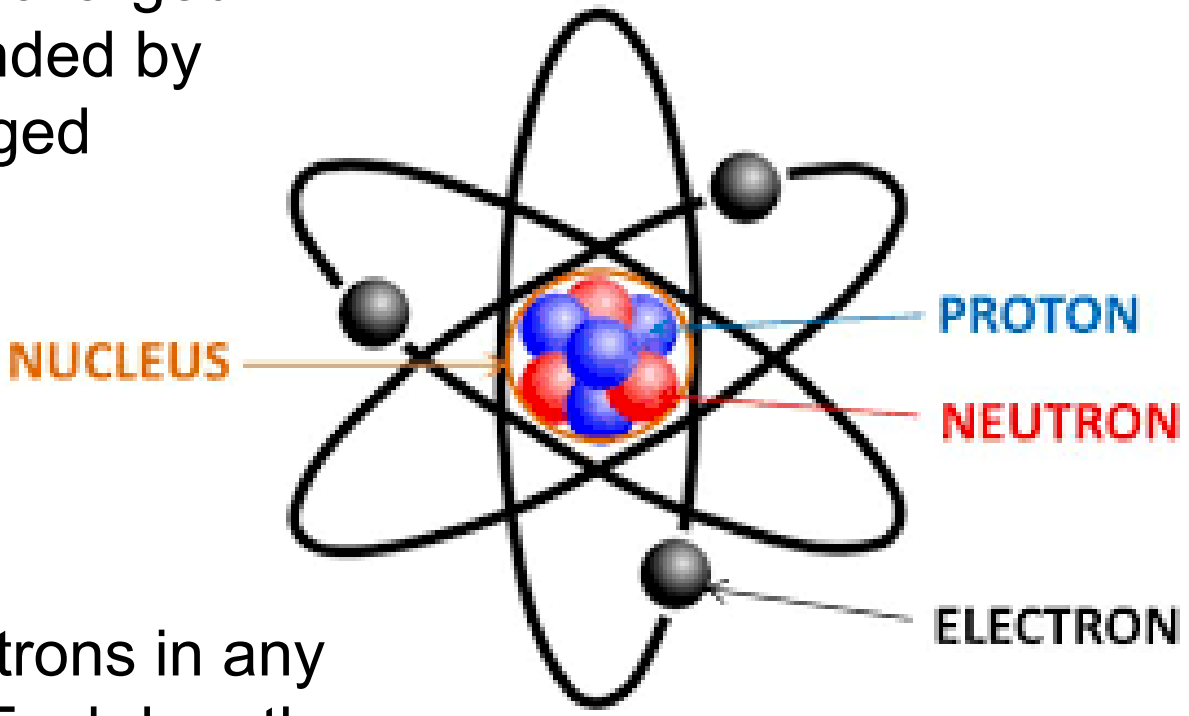
Electric Charges are found in atoms:

- *Proton p* (within nucleus):
  - Positive (+) electric charges
  - Repel positives, but attract negatives
- *Electron* e^- (outside of nucleus):
  - Negative (-) electric charges
  - Repel negatives, but attract positives
- *Neutrons* n (within nucleus):
  - Neutral electric charge



Fundamental facts about atoms

1. Every atom is composed of a tiny positively charged nucleus surrounded by negatively charged electrons.



2. Each of the electrons in any atom all identical. Each has the same quantity of negative charge and the same mass.

- Fundamental facts about atoms (continued)
  3. Protons and neutrons compose the nucleus. Protons are about 1800 times more massive than electrons, but **each proton carries an amount of positive charge equal to the negative charge of electrons.**

  → Neutrons have slightly more mass than protons and have no charge.

