Atomic Structure and the Periodic Table

Unit: Atomic Structure

NGSS Standards/MA Curriculum Frameworks (2016): HS-PS1-1

Mastery Objective(s): (Students will be able to…)

- Identify subatomic particles and their locations within the atom.

Success Criteria:

- Protons and neutrons are correctly located in the nucleus.
- Electrons are correctly located outside the nucleus.
- Relative masses of protons, neutrons and electrons are correct.
- Chemical symbols are written correctly with correct value and placement of atomic symbol, atomic number, atomic mass and charge.

Tier 2 Vocabulary: nucleus, charge

Language Objectives:

- Correctly describe the parts of the atom and their locations within the atom.

Summary of Concepts:

- All matter in the universe is made of atoms.
- Atoms are made of protons, neutrons and electrons.
- Protons and neutrons are in a region at the center of the atom called the nucleus.
- Electrons are much smaller than protons and neutrons, and are located outside of the nucleus.
- Protons have a positive electric charge. Electrons have a negative electric charge. Neutrons are neutral, which means they have no electric charge.
- Every element has a chemical symbol, which is a one- or two-letter abbreviation of the name of the element (usually but not always in English).
- There are quantities associated with atoms—such as the atomic number, mass number and charge—which are related to the number of protons, neutrons and electrons in that atom.
- The properties of an atom (and therefore the chemical and physical properties of an element) are determined by the number and arrangement of the protons, neutrons and electrons that it is made of.
- The Periodic Table of the Elements is a chart showing all of the elements that have been discovered. The position of each element on the chart is related to its structure, and therefore to its chemical and physical properties.

Use this space for summary and/or additional notes:

Notes:

atom: the smallest piece of an element that retains the properties of that element.

nucleus: a dense region in the center of an atom. ***The nucleus is made of protons and neutrons, and contains almost all of an atom's mass.***

proton: a subatomic particle **found in the nucleus** of an atom. It has a ***charge of +1***, and a ***mass of 1 atomic mass unit*** (amu). ***The number of protons in an atom cannot change*** except through radioactive decay.

neutron: a subatomic particle ***found in the nucleus*** of an atom. It has ***no charge*** (is neutral), and has a **mass of 1 amu**. ***The number of neutrons in an atom cannot change*** except through radioactive decay.

electron: a subatomic particle ***found outside the nucleus*** of an atom. It has **charge of −1** and a ***mass of 0 amu*** (really about $^{1}/_{2000}$ amu). ***Atoms can gain, lose, or share electrons in chemical reactions.***

charge: electrical charges can be positive or negative. Opposite cancel each other out, so the charge of an atom is the difference between how many positive charges (protons) it has, and how many negative charges (electrons) it has. For example, a chlorine atom with 17 protons (+17) and 18 electrons (−18) would have a charge of −1. (The difference is 1, and it's negative because it has more negatives than positives.)

neutral atom: an atom with no net electrical charge (a charge of zero, meaning that the positive charge = the negative charge).

ion: ***an atom or molecule that has a charge*** (either positive or negative).. This means ***it has either more negative charges (electrons) than positive charges (protons), or more positive charges (protons) than negative charges (electrons).*** Because the number of protons and neutrons in an atom cannot change, ***ions are formed by an atom either gaining or losing electrons***.

atomic number (*Z*): the identity of an atom is based on the amount of (positive) charge in its nucleus. (This works because particles from the nucleus cannot be given to or shared with another atom.) ***The atomic number is the number of protons*** in the nucleus. Each element has a unique atomic number.

mass number (*A*): ***the total number of protons + neutrons*** in the nucleus of an atom. (Protons and neutrons each have a mass of almost exactly 1 amu, and the electrons are so small that their mass is negligible.) Generally equal to the whole number that is closest to the atomic mass.

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isotopes: atoms of the same element (same atomic number = same # of protons), but that have different numbers of neutrons (and therefore different mass numbers) from each other.

Isotopes are described by their mass numbers. For example, carbon-12 (^{12}C) has 6 protons and 6 neutrons, which gives it a mass number of 12. Carbon-14 (^{14}C) has 6 protons and 8 neutrons, which gives it a mass number of 14.

atomic mass of an atom: the actual mass of a specific atom; the sum of the actual masses of its protons, neutrons, and electrons (minus a small amount of mass that is converted to energy to hold the atom together). Always close in value to the mass number.

average atomic mass: the weighted average of the masses of all of the known isotopes of an element. ***Unless there is only one known isotope of an element, the average atomic mass is different from the mass of any single atom of that element.***

element symbol: ***a one- or two-letter abbreviation for an element***. (New elements are given temporary three-letter symbols.) ***The first letter in an element symbol is always capitalized. Other letters in an element symbol are always lower case.*** *This is important to remember.* For example, Co is the element cobalt, but CO is the compound carbon monoxide, which contains the elements carbon and oxygen.

chemical symbol: a shorthand notation that shows information about an element, including its element symbol, atomic number, mass number, and charge. For example, the symbol for a magnesium-25 ion with a +2 charge would be:

$$^{25}_{12}Mg^{2+}$$

What we know (or can calculate) from the chemical symbol:

