

STAAR Science Tutorial 06

TEK 8.5B: Atomic Structure & Chemical Properties

TEK 8.5B: Identify that protons determine an element's identity and valence electrons determine its chemical properties, including reactivity.

Valence Electrons & Chemical Properties

- Each element has a unique number of protons in all of its atoms. The **atomic number** of an element is the number of protons in each of its atoms. To identify which element a model of an atom is depicting, count the number of protons in the nucleus and find the element on the periodic table with that atomic number.
- The total number of electrons in an (electrically neutral) atom equals the number of protons. Thus, an atom can also be identified by the total number of electrons shown in the Electron Cloud Model or Bohr Model.
- In the Bohr Model of the atom, electrons fill different electron orbitals (also known as electron shells or energy levels) from the inside-out. The first orbital can only hold 2 electrons. The second orbital can hold 8 electrons, the third can hold up to 18, and the fourth up to 32, but the outermost orbital can never have more than 8 electrons. Only these outermost electrons, known as **valence electrons**, can interact with other atoms in chemical reactions.
- The following chart summarizes the maximum number of electrons that can be in each orbital (if it is not the outermost orbital):

Orbital Number	1	2	3	4	5	6	7
No. of Electrons	2	8	18	32	32	18	8

- In general, elements with the same number of valence electrons, usually found in the same group on the periodic table, have similar chemical properties.
- For the Representative Elements in Groups 1 - 2 and 13 -18, the number of valence electrons is equal to the ones digit of the group number. For example, there is 1 valence electron in Group 1 elements, and 3 valence electrons in Group 13 elements.
- The following chart summarizes the number of valence electrons for the representative elements:

Group/Family Number	1	2	13	14	15	16	17	18
Valence Electrons	1	2	3	4	5	6	7	8

- The following diagrams show a Bohr model and electron dot diagram of the atoms for each of the period 2 elements. Elements in other periods would have more electron orbitals, but the outer valence electron orbitals would be the same as those shown for period 2.

Representative Elements

	1															18		
	1	2	Period 2										13	14	15	16	17	18
	1	2											5	6	7	8	9	10
	3	4											13	14	15	16	17	18
	11	12	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	19	20											31	32	33	34	35	36
	37	38											49	50	51	52	53	54
	55	56											81	82	83	84	85	86
	87	88												114		116		118

Period 2 Elements

	1	2	13	14	15	16	17	18
	3 Li Lithium 6.941	4 Be Beryllium 9.012	5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180

Valence Electrons & Reactivity

- There are two kinds of bonds that can be created in a chemical reaction: ionic bonds and covalent bonds.
- In an **ionic bond**, one atom either gives or takes one or more electrons from another atom, so that both atoms either fill an existing outer electron shell, or lose all electrons in an incomplete shell to expose the next inner complete shell. Both atoms become stable because their valence electron shells are full. The atoms also become bonded to one another, because each has gained an opposite electrical charge.
- An example of a chemical reaction forming an ionic bond is one atom of sodium (Na) bonding with one atom of chlorine (Cl), forming one molecule of sodium chloride (NaCl). Sodium has one valence electron, and gives that up to the chlorine atom, which has seven valence electrons. At the end of the reaction, both the sodium and chlorine atoms have eight valence electrons, and thus are stable. The sodium atom has one more proton than electron, and thus has a positive charge. The chlorine atom has one more electron than proton, and thus has a negative charge. The sodium and chlorine atoms bond to one another because of their opposite charges.
- In a **covalent bond**, two or more atoms share one or more pairs of their valence electrons, so that each atom acts as if it has a complete outer shell. The atoms are bonded to one another because they rely on one another for the shared electrons.
- An example of a covalent bond is a water molecule, where the two hydrogen atoms each share their one electron with the oxygen atom, which shares two of its electrons. Each hydrogen atom has two shared electrons, which makes them stable because their only shell can hold only two electrons. The oxygen atom has a total of eight electrons, including the two it shares with the hydrogen atoms.
- Atoms are most stable, and thus will not react with other atoms, when their outer (valence) electron orbital is completely full. For the period 1 elements, this is two electrons; for other elements, this is eight electrons. All of the group 18 elements, known as the noble gases, have a full valence electron orbital, and thus are completely non-reactive.
- Atoms that only have one valence electron (group 1 elements) are very reactive, because they need only lose that one electron in a reaction to expose an inner full electron orbital and become stable (hydrogen excepted).
- Atoms that have 7 valence electrons (group 17 elements) are very reactive, because they need only gain one electron in a reaction to complete their outer valence electron orbital.
- Atoms that need to gain or lose more than one electron are less reactive. The more electrons they have to move or share, the less reactive they are.

Practice Problems

1. How many valence electrons would atoms of the element boron (B) have?

2. How many valence electrons would atoms of the element sodium (Na) have?

3. How many valence electrons would atoms of the element oxygen (O) have?

4. How many valence electrons would atoms of the element neon (Ne) have?

5. Of the elements N, O, Cl, Na, and S, which two would likely have similar chemical properties? **Why?** _____

6. Which elements are likely to be the least reactive, based on the number of valence electrons? **Why?** _____

7. Which elements are likely to be the most reactive, based on the number of valence electrons? **Why?** _____
