Dot and cross diagram to represent a hydrogen bromide molecule

You have already seen examples of substances that contain covalent bonds. One substance mentioned earlier was water (\(\ce{H2O}\)). It can be said from its formula that it is not an Ionic compound; it is not composed of a metal and a nonmetal. As a result, its properties are different from those of ion compounds. Previously, we discussed the ion bond in which electrons can be transferred from one atom to another so that both atoms have an external electron shell stable to energy. Since most filled electron shells have eight electrons, chemists have called this trend the octet rule. However, there is another way an atom can get a full-valued shell: atoms can share electrons. This concept can be illustrated using two hydrogen atoms, each of which has a single electron in its valence shell. (For small atoms such as hydrogen atoms, the valence shell will be the first shell, which contains only two electrons.) We can represent the two individual hydrogen atoms as follows: On the contrary, when two hydrogen atoms come close enough to share their electrons, they can be represented as follows: by sharing their valence electrons, both hydrogen atoms now have two electrons in their valence shells. Since each valence shell is now filled, this arrangement is more stable than when the two atoms are separated. Electron sharing between atoms is called a covalent bond, and the two electrons that join atoms into a covalent bond are called the bond electron pair. A discrete group of atoms connected by covalent bonds is called the molecule , the smallest part of a compound that maintains the chemical identity of that compound. Chemists frequently use Lewis diagrams to represent the covalent bond in molecular substances. For example, the Lewis diagrams of two separate hydrogen atoms are as follows: the Lewis diagram of two hydrogen atoms sharing electrons is similar to the following: this representation of molecules is further simplified by using a hyphen to represent a covalent bond. The hydrogen molecule is then represented as follows: Remember that the hyphen, also known as a single bond, represents a pair of electrons. The bond in a hydrogen molecule, measured as the distance between the two nuclei, is about 7.4 × 10−11 m, or 74 picometers (pm; 1 pm = 1 × 10−12 m). This particular bond length represents a balance between different forces: the attractiveness between electrons and nuclei charged in the opposite way, the repulsion between two negatively charged electrons, and the repulsion between two positively charged nuclei. If the nuclei were closer, they would repelling strongly to each other; if the nuclei were further apart, there would be less attraction between positive and negative particles. Fluorine is another element whose atoms bind together in pairs to form biatomic molecules (two atoms). Two separate fluorine atoms have Electronic point diagrams: Each fluorine atom contributes with a valence electron, making a single bond and giving each atom a complete-valued shell, which satisfies the octet rule: Circles show that each fluorine atom has eight electrons around it. As with hydrogen, we can represent the fluorine molecule with a hyphen instead of binding electrons: each fluorine atom has six electrons, or three pairs of electrons, that do not participate in the covalent bond. Rather than being shared, they are considered to belong to a single atom. These are called nonbonding pairs (or solitary pairs) of electrons. Now that we've looked at the electronic sharing between atoms of the same element, let's look at the formation of covalent bonds between atoms of different elements. Consider a molecule composed of a hydrogen atom and a fluorine atom: each atom needs an additional electron to complete its valence shell. With each electron contributing, they make the following molecule: In this molecule, the hydrogen atom has no nonbonding electrons, while the fluorine atom has six nonbonding electrons (three pairs of solitary electrons). The circles show how valence electronic shells are filled for both atoms. Example \(\PageIndex{1}\) Use Lewis diagrams to indicate the formation of the following: Solution a. When two chlorine atoms form a chlorine molecule, they share a pair of electrons. In molecule cl2, each chlorine atom is surrounded by a number of electron octets. The Lewis diagram for a molecule cl2 is similar to that for F2 (shown above). B. When a hydrogen atom and a bromine atom form HBr, they share a pair of electrons. In the molecule HBr, H reaches a complete valence of two electrons (duet) while Br reaches an octet. The Lewis diagram for HBr is similar to the HF diagram shown above. Exercise \(\PageIndex{1}\) Draw the Lewis diagram for each compound. a molecule composed of a chlorine atom and a fluorine atom a molecule composed of a hydrogen atom and an iodine atom Answer to: Answer b: The formation of a water molecule from two hydrogen atoms and an oxygen atom can be illustrated using Lewis point symbols (shown below). The structure on the right is lewis's electronic structure, or Lewis structure, for H2O. With two bonding pairs and two solitary pairs, the oxygen atom has now completed its octet. In addition, by sharing a pair of bonds with oxygen, each hydrogen atom now has a full valence shell of two electrons. Chemists usually indicate a bonding pair with a single line, as shown (below). Other large molecules are built in a similar way, with some atoms participating in of a covalent bond. For example, methane (\(\ce{CH4}\)), the central carbon atom bound to four hydrogen atoms, can be represented using one of the underlying Lewis structures. Once again, electron sharing between the atoms C and H results in C reaching and octet while H reaches a number of electrons. The number of bonds an atom can form can often be predicted by the number of electrons needed to reach an octet (eight valence electrons). In the