

PART 4. ELECTRON-DOT SYMBOLS

1. The symbol for an element together with dots representing the number of electrons in the outermost level is called an *electron-dot-symbol*.

Example:

Na• = sodium, which has one electron in its outermost level

•Cl• = chlorine, which has seven electrons in its outermost energy level

How many electrons are in the outer energy levels of these elements?

- a. Ca _____ b. •N• _____

2. To determine the electron-dot symbol, the arrangement of electrons in the energy levels must be known.

Example:

Element	Number of Electrons	Arrangement of Electrons in Energy Levels			
		1	2	3	4
Mg	12	2	8	2	

In the element magnesium the number of electrons in the last level is two. The electron-dot symbol is (Mg:).

The electron-dot symbols for the most common elements are listed below.

H•							•He•
Li•	•Be•	•B•	•C•	•N•	•O•	•F•	•Ne•
Na•	•Mg•	•Al•	•Si•	•P•	•S•	•Cl•	•Ar•
K•	•Ca•						

Note that in most cases the electrons will form pairs.

- a. Write the electron-dot symbol for the following element. _____

Element	Number of Electrons	Arrangement of Electrons in Energy Levels			
		1	2	3	4
P	15	2	8	5	

- b. Number of electrons in the last level? _____

3. Write the electron-dot symbols for the following elements.

- a. Na _____ b. K _____
c. Mg _____ d. Ca _____
e. N _____ f. P _____
g. F _____ h. Cl _____

PART 5. ION FORMATION

1. Ions are atoms or groups of atoms that have lost or gained electrons. When an atom has more electrons than protons, or vice versa, it becomes an ion. A sodium atom, for example, has 11 protons and 11 electrons. A sodium ion has 11 protons but only 10 electrons. This information is summarized in the following table.

	Protons		Electrons		Charge on Atom or Ion	Symbol
sodium atom	(+11)	+	(-11)	=	0	Na
sodium ion	(+11)	+	(-10)	=	+1	Na ¹⁺

Note that the +1 charge shows up in the symbol for the ion.

Write the symbol for this ion, showing the correct charge.

	Protons		Electrons		Charge on Ion	Symbol and Charge
Mg ion	(+12)	+	(-10)	a. _____	b. _____	

2. Use your periodic table to find the symbol for this ion and write the symbol with the correct charge. Keep in mind that the number of protons is the atomic number.

Protons	Electrons	Charge on Ion	Symbol and Charge
(+17)	+	(-18)	a. _____ b. _____

3. Use your periodic table to find the symbols for these ions and write the symbol, showing the correct charge.

Protons	Electrons	Symbol and Charge
(+11)	+	(-10) a. _____
(+8)	+	(-10) b. _____
(+16)	+	(-18) c. _____
(+13)	+	(-10) d. _____

4. To understand why atoms lose or gain electrons to form ions, we must look at the number of electrons in the outermost energy level. Most elements seek to have eight electrons in the outermost energy level. To accomplish this, they gain or lose electrons in the following manner.

Example:

	Electron Arrangement	Symbol and Charge
	1 2 3	
sodium atom	2 8 1	Na (no charge)

If sodium could lose the one electron in its third energy level, the second level would be the outermost level and would contain eight electrons.

	Electron Arrangement	Symbol and Charge
	1 2 3	
sodium ion	2 8	Na ¹⁺

When the sodium atom loses one electron, it forms the sodium ion with a charge of +1. (Keep in mind that electrons have a -1 charge and that when you subtract a -1 you get a +1.)

Here is a table showing how three atoms lose electrons to form ions. Note that after losing the electrons each element will have eight electrons in its outer energy level.

Element	Electron Arrangement	Ion Formed
Na	2 8 1	(lose one) → Na ¹⁺
Mg	2 8 2	(lose two) → Mg ²⁺
Al	2 8 3	(lose three) → Al ³⁺

Write the electron arrangement, state the number of electrons lost, and give the symbol of the ion for the following element.

