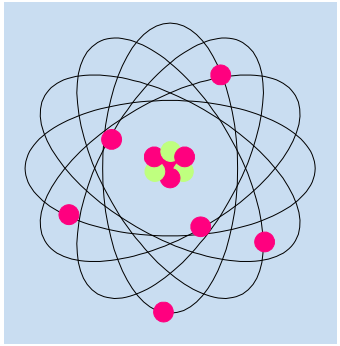


The Atom's Family

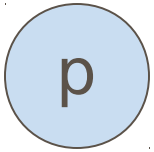
A deeper look at the elements in the Periodic Table

Atoms, Elements and Molecules

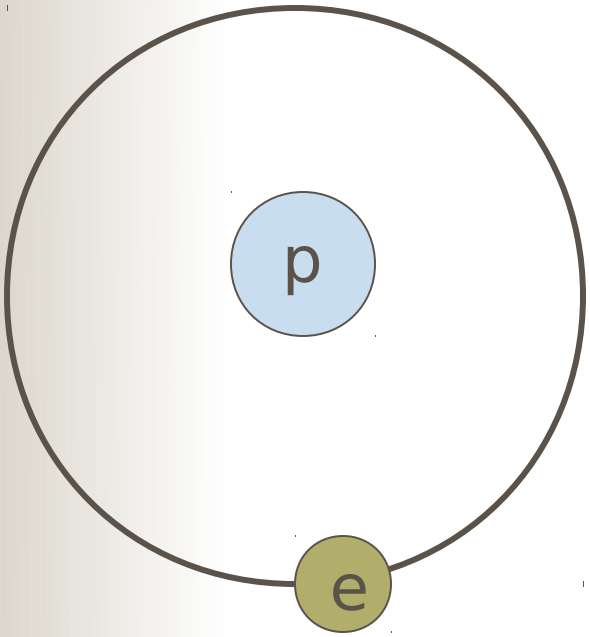
- Atom = smallest unit of an element
- Element =
- Molecule = a collection of atoms, bound together.
  - Molecules can be made from only one element, such as H_2 or O_2
  - Molecules can be made from different elements, such as H_2O or CO_2

Parts of an Atom

- Each element in the Periodic Table has a different number of protons in its nucleus
  - Protons have positive charge
  - Change the number of protons → change elements
  - This is called nuclear physics
- The element also has the same number of electrons
  - Electrons have negative charge
  - Change the number of electrons → ionize the element
  - This is called chemistry
- Some elements also have neutrons
  - Neutrons have no charge
  - They act as glue to hold the nuclei together



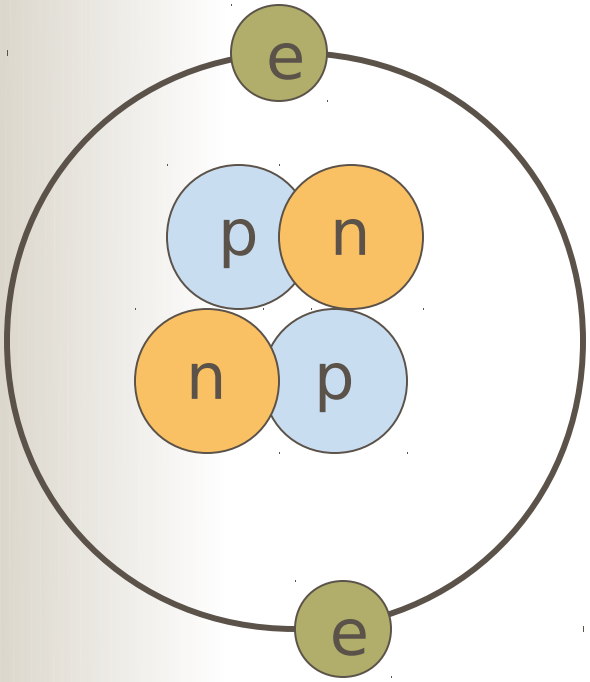
The Hydrogen Atom



^{1}H

- One electron orbiting a nucleus
- 1 proton = Z = atomic number
- 0 neutrons = N
- Total mass = A = Z+N =1
- Singly ionized Hydrogen is missing one electron = $^{1}H^{+}$
- Add a neutron and you have Deuterium = ^{2}H = D