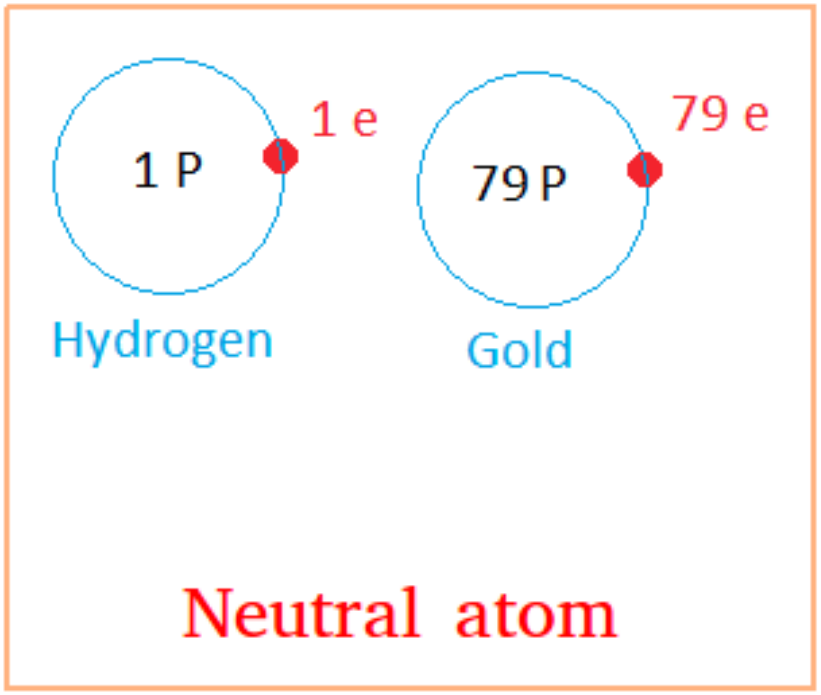
  Q: If protons repel each other, why don't nuclei (*nuclei* is the plural of *nucleus*) fly apart?

  A: The nucleus is held together by a separate, attractive force called the strong nuclear force.

- Fundamental facts about atoms (continued)

  4. **Atoms usually have as many electrons as protons, so the atom has zero net charge.**

- H:
- 1 p
- 1 e^-
- net charge:
- +1 + (-1)
- = 0
- neutral



- Au (gold):
- 79 p
- 79 e^-
- net charge:
- +79 + (-79)
- = 0
- neutral

Why gravity is important on the large scale

A) The electrical force is *much stronger* than the gravitational force.

B) Most objects have equal numbers of (+) and (-) charges, and are *neutral*.

C) So the **huge** repulsions between *like* charges is exactly balanced by a **huge** attraction between unlike charges.

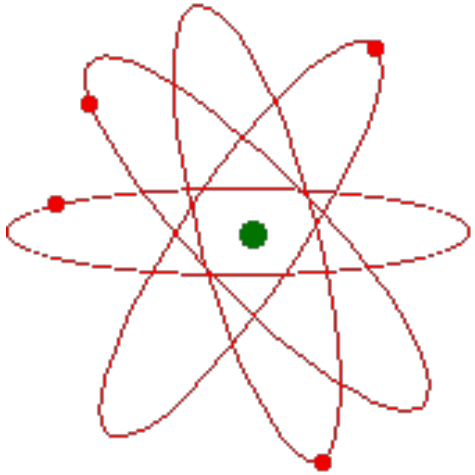
→ No net electrical force between Earth and Moon

→ The weaker gravitational force wins out

because + and – charges cancel out.

→ Same is true for the Sun and planets, etc.

Why don't protons pull electrons into the nucleus?



wrong!

wrong!!

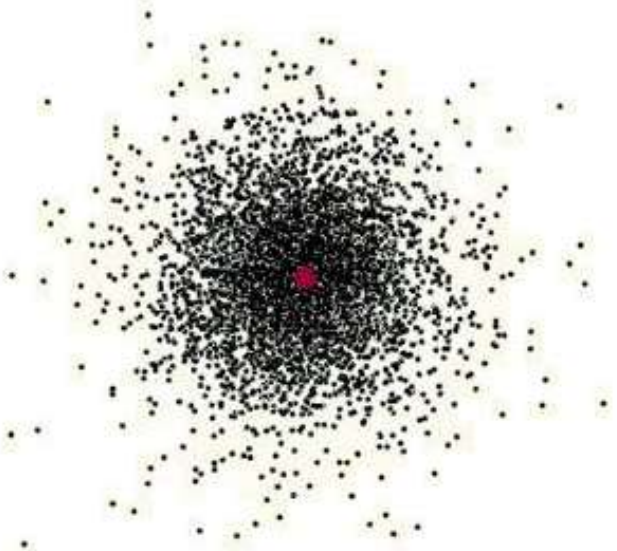
wrong!!!

wrong!!!!

