Atomic Structure and Coulomb's Law

Atomic Theory: Matter is anything that has mass and takes up space.

➔ All matter is made up of atoms.

Structure of the Atom

The atom can be divided into two regions: the nucleus and the electron cloud.

1. The nucleus is a very small region near the center of an atom that is positively charged.
2. The e⁻ cloud is a very large region that surrounds the nucleus and is negatively charged. It consists mostly of empty space.

The Three Subatomic Particles

Particle	Symbol	Approximate Relative Mass	Relative Charge	Location in Atom
Proton	p^+	1	1+	Inside nucleus
Neutron	n	1	0	Inside nucleus
Electron	e^-	0.000545	1−	Outside nucleus

***Note**: the unit of mass for atomic particles is the atomic mass unit (amu)

→ 1 amu = one-twelfth the mass of a carbon atom containing six protons and six neutrons.

Isotopes

What are **isotopes**? Atoms of the same element, but different mass

This means the number of protons is the same, and the number of neutrons is different.

➔ Mass of an isotope = # protons + # neutrons

Two ways to write isotopes:

Type	hyphen-notation		isotope notation/ nuclide symbol
Definition	name-mass	VS	mass # / atomic # Symbol
Example	carbon-12		$^{12}_{6}C$

Let's Practice with Tasty Isotopes! Complete the chart below.

Hyphen notation	Isotope Notation	Mass #	Atomic #	Protons	Neutrons	Electrons
boron-10	$^{10}_{5}B$	10	5	5	5	5
phosphorus–30	$^{30}_{15}P$	30	15	15	15	15
Zinc-66	$^{66}_{30}Zn$	66	30	30	36	30

Directions: Consider the following sets of isotopes and then explain the similarities and differences between *each* set.

Set I

$^{12}_{6}C$ $^{13}_{6}C$

Similarities: Same # p^+, e^- (6)

⇒ Same element

Differences:

6 vs. 7 n°

⇒ different mass

Set II

$^{24}_{12}Mg$ ~~$^{26}_{12}Mg$~~ $^{24}_{11}Na$

Similarities:

same mass ⇒

same # particles in nucleus (p^+ + n°)

Differences:

different element

⇒ different # of p^+

Understanding the Periodic Table

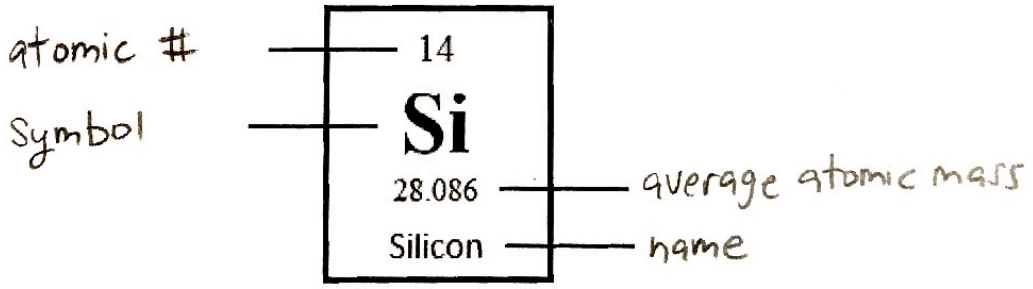
Atomic Number: the **number** that tells you the identity of the element; number of p^+

Average Atomic Mass: **average** mass of all of the element's isotopes

- To find the mass of a SPECIFIC (isotope) atom, you must add up the protons + neutrons

Symbol: shortened element name; starts with a CAPITAL letter

Name: the identity of an atom (NOT a proper noun = not capitalized in sentences! ☺)



Directions: Complete the following table using your knowledge of atomic structure.

Element	Hyphen notation	Atomic Number	Number of Protons	Number of Neutrons	Number of Electrons	Mass Number
$^{1}_{1}H$	hydrogen-1	1	1	∅	1	1
$^{35}_{17}Cl$	chlorine-35	17	17	18	17	35
$^{60}_{27}Co$	cobalt-60	27	27	33	27	60

Coulomb's Law: fundamental relationship between electrostatic attraction and repulsion.

- It applies to charged particles, magnets, gravitation, etc.
- In chemistry, we are most interested in the energy of attraction or repulsion between subatomic particles

Coulomb's Law: $E \propto \frac{Q_1 Q_2}{r}$

E= energy of attraction or repulsion between particles
Q_1 = charge of first particle
Q_2 = charge of second particle
r = distance between charged particles

In short:

- Energy of attraction/repulsion ↑ as the magnitudes (sizes) of the charges ↑
- Energy of attraction/repulsion ↓ as the distance between the charges ↑

Thought question: will an electron be more attracted to the nucleus of a hydrogen atom or a helium atom, and why?

He! He has 2 p^+ while H has only 1 p^+ : ↑ + means − (e^-) will be more attracted.

Coulomb's Law Practice

a) (+) (−)

b) (+)(+) (−)

c) (+) (−)

d) (−) (−)

distance →

1. Which set of particles shown the left will experience:
   a. the greatest attraction to each other? b)
   b. the greatest repulsion from each other? d)

2. The particles in (a) will experience _____ attraction to each other than the particles in (c) because:
   (a) greater, the distance between them is less.
   b. smaller, the distance between them is less.
   c. the same, distance is irrelevant to force of attraction.

3. The particles shown above in (a) will experience _____ attraction to each other than the particles in (b) because:
   a. greater, the nucleus has one proton instead of two.
   (b) smaller, the nucleus has one proton instead of two.
   c. the same, charge is irrelevant to force of attraction.

4. An electron in the lowest energy level would be most attracted to the nucleus of which element? (assuming same distance apart)
   a. lithium = 3 p^+
   b. sodium = 11 p^+
   c. potassium = 19 p^+
   (d.) rubidium = 37 p^+

5. A proton would be least repulsed by the nucleus of which element?
   (a.) helium = 2 p^+
   b. neon = 10 p^+
   c. argon = 18 p^+
   d. krypton = 36 p^+