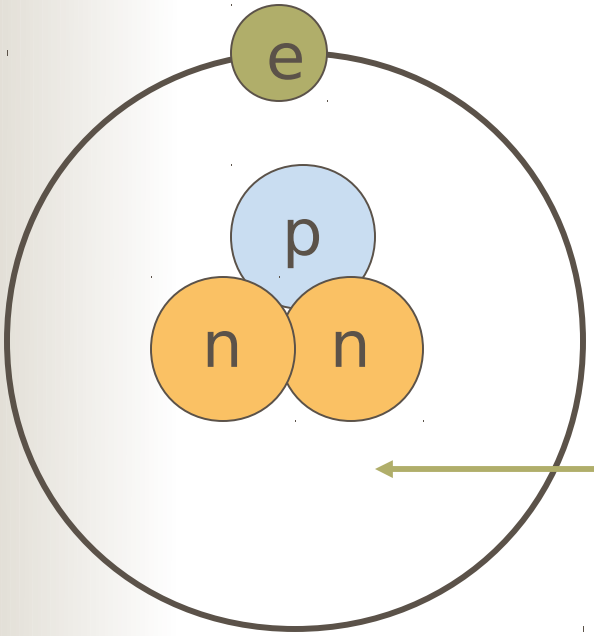
The Helium Atom



^4He

- Two electrons orbiting a nucleus
- 2 protons = Z = atomic number
- 2 neutrons = N
- Total mass = A = Z+N =4
- Singly ionized Helium is missing one electron = $^4He^+$
- Doubly ionized Helium is missing both electrons = α particle = $^4He^{++}$

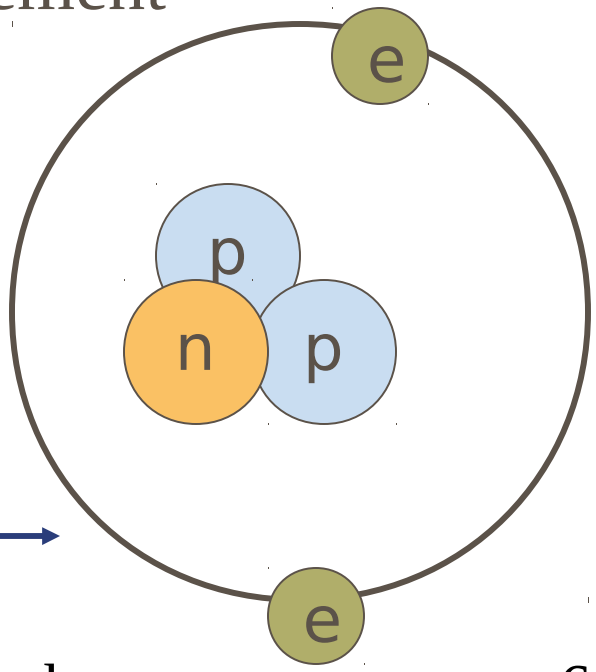
Isotopes and Elements



- If Helium loses one of its protons (and one of its electrons), it becomes a different element

^{3}H

(Tritium)



- If Helium loses one of its neutrons, it becomes an isotope

^{3}He

Alphas, Betas and Gammas

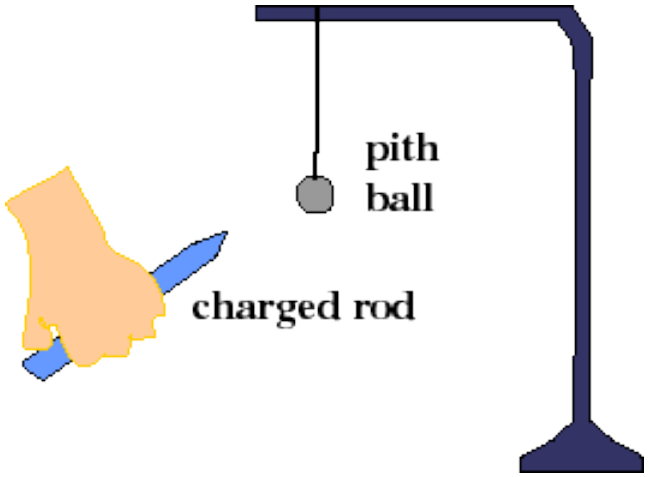
- Alpha particles are doubly ionized Helium nuclei $^{4}He^{++}$
- Beta particles are either electrons (e^{-}) or their anti-particles, positrons (e^{+})
- Gamma rays are the most energetic type of light – they are not particles at all!
- Alphas, beta and gammas are often emitted by radioactive decay of unstable nuclei
- Example: $^{3}H \rightarrow {}^{3}He + ?$