Lewis structure, the number of bonds formed by an element in a neutral compound is the same as the number of unspoken electrons it must share with other atoms to complete its electron octet. For example, each atom of a group element 4A (14) has four electrons in its out outer shell and therefore requires four more electrons to reach an octet. These four electrons can be obtained by forming four covalent bonds, as shown here for carbon in CH4 (methane). Elements of Group 5A (15) such as nitrogen have five valence electrons in the Lewis atomic symbol: a solitary pair and three unseated electrons. To obtain an octet, these atoms form three covalent bonds, as in NH3 (ammonia). Oxygen and other atoms in group 6A (16) obtain an octet forming two covalent bonds. Fluorine and other group 7A (17) aedogens have seven valence electrons and can obtain an octet forming a covalent bond. Typically, atoms in group 4A form 4 covalent bonds; group 5A forms 3 bonds; group 6A forms 2 bonds; and group 7A form a single bond. The number of electrons required to obtain an octet determines the number of covalent bonds an atom can form. This is summarized in the following table. In any case, the sum of the number of bonds and the number of solitary pairs is 4, which is equivalent to eight electrons (octet). Atom (group number) Number of bonds Number of carbon solitary pairs (group 14 or 4A) 4 0 Nitrogen (Group 15 or 5A) 3 1 Oxygen (Group 16 or 6A) 2 2 Fluorine (Group 17 or 7A) 1 3 Since hydrogen needs only two electrons to fill its valence shell, the duet rule follows. It's an exception to the octet rule. Hydrogen just has to form a bond. This is why H is always a terminal atom and never a central atom. Figure \(\PageIndex{1}\) shows the number of covalent bonds that various atoms typically form. The transition elements and internal transition elements also do not follow the octet rule since they have electrons d and f involved in their valence shells. Figure \(\PageIndex{1}\): How many covalent bonds are formed? In molecules, there is a pattern to the number of covalent bonds that different atoms can form. Each block with a number indicates the number of covalent bonds formed by that atom into neutral compounds. Example \(\PageIndex{2}\) Examine the lewis structure of OF2 below. Count the number of bonds formed by each element. Depending on the position of the item in the periodic table, it corresponds to the expected number of shown in Table 4.1? Does the Lewis structure below follow the octet rule? Solution Yes. F (group 7A) forms a bond and O (group 6A) forms 2 bonds. Each atom is surrounded by 8 electrons. This structure satisfies the octet rule. Exercise \(\PageIndex{2}\) \(\PageIndex{2}\) Lewis's structure of NCl3 below. Count the number of bonds formed by each element. Depending on the position of the item in the periodic table, does it correspond to the expected number of bonds shown in Table 4.1? Does the Lewis structure below follow the octet rule? Respond to both Cl and N from the expected number of bonds. Cl (group 7A) has a bond and 3 solitary pairs. The central atom N (group 5A) has 3 bonds and a solitary pair. Yes, the Lewis structure of NCl3 follows the octet rule. How is a covalent bond formed between two atoms? How does the covalent bond allow atoms in group 6A to meet the octet rule? Covalent bonds are formed by two atoms that share electrons. Atoms in group 6A make two covalent bonds. What is electron sharing? Draw the Lewis diagram for the covalent bond in the molecule H2. Draw the Lewis diagram for the covalent bond in the Br2 molecule. Draw the Lewis diagram for the covalent bond in the HCl molecule. What is the difference between a molecule and a formula unit? Why do hydrogen atoms not follow the octet rule when forming covalent bonds? Draw the Lewis diagram for the covalent bond in H2S. How many bonding electrons and nonbonding electrons are there in the molecule? Draws the Lewis diagram for the covalent bond in CF4. How many bonding electrons and nonbonding electrons are there in the molecule? Draw the Lewis diagram for the covalent bond in PCl3. How many bond electrons and nonbonding electrons are there in the molecule? How many covalent bonds typically form a hydrogen atom? Because? How many covalent bonds typically form an oxygen atom? Because? Tellurium atoms make covalent bonds. How many covalent bonds would a tellurium atom make? Predict the formula of a compound between tellurium and hydrogen. Tin atoms make covalent bonds. How many covalent bonds would a tin atom make? Predict the formula of a compound between tin and hydrogen. Astatin is a synthetic element, made one atom at a time in huge atom-smasher machines. It is in the aogen group on the periodic table. How many covalent bonds would an atom of this element form? There have been reports that atoms of element 116 (Lv) were made by destroying smaller atoms together. Using the periodic table, determine in which column element 116 is located and suggest how many covalent bonds an atom of this element would form. 1. A covalent bond is formed when two atoms share electrons. 2. Electronic sharing combines two atoms into a covalent bond. This is a more stable arrangement of 2 individual atoms. 3. 4. 5. 6. A molecule is a discrete combination of atoms; a unit of formula is the ratio low ions in a crystal. 7. Hydrogen atoms follow the duet rule (not the octet rule). This is because it has only one shell and this shell can hold only 2 electrons. 8. binding electrons: 4; nonbonding electrons: 4 9. binding electrons: 8; nonbonding electrons: 24 10. binding electrons: 6; 6; electrons: 20 11. Hydrogen atoms form a single covalent bond because they have only one valence electron to pair. 12. Oxygen atoms form 2 covalent bonds because oxygen atoms have 6 valence electrons (2 solitary pairs plus 2 unspoken electrons that are shared to get the octet). 13. two; H2Te 14. four: SnH4 SnH4

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