Lewis Dot Structures of Atoms and Ions

Why?

The chemical properties of an element are based on the number of electrons in the outer shell of its atoms. We use Lewis dot structures to map these *valence electrons* in order to identify stable electron configurations. Most atoms tend to lose or gain electrons in order to achieve *noble gas stability*. For example, the metal sodium will react violently with the gas chlorine, but once the elements form the compound sodium chloride (table salt) they are very stable due to the stable electron configuration.

Learning Objectives

• Use Lewis dot structures to represent the valence shells of metal and nonmetal atoms and ions.

Success Criteria

• Accurate drawings of Lewis dot structures for atoms and ions.

Resources

- Periodic table including electron configurations
- Reference material containing the names and symbols of elements

New Concept

• The stability of the noble gas electron configuration of 8 electrons

Prerequisites

- Definition of an atom and an atomic ion
- Knowledge of valence electrons
- Knowledge of charges on ions formed by metals and nonmetals
- Definitions of ionization energy and electronegativity
- Knowledge that positive and negative charges strongly attract each other.

Task

Watch the video clip at: <u>http://jchemed.chem.wisc.edu/JCESoft/CCA/CCA0/Movies/NACL1.html</u>

Key Questions

1. What is the product of sodium metal reacting with chlorine gas?

2. Is energy released or absorbed in the reaction?

3. Is the reaction product (sodium chloride) more or less stable than the reactants (sodium metal and chlorine gas)? Explain.

Model: Drawing Lewis Dot Structures for Atoms and Ions

A. Lewis dot structure for an atom of chlorine is

: CI .

The number of valence electrons for an atom is the number of electrons in the outer energy level (shell) of the atom. Chlorine's electron configuration is 2-8-7; therefore it has seven valence electrons and needs to have seven dots drawn around its symbol.

B. Lewis dot structure for a chloride ion is

$\left(\begin{array}{c} \vdots \\ \vdots \\ \vdots \\ \vdots \\ \end{array}\right)^{-1}$

Chlorine needs an additional electron to attain the stable noble gas configuration of 8 valence electrons. Since chlorine is a nonmetal, it has relatively high values for electronegativity and ionization energy. This means that it will gain electrons until it achieves a stable octet. When chlorine becomes an ion we add one more dot to the atom's diagram, and put in the resulting charge of -1. The ion has 17 protons in the nucleus, with a total of 18 electrons, giving it a net charge of -1.

C. Lewis dot structure for an atom of sodium is

Na

Sodium has an electron configuration of 2-8-1, therefore it has one valence electron, and needs one dot.

D. Lewis dot structure for a sodium ion

Na⁺¹

Since sodium is a metal, it has relatively low values for ionization energy and electronegativity. This means that sodium loses an electron to achieve the stable noble gas configuration of 8 valence electrons. We must take away 1 dot from the dot diagram of the sodium atom and put in the resulting charge of +1. The ion has 11 protons in the nucleus, but only 10 electrons remain, giving a net charge of +1.

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Review of Prerequisite Concepts

- 1. What is a valence electron?
- 2. How can you determine the number of valence electrons in an atom?

Key questions

- 4. How many valence electrons does a chloride ion have?
- 5. In general terms, what is the difference between an atom and an ion?
- 6. In general, how do metals form ions to achieve the stable noble gas configuration?
- 7. In general, how do nonmetals form ions to achieve the stable noble gas configuration?
- 8. What will happen when metals and nonmetals come into contact with each other?

9. Based on the number of valence electrons for each element, why don't elements in group 18 readily form compounds with other elements.

Exercises

1. Draw the dot diagram for an atom of potassium.

2. Draw the dot diagram for an atom of bromine.

3. In the compound potassium bromide, determine the charge on the potassium ion and the charge on the bromide ion.

4. Draw the dot diagrams for calcium and oxygen.

5. Based on the dot diagram for the atoms in Exercise 4, identify what you expect the charges on calcium ions and oxide ions to be when they form compounds. Explain your answer.

6. Draw the dot diagram for an atom of carbon.

6. Identify how carbon can attain the stable noble gas configuration of 8 electrons.

Rb	Ar
C-4	Ca ⁺²
S	Cl ⁻¹
Fr ⁺¹	O ⁻²

7. Indicate whether the following species have a stable noble gas configuration.

Problems:

1. Using Lewis dot diagrams, show how some number of atoms of magnesium and atoms of fluorine can transfer electrons to form ions of each element with stable octets. Be sure to include the resulting charges of the ions. Circle the part of your diagram that shows the formation of one formula unit of magnesium fluoride.

2. Draw a diagram to show how at least 3 magnesium ions and at least 3 fluoride ions might be arranged in space to form the solid salt magnesium fluoride.

3. What is the force of attraction that holds the magnesium and fluoride ions together? Would you expect the ions in a sample of magnesium fluoride to have a strong or a weak attraction for each other? Explain your answer.

Implementation Plan

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This lesson is designed to be used as a part of a regular or honors chemistry class. This will be done after the units on atomic structure and periodic trends are completed. Particular attention will be given to reviewing the loss of electrons by metals and the gain of electrons my nonmetals.

This lesson will be done in groups of four that are randomly assigned (as long as they are self-sufficient). The roles will be randomly assigned within the groups.

As part of the motivation/why a clip of sodium added to chlorine can be shown. <u>http://jchemed.chem.wisc.edu/JCESoft/CCA/CCA0/Movies/NACL1.html</u>