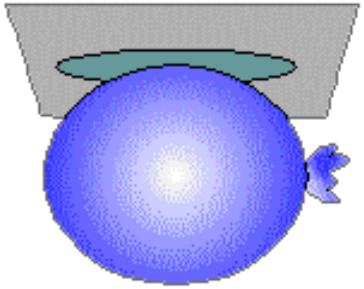
First Activity: A deeper look at charge

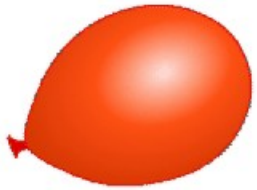
- How do we know that there are two different types of charged particles?
- How can you show that there are two types of charges?
- How can you figure out whether like or unlike charges attract each other?
- Why did we decide that the negatively charged particles were the electrons?

Equipment for first activity

- Silk
- Fur
- Plastic rods
- Pith balls (styrofoam ball covered with metal foil)
- Balloons
- Small pieces of paper





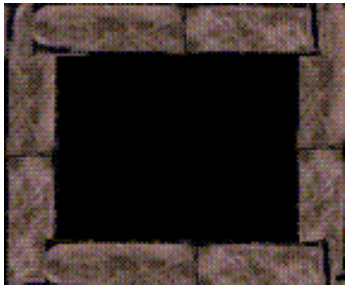


More questions for first activity

- What happens when you first bring the plastic rod near the pith ball? Why?
- What happens if you touch the rod to the pith ball?
- What is the difference between the silk and the fur?
- Why does a balloon stick to the ceiling if you rub it with wool?
- Why does the balloon attract small pieces of paper?

Electrons and Ben Franklin

Ben Franklin's "single fluid theory" showed that a given body possessing a normal amount of electric fluid was called *neutral*. During the process of charging, the fluid was transferred from one body to the other; the body with the deficiency being charged *minus* and the body with the excess charged *plus* . But no fluid is lost. Ben's "single fluid theory" led to the electron theory in 1900: *electrons move about conductors much as a fluid might move.*



http://www.franklinbusybody.com/

Second Activity: A deeper look at electrons

- How can we tell which elements are good electrical conductors?
- Are all metals good conductors?
- Are all good conductors metals?
- How can we tell which materials are good electrical insulators?
- How do you think the electrons in conductors differ from those in insulators?