Electrons do not orbit around the nucleus.

If they did, the atom would collapse!

Correct view of electron probabilities:

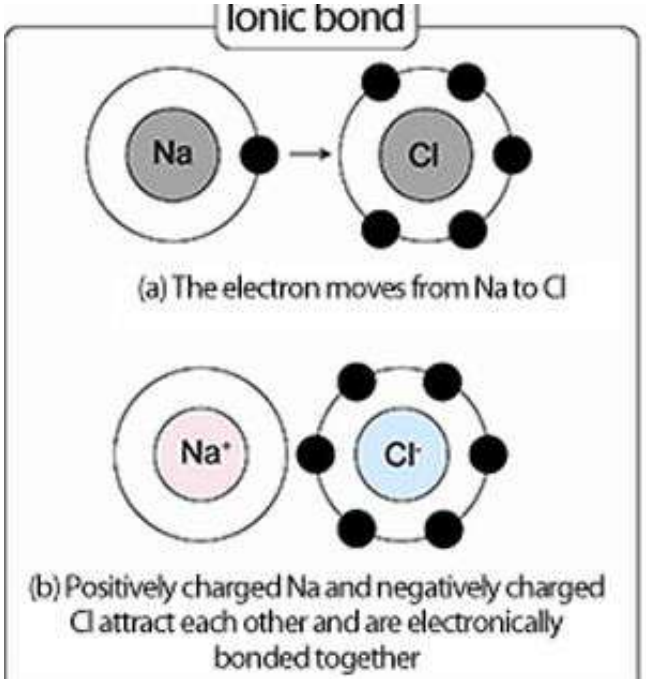


Electrons in an atom act like waves. Each electron requires space for its wave!

Chemical bonding is what holds atoms together to form molecules.

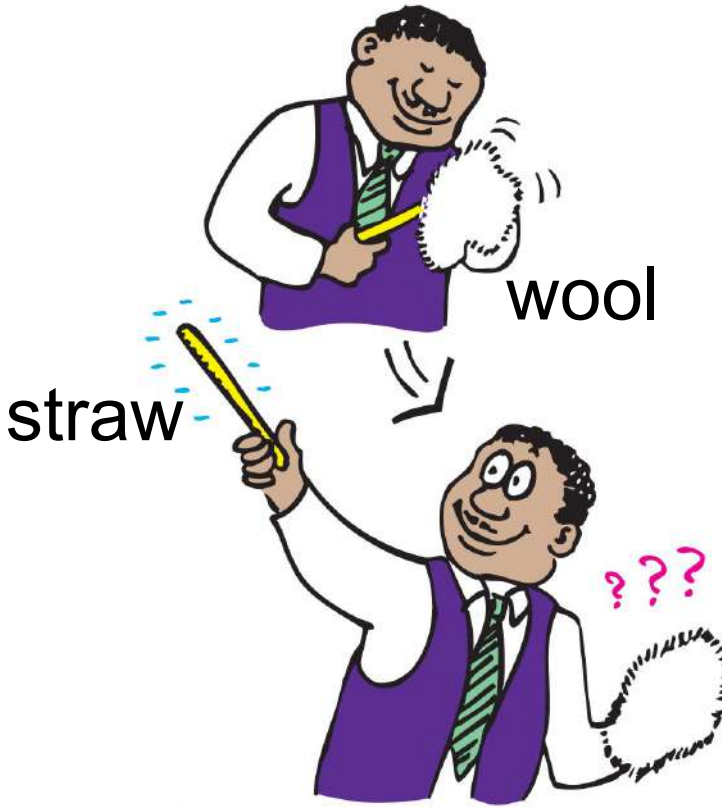
Bonding depends electric forces!

electrons transferred: electrons shared:



Section 22.3 Electrons can be added or taken away, but never destroyed

A plastic straw and wool are neutral to begin. If you rub the straw on the wool, the straw becomes *negatively* charged (because it has an excess of electrons.)



