ATOMS, ELEMENTS AND THE PERIODIC TABLE

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The metals, nonmetals, and metalloids

Rare earth elements

Lanthanides

Actinides

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Structure of atoms

- Proton
- Neutron
- Electron

Electron Shells

Nucleus
• each **ELEMENT** has its own distinct number of + protons

• **neutral atoms** have the same # of + protons and – electrons

• the number of – electrons determines how an element will behave when combining with others to form molecules and compounds
ATOMS AND MOLECULES ARE MOSTLY EMPTY SPACE
The periodic table of the elements

- There are 92 naturally occurring elements, and over 25 man-made elements.
-Elements are arranged by atomic number – number of protons in nucleus:

-Smallest: Hydrogen, atomic # 1 – top left corner; read table like a paragraph

-As you read from left to right, atomic #’s increase by 1 proton; so elements get larger from left to right, and top to bottom – largest elements at bottom right corner of table
Reading the periodic table: Atomic Number, Mass Number, and Atomic Mass

Below is a typical entry for an element on the periodic table.
The element in this example is Carbon.

1. The whole # above the letter(s) is the **ATOMIC NUMBER**
2. The letter(s) is/are the **ATOMIC SYMBOL**
3. The decimal # below the letter(s) is the **ATOMIC MASS**

**DEFINITIONS:**

1. **ATOMIC NUMBER**: indicates the NUMBER OF PROTONS in the nucleus of each atom of that particular element. EACH ELEMENT HAS ITS OWN DISTINCT ATOMIC NUMBER.
2. **ATOMIC SYMBOL**: is a one, two or three letter “code” or abbreviation that represents that particular element.
3. **ATOMIC MASS**: indicates the **AVERAGE** NUMBER OF PROTONS + NEUTRONS in the nucleus of each isotope of that particular element.
*SUMMARY AND IMPORTANT TERMS:

*An atom with a particular number of Protons =

*An atom of an Element that has a different number of Neutrons =

*An atom of an Element that has a different number of Electrons =
Elements, protons, and atomic number

Lithium -
atomic # 3 ;
3 protons

Beryllium- atomic # 4; 4 protons (Note that it also has more neutrons and electrons than Lithium)
Lithium, atomic # 3; 3 protons & 4 neutrons in its nucleus.

Lithium as well, but with 5 neutrons in its nucleus - one more than “normal.” This is an ISOTOPE of Lithium, Li-8.
What then is the MASS NUMBER?

• **MASS NUMBER**: is the number of protons + the number of neutrons of ONE PARTICULAR ISOTOPE of an element.

• For example, carbon isotopes can have 12, 13, or 14 protons + neutrons.

• The MASS NUMBER of Carbon-14 is 14: this tells us that for this isotope, there are 14 protons + neutrons.
**MASS NUMBER – ATOMIC NUMBER = # OF NEUTRONS**

- So, for the isotope carbon-14:
  - $14 - 6 = 8$ neutrons, and 6 protons.

*most common mass number: round the atomic mass, and then complete the calculation. For carbon:*

12.01 → 12; $12 - 6 = 6$ neutrons, and 6 protons in the average atom of carbon.
Electrons and Ions of Elements

Lithium: 3 protons and 3 electrons

Lithium as well, but with 2 electrons. This is an ION of Lithium, Li \(^{+1}\).
CHARGE AND IONS:

• to calculate the electromagnetic charge of an atom, subtract the number of electrons from the number of protons:

• * for neutral atoms (most atoms): the # of protons = the number of electrons, so there is no charge:
example 1: neutral carbon:
6 protons – 6 electrons = 0 charge

eexample 2: negative carbon ion:
6 protons – 7 electrons = -1 charge

eexample 3: positive carbon ion:
6 protons – 5 electrons = +1 charge
Reading the Periodic Table: Metals, Non-Metals, and Metalloids
Across the Periodic Table

Periods: Are arranged horizontally across the periodic table

PERIOD # = number of electron orbital shells.
Down the Periodic Table

• **Groups/Families of elements:** Are arranged vertically down the periodic table
• These elements have the same number of electrons in the outer most shells, the valence shell.
• Groups 1 & 2: same # of valence electrons as group #
• Groups 13-18: group # minus 10 = # of valence electrons

**Alkali Family:**
1 e- in the valence shell

**Halogen Family:**
7 e- in the valence shell
ATOMIC STRUCTURE: ELECTRON SHELLS

- **1\textsuperscript{st} shell**: maximum of 2 electrons
- **2\textsuperscript{nd} shell**: maximum of 8 electrons
- **3\textsuperscript{rd} shell**: maximum of 8 electrons
Bohr Diagram — shows all shells with electrons and protons and neutrons in nucleus.

- Bohr Diagram for Carbon

\[
\text{Nucleus} \\
6 \text{ protons (}) \vphantom{+} \text{)} \\
6 \text{ neutrons (0)} \\
\]

Carbon: period 2 = 2 shells;  
Group 4 = 4 valence electrons
HOW TO SKETCH BOHR MODELS

1. Find the element to be sketched on the periodic table
2. Identify its **period #** (horizontal) – this indicates the number of electron **shells** you will sketch
3. Identify its **atomic #** – this indicates the number of electrons you will sketch, as well as the number of protons that you will label the nucleus as having
4. Identify its **group/family #** (vertical) – this indicates the number of valence electrons you will sketch
5. **REMEMBER SHELL/ELECTRON MAXIMUMS:**
   1. Sketch shell 1 first = maximum 2 electrons
   2. Sketch shell 2 second = maximum 8 electrons
   3. Sketch shell 3 third = maximum 8 electrons
Lewis Dot Structure — only shows outer shell and valence electrons. (electrons placed in pairs around four sides of element symbol.)