Equipment for second activity

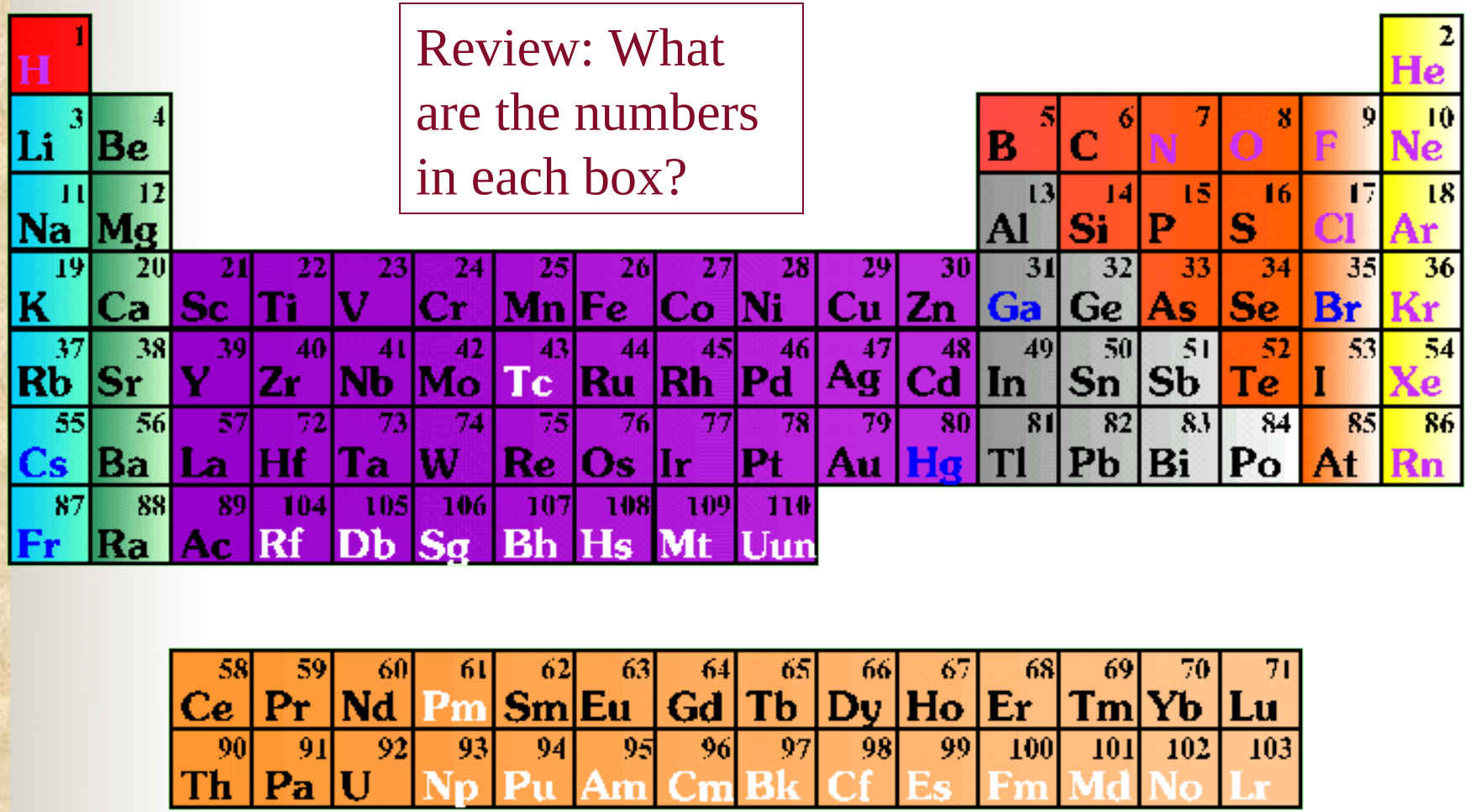
- Insulated wires
- Batteries
- Bulbs
- Other things like rubber, wood, glass, plastic, aluminum, paper clips, etc.
- Masking tape

More questions for second activity

- Why is a circuit called a circuit?
- Were you surprised by the some of the items that were conductors?
- Were you surprised by some of the items that were insulators?
- What did the conductors have in common?
- What did the insulators have in common?

Periodic Table of the Elements

Review: What are the numbers in each box?



Navigating the Periodic Table

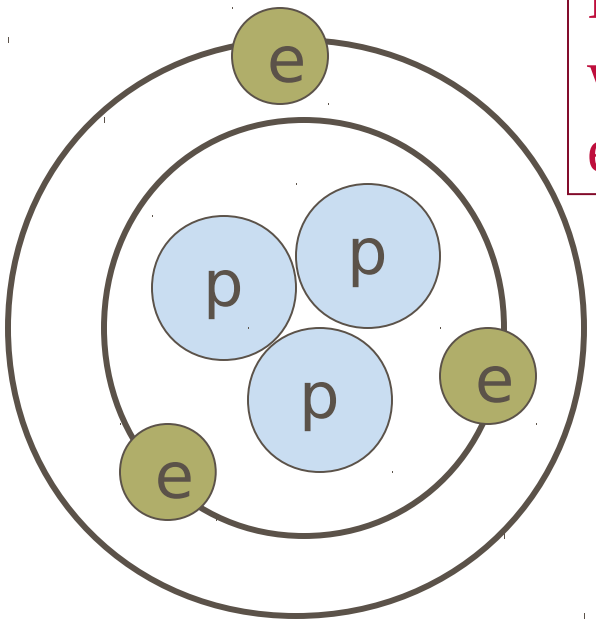
- The rows are the “periods”
  - Each period starts a new shell of electrons
  - The periods are numbered starting with 1 at the top
- The columns are the “groups”
  - Each group has similar chemical properties
  - The groups are numbered starting with 1 at the left
  - Similar properties come from electron shell structure

Electron shells and atomic structure

1. The first shell will hold up to **two** electrons.
2. The second (and third) shells will hold up to **eight** electrons
3. Sometimes shells are made of sub-shells (2+6=8, 8+10=18)
4. Filled outer shells make an atom very stable
5. Elements with electrons outside of filled shells or with missing electrons are very chemically reactive

Let's do some examples

- Carbon=C
- Sodium=Na
- Neon=Ne
- Chlorine=Cl



Review: what is this element?