Where did the electrons on the straw come from? wool

Is the wool charged + or -? +

Why? it lost electrons to the straw

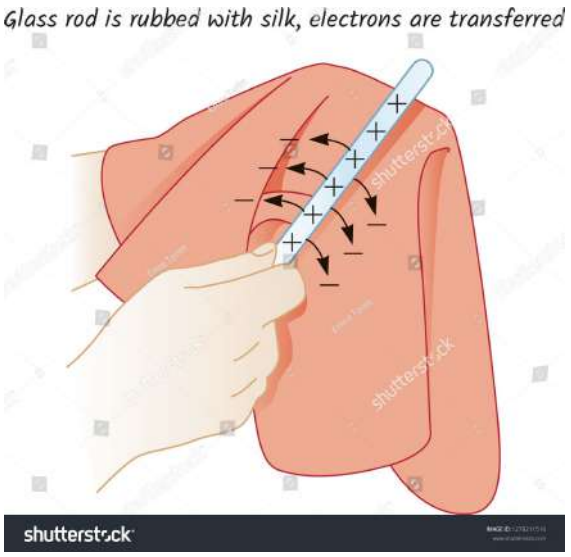
This is called….

- **The Law of Conservation of Charge**
  - In any charging process, no electrons are created or destroyed.
  - Electrons are simply transferred from one material to another.

(Electrons are more easily transferred than protons because they are furthest from the atom's center, and the outer electrons are most easily removed.)

- Electrons in an atom
  - Examples:
    - When rubbing a comb through your hair, electrons transfer from your hair to the comb. Your hair has a deficiency of electrons (positively charged).

    - When rubbing a glass rod with silk, electrons transfer from the rod onto the silk and the rod becomes positively charged.



Electric Force and Charges
CHECK YOUR NEIGHBOR

When you brush your hair and scrape electrons from your hair, the charge of your hair is

A. positive.
B. negative.
C. Both A and B.
D. Neither A nor B.

Electric Force and Charges
CHECK YOUR ANSWER

When you brush your hair and scrape electrons from your hair, the charge of your hair is

A. positive.

Comment:

And if electrons were scraped off the brush onto your hair, your hair would have a negative charge.

- Start with **neutral** atom: equal #'s of + and –
- Taking away or adding electrons → Ions
- *Positive* ion—atom losing one or more electrons has positive net charge.

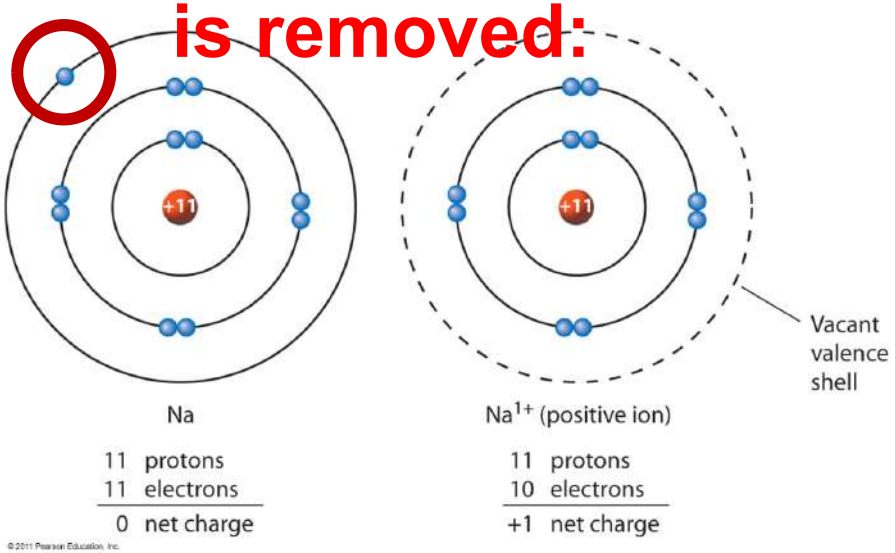
Atom has:

11 p = +11

11 e- = -11

charge = 0

1 electron is removed:



Now it has:

11 p = +11

10 e- = -10

charge = +1

- Positively charge object:

# of protons > # of electrons

Negative ion—atom gaining one or more electrons has negative net charge.