Carbon is a group 14 element, so it has 4 valence electrons.

Chlorine is a group 17 element, so it has 7 valence electrons.
Chemical Bonding Notes

• Chemical bonds form due to interactions of **electrons**

• Elements: most stable with 8 electrons in their **outermost** shell

• Except for H and He, all elements have “room” for 8 electrons in the outer, or VALENCE electron shell

• Elements “want to” combine to form compounds so that the total # of valence electrons = 8; “the rule of 8”

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Alkali Family:
1 e- in the valence shell

Halogen Family:
7 e- in the valence shell
Ionic bonding

Electrons are **TRANSFERRED** from one atom to another in an ionic bond.

This forms **COMPOUNDS**.

**OPPOSITELY** charge ions are attracted to each other – **THIS HOLDS IONIC BONDS TOGETHER**.

Covalent bonding

Atoms **SHARE** electrons in a covalent bond.

This forms **MOLECULES or COMPOUNDS**.

**LEWIS DOT STRUCTURE:**
A Lewis dot structure is a model that represents the **VALENCE** electrons of an atom
COVALENT BONDING: Cl₂ – CHLORINE

1st, sketch Lewis structure diagrams for each atom:

\[ \begin{align*}
\text{Cl} & \quad \text{Cl} \\
\text{Cl} & \quad \text{Cl}
\end{align*} \]

Next, draw circles around each atomic symbol, so that each circle contains a full valence shell of 8 electrons:

\[ \begin{align*}
\text{Cl} & \quad \text{Cl} \\
\text{Cl} & \quad \text{Cl}
\end{align*} \]
IONIC BONDING: K + I – POTASSIUM AND IODINE

1st, sketch Lewis structure diagrams for each atom:

Next, draw an arrow(s) from the atomic symbol of the element with less valence electrons, to the element with more. The element receiving electron(s) should now contain a full valence shell of 8 electrons:
Electron Configuration (just for fun – don’t worry about this 😊)

1 s orbital (2 electrons)
2 s orbital (2 electrons)
2 p orbitals (6 electrons)

Bohr’s planetary model
Electron Configuration (just for fun – don’t worry about this 😊)
Electron Configuration (just for fun – don’t worry about this 😊)

Uranium atom electron configuration

Electron Configuration:
1s\(^2\) 2s\(^2\)p\(^6\) 3s\(^2\)p\(^6\)d\(^{10}\) 4s\(^2\)p\(^6\)d\(^{10}\)f\(^{14}\) 5s\(^2\)p\(^6\)d\(^{10}\)f\(^{3}\) 6s\(^2\)p\(^6\)d\(^1\) 7s\(^2\)
Additional Resources

http://www.wolframalpha.com
- Enter the name of any element, and important information about that element will be provided

http://chemsite.lsrhs.net/HomepageStuff/flashLinks.html
- Click on and review the density meter activity, with a copy of the periodic table by your side. Consider the masses of different elements as you explore the animation.
Are you ready to be quizzed?

Left click to begin; hit the “esc” key to exit at any time
1. How many naturally occurring elements are there?

- A – 118
- B – 17
- C – 92
- D – unknown
Sorry

That was the wrong answer
Correct!

Congratulations
2. Which of the following determines the identify of an element?

- A – # of neutrons
- B – # of protons
- C – # of electrons
- D – # of atoms
Sorry
That was the wrong answer
Correct!

Congratulations
3. Which of the following determines the identify of an isotope of an element?

- A – # of protons
- B – # of electrons
- C – # of atoms
- D – # of neutrons
Sorry

That was the wrong answer
Correct!

Congratulations
4. Which of the following are used by atoms to create bonds with other atoms, forming molecules/compounds?

- A – protons
- B – electrons
- C – neutrons
- D – ions
Sorry

That was the wrong answer
Correct!

Congratulations
5. How many electrons are needed to fill an element’s valence shell?

- A – 1
- B – 2
- C – 8
- D – 18
Sorry

That was the wrong answer
Correct!

Congratulations
6. Which of the following elements would an element with 7 valence electrons be most likely to bond with?

- A – carbon
- B – oxygen
- C – helium
- D – hydrogen
Sorry

That was the wrong answer
Correct!

Congratulations
You have completed the quiz!

Click to exit
1. How many neutrons does C-14 have? (atomic # C = 6)
   - Mass 14 – atomic # 6 = 8 neutrons

2. What is the mass of a nitrogen atom with 7 neutrons?
   - (atomic # N = 7)
   - 7 neutrons + atomic # 7 = mass 14

3. What is the charge of a carbon atom with 4 electrons?
   - Atomic #6 is 6 protons – 4 electrons = +2

4. How many electrons does a hydrogen ion with a negative 2 charge have? (atomic # H = 1)
   - -2 = 1 proton + 3 ELECTRONS