How many protons and electrons do these elements have?

Draw the electron shell structure for each.

Shells: thinking deeper

1. Where are the elements with very stable outer shells in the periodic table? What do we call them?
2. Where are the elements with one electron outside a filled shell?
3. Where are the elements that need one electron to fill their shells?
4. What happens when these two types of elements are combined chemically?

Conductors: A deeper look

- The best conductors are Copper (Cu), Silver (Ag) and Gold (Au)
- Cu has Z=29, Ag has Z=47 and Au has Z=79
- How are these electrons arranged?

$29 = 2+8+8+10\mathbf{+1}$

$47 = 2+8+8+18+10\mathbf{+1}$

$79 = 2+8+8+18+18+14+10\ \mathbf{+1}$

- So, why are these elements good conductors?

Third activity: A deeper look at magnets

- How can you show that there are two types of magnetic poles? Do all magnets have exactly two poles?
- How can you figure out whether like or unlike poles attract each other?
- How did we decide which pole to call North?
- What is the orientation of the magnet inside the Earth?

Equipment for third activity

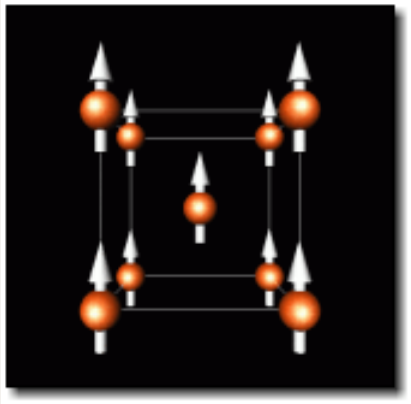
- Magnets of various sizes and shapes
- Some pieces of non-magnetized metal
- Other things like rubber, wood, glass, plastic, aluminum, paper clips, etc.
- Compasses
- Mystery plates

More questions for third activity

- What is located at each labeled spot on the Mystery plates?
- Are all metals attracted to magnets?
- How can you tell the difference between a magnet and a metal?
- Where are the poles in a bar magnet?
- Where are the poles in a horseshoe magnet?
- Where are the poles in a refrigerator magnet? How many are there?

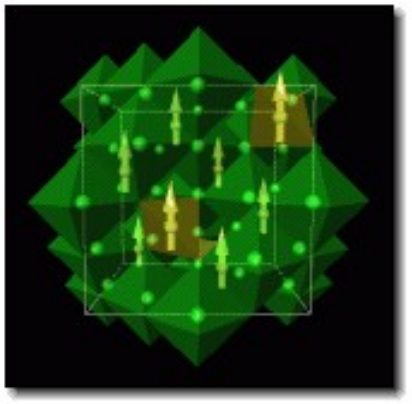
Magnetic elements: A deeper look

- Individual electrons can act as magnets
- In Iron, it is easier to make the electrons line up than in other materials. When electrons line up, they make a stronger magnet.



Iron

Lodestone
(Magnetite)



Magnets: Thinking deeper

- In most materials, if you add energy to the electrons, you can get them to move and realign
- Can you think of ways to add energy to electrons?
- How can you make a magnet?
- How can you demagnetize a magnet?
- What happens when you break a magnet?

Resources

- http://www.bbc.co.uk/education/gcsebitesize/science_physics/electricity_and_magnetism/electric_charge_and_current_rev.shtml#charge
- http://blueox.uoregon.edu/~courses/dlivelyb/ph161/L6.html#charge
- http://chemicool.com/
- http://www.bbc.co.uk/education/gcsebitesize/science_chemistry/structures_of_materials/electron_shells_rev.shtml
- http://www.thetech.org/exhibits_events/noyce_center/topics/13g.html
- Physics by Inquiry – L. McDermott and the PEG at U Washington

Resources (continued)

- http://www.ill.fr/dif/3D-crystals/magnets.html
- http://www2.worldbook.com/assets/products_gfx/60031.pdf
- http://www.lessonplanspage.com/ScienceMagnetismUnit3MakeUseCompass2.htm (second grade lesson plan)
- http://www.askeric.org/Virtual/Lessons/Science/Earth_Science/EAR0071.html (fourth-fifth lesson plan)