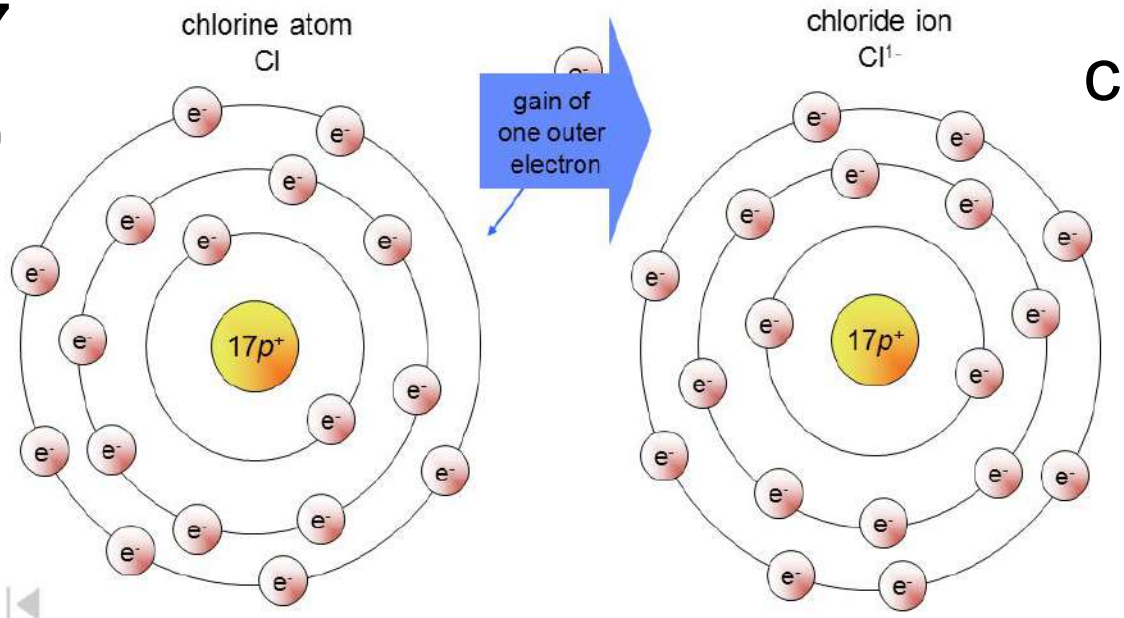
Atom has:

17 p = +17

17 e- = -17

charge = 0

1 electron is added:



Now it has:

17 p = +17

18 e- = -18

charge = -1

- Negatively charged object:

  # of protons < # of electrons

Charge is "quantized"

1. Any charged object has an excess or a lack of some **whole number** of electron charges.

→ *You don't find 0.5 of an electron charge*

→ *You don't find 3.9 x a proton charge*

→ *You **do** find 6 charges or 150 charges, etc.*

2. The charge on an electron or a proton is **fundamental**—there is no smaller charge that is found be itself or on an objects

3. The electron or proton charge is exactly one **quantum (or fundamental)** charge.

Classwork: Take out your book. Take out sheet. Write name at top. Write: Page 425: # 1-9

1. What term is used for "electricity at rest"?

2. Why does the gravitational force between Earth and the Moon predominate over electrical forces?

3. Which part of an atom is positively charged, and which part is negatively charged?

4. How does the charge of one electron compare with the charge of another electron? How does it compare with the charge of a proton?

5. What is most commonly the net charge of an atom?

6. What is a positive ion? A negative ion?

7. What is meant by conservation of charge?

8. What is meant by saying that charge is *quantized*?

9. Name one particle that has exactly one quantum unit of charge.