- The symbol Mg tells us that the element is magnesium.
- The number on the bottom left (12) is the atomic number for magnesium. This means that a magnesium atom has 12 protons. ***The atomic number is always the same as the number of protons.***
- The number on the top left (25) is the mass number for this particular atom. ***The mass number includes protons and neutrons.*** This means:

$$(\#\text{ protons}) + (\#\text{ neutrons}) = 25$$
$$12 + (\#\text{ neutrons}) = 25$$
$$\#\text{ neutrons} = 25 - 12$$
$$\#\text{ neutrons} = 13$$

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- The number on the top right (2+) is the charge of the ion. The charge of 2+ means that there are 2 more positives (protons) than negatives (electrons).

$$(\#\text{ protons}) + (-\#\text{ electrons}) = \text{charge}$$
$$12 - (\#\text{ electrons}) = +2$$
$$\#\text{ electrons} = 10$$

The charge of 2+ means the atom lost two of its electrons at some point. By convention, ions are labeled with the number before the charge sign, so we write 2+ instead of +2.

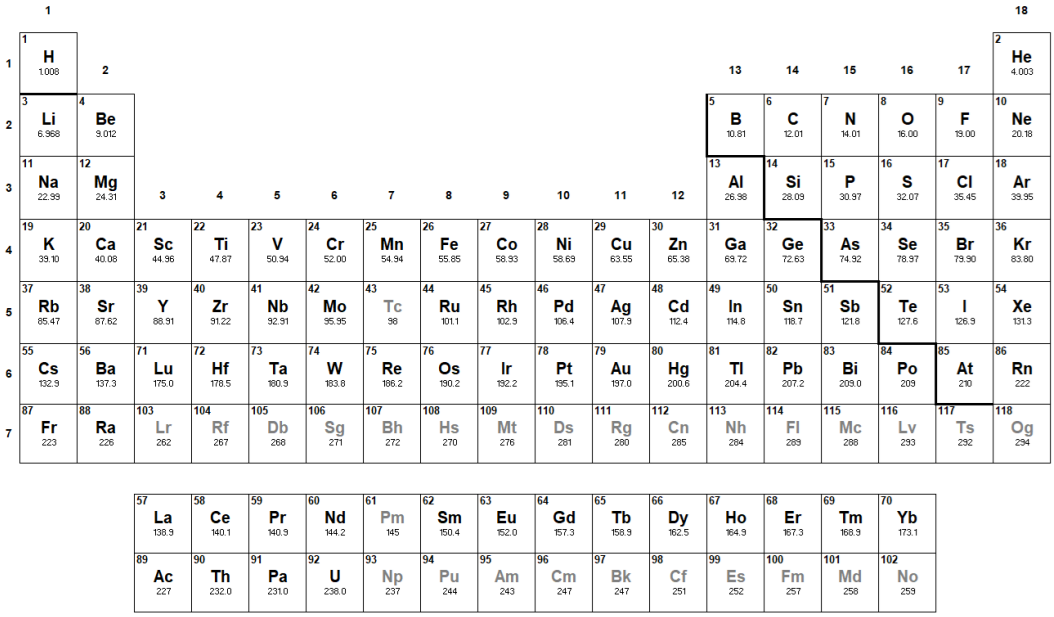
The Periodic Table of the Elements

The periodic table of the elements is a chart that shows all of the known chemical elements. The position of each element in the table corresponds with aspects of its structure.

Because an element's properties result from its size and structure, an element's location in the table gives information about its properties. These properties will be studied in more detail in the *Introduction*: Periodicity unit, starting on page 225.

The periodic table looks like this:

Periodic Table of the Elements



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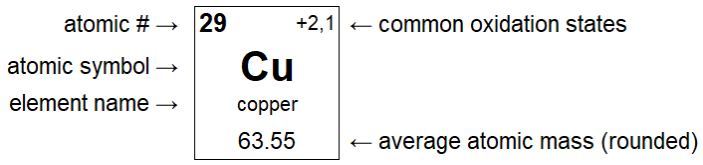
Each element in the periodic table is in a box, and information in each box pertains to that particular element.

The specific information in each box can be different from one periodic table to another. The only things that *must* be included on every periodic table are the element number and element symbol.

For example, the box for copper on a periodic table might look like this.



This particular periodic table gives the following information about each element:

- atomic symbol (center)
- atomic number (upper left corner)
- name of element (below symbol)
- average atomic mass (bottom center)
- common oxidation states (upper right corner)

We will use the periodic table to look up information that we need throughout this course.

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Homework Problems

Each row in this table is like a Sudoku puzzle. For each row, use the numbers given, the relationships between the columns, and the periodic table of the elements to fill in the rest of the row. Use the first row as an example.

symbol	atomic #	mass #	protons	neutrons	electrons	charge
$^{41}_{20}Ca^{2+}$	20	41	20	21	18	+2
B				6	5	
		56	24			0
Ca^{2+}				20		
	60			84	57	
		207			80	+2
				0	0	+1
Kr		84				0
			35	39	36	

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