Element	Electron Arrangement	Number of Electrons Lost	Symbol for Ion
Ca	a. _____	b. _____	c. _____

5. Indicate the electron arrangement, state the number of electrons lost, and give the symbol of the ions for these elements.

Element	Electron Arrangement	Number of Electrons Lost	Symbol for Ion
B	a. _____	b. _____	c. _____
K	d. _____	e. _____	f. _____

6. When elements have one, two, or three electrons in the outer energy level, they will lose these electrons to form ions. When they have five, six, or seven electrons in the outer energy level, they will gain electrons to form ions. Examples of this are shown below.

Element	Electron Arrangement	Ion Formed
N	2 5 $\xrightarrow{\text{(gain three)}}$	N^{3-}
O	2 6 $\xrightarrow{\text{(gain two)}}$	O^{2-}
F	2 7 $\xrightarrow{\text{(gain one)}}$	F^{1-}

Note that, when these elements gain electrons, they have eight electrons in the outer energy level. When electrons are gained, the ion is negatively charged.

Write the electron arrangement, state how many electrons were gained, and give the symbol of the ion for the following element.

Element	Electron Arrangement	Number of Electrons Gained	Symbol for Ion
S	a. _____	b. _____	c. _____

7. Write the electron arrangement, state the number of electrons gained, and give the symbol of the ion formed for these elements.

Element	Electron Arrangement	Number of Electrons Gained	Symbol for Ion
P	a. _____	b. _____	c. _____
Cl	d. _____	e. _____	f. _____

PART 6. ATOMIC STRUCTURE RELATED TO THE PERIODIC TABLE

1. The elements are arranged in groups in the periodic chart of the elements. The groups are the vertical columns labeled IA, IIA, and so on. There is a relationship between the group an element belongs to and the charge on the ion that it forms. This relationship is illustrated in the table below.

Element	Group in Periodic Chart	Arrangement of Electrons	Symbol for Ion
Na	IA - 1	2 8 1	Na^{1+}
Mg	IIA - 2	2 8 2	Mg^{2+}
Al	IIIA - 13	2 8 3	Al^{3+}

Elements in Group IA lose one electron, elements in Group IIA lose two electrons, and elements in Group IIIA lose three electrons to form ions.

Use the periodic chart to find the charge on these ions.

- a. K _____ b. Ca _____ c. B _____

2. Elements in Groups VA, VIA, and VIIA gain electrons to form ions, as shown below.

Element	Group in Periodic Chart	Arrangement of Electrons	Symbol for Ion
N	VA-15	2 5	N ³⁻
O	VIA-16	2 6	O ²⁻
F	VIIA-17	2 7	F ¹⁻

Use the periodic chart to find the charge on these ions.

- a. P _____ b. S _____ c. Cl _____

3. Here is a summary of the relationship between the position of the element on the periodic chart and the charge on its ion.

Group on Chart	1	2	3	15	16	17
Charge on Ion	+1	+2	+3	-3	-2	-1

You will notice that nothing has been said about group IVA, containing elements that have four electrons in the outer energy level. Group IVA elements tend to neither gain nor lose electrons and hence do not form ions. We will deal with this group later.

Those elements in the B groups of the periodic chart have the last two energy levels only partially filled with electrons. Consequently, we cannot use their position in the periodic chart to predict the charge on their ions. We will learn later that they have variable charges.

Example:

Element	Group in Periodic Chart	Arrangement of Electrons
Mn	VIIB	2 8 13 2

Both levels can lose electrons.

Tell what charge the ions in the following groups would have.

Group	Charge on Ion	Group	Charge on Ion
3-III A	a. _____	2-II A	b. _____
17-VII A	c. _____	16-VI A	d. _____
1- I A	e. _____	15-V A	f. _____

4. Give the symbol and charge of the following.

- a. proton _____ b. neutron _____ c. electron _____

5. What is the atomic number of the following?

- a. Na _____ b. As _____ c. Br _____