

Ions

How are ions made from neutral atoms?

Why?

You have learned that not all atoms of an element are the same. Variation in the number of neutrons results in different isotopes of the element. In this activity we will explore another variation that can take place—the loss and gain of electrons. The exchange of electrons between atoms is a very common way for chemical change to take place. We will see it many times throughout the year.

1. Use Model 1 to complete the following table.

	Metal or Nonmetal	Is the number of protons the same in the atom and the ion?	Is the number of neutrons the same in the atom and the ion?	Is the number of electrons the same in the atom and the ion?	Charge on the ion
Lithium	metal				1+
Magnesium					2+
Aluminum		yes			3+
Fluorine				no	1–
Oxygen	nonmetal		yes	no	2–
Nitrogen					3–

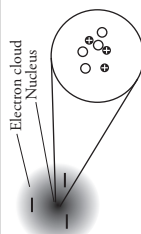
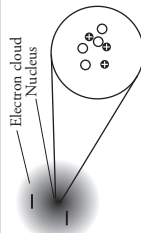
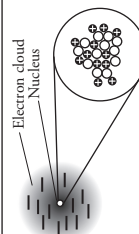
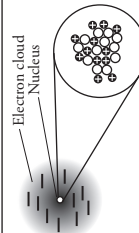
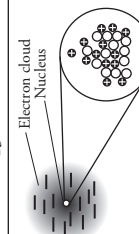
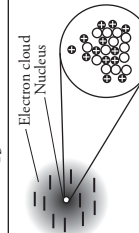
2. Based on the table you completed in Question 1, what distinguishes a neutral atom from an ion?
3. Examine the isotope symbols in Model 1.
 - a. Where is the ion charge located in the isotope symbol?
 - b. Is a charge indicated on the neutral atoms? If yes, where is it located?
4. Which subatomic particle carries a positive charge?
5. Which subatomic particle carries a negative charge?

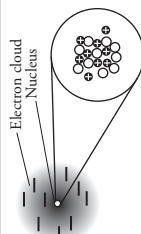
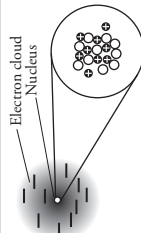
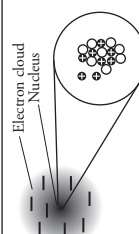
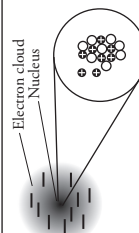
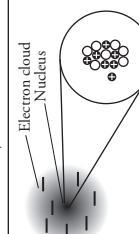
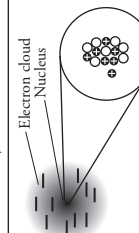


6. Propose a mathematical equation to calculate the charge on an ion from the number of protons and electrons in an ion. Confirm that your equation works using two positive ion examples and two negative ion examples from Model 1.



Model 1 – Atoms and Ions

Neutral Atoms		Ions	
Atom of Lithium		Ion of Lithium	
Symbol	${}^7_3\text{Li}$	Symbol	${}^7_3\text{Li}^{1+}$
Atomic Diagram		Atomic Diagram	
No. of Protons $\oplus$	3	No. of Protons $\oplus$	3
No. of Neutrons $\bigcirc$	4	No. of Neutrons $\bigcirc$	4
No. of Electrons ---	3	No. of Electrons ---	2
Atom of Magnesium		Ion of Magnesium	
Symbol	${}^{24}_{12}\text{Mg}$	Symbol	${}^{24}_{12}\text{Mg}^{2+}$
Atomic Diagram		Atomic Diagram	
No. of Protons $\oplus$	12	No. of Protons $\oplus$	12
No. of Neutrons $\bigcirc$	12	No. of Neutrons $\bigcirc$	12
No. of Electrons ---	12	No. of Electrons ---	10
Atom of Aluminum		Ion of Aluminum	
Symbol	${}^{27}_{13}\text{Al}$	Symbol	${}^{27}_{13}\text{Al}^{3+}$
Atomic Diagram		Atomic Diagram	
No. of Protons $\oplus$	13	No. of Protons $\oplus$	13
No. of Neutrons $\bigcirc$	14	No. of Neutrons $\bigcirc$	14
No. of Electrons ---	13	No. of Electrons ---	10

Neutral Atoms		Ions	
Atom of Fluorine		Ion of Fluorine	
Symbol	${}^{19}_9\text{F}$	Symbol	${}^{19}_9\text{F}^{1-}$
Atomic Diagram		Atomic Diagram	
No. of Protons $\oplus$	9	No. of Protons $\oplus$	9
No. of Neutrons $\bigcirc$	10	No. of Neutrons $\bigcirc$	10
No. of Electrons ---	9	No. of Electrons ---	10
Atom of Oxygen		Ion of Oxygen	
Symbol	${}^{16}_8\text{O}$	Symbol	${}^{16}_8\text{O}^{2-}$
Atomic Diagram		Atomic Diagram	
No. of Protons $\oplus$	8	No. of Protons $\oplus$	8
No. of Neutrons $\bigcirc$	8	No. of Neutrons $\bigcirc$	8
No. of Electrons ---	8	No. of Electrons ---	10
Atom of Nitrogen		Ion of Nitrogen	
Symbol	${}^{14}_7\text{N}$	Symbol	${}^{14}_7\text{N}^{3-}$
Atomic Diagram		Atomic Diagram	
No. of Protons $\oplus$	7	No. of Protons $\oplus$	7
No. of Neutrons $\bigcirc$	7	No. of Neutrons $\bigcirc$	7
No. of Electrons ---	7	No. of Electrons ---	10

Read This!

Chemists refer to positively charged ions as **cations**. Chemists refer to negatively charged ions as **anions**.



7. Fill in the following table.

Symbol	${}^{88}_{38}\text{Sr}^{2+}$	${}^{32}_{16}\text{S}^{2-}$		
Atomic Number				35
Mass Number			70	
Number of protons			31	
Number of electrons			28	36
Number of neutrons				45
Cation or anion				

8. Could a +3 ion of aluminum be made by adding three protons to an aluminum atom? Explain.

9. One of your classmates is having trouble understanding ions. He explains the formation of a cation like this:

“When you add an electron, you get a positive charge because adding is positive in math.”

a. As a group, explain in a grammatically correct sentence why this student is incorrect.

b. Provide a better description of how math relates to electrons and ion formation.

Model 2 – Ion Charges for Selected Elements

	I	II					III	IV	V	VI	VII	VIII
1	H ⁺											
2	Li ⁺								N ³⁻	O ²⁻	F ¹⁻	
3	Na ⁺	Mg ²⁺	transition elements				Al ³⁺		P ³⁻	S ²⁻	Cl ¹⁻	
4	K ⁺	Ca ²⁺	Fe ²⁺ Fe ³⁺	Ni ²⁺ Ni ³⁺	Cu ⁺ Cu ²⁺	Zn ²⁺	Ga ³⁺				Br ¹⁻	
5	Rb ⁺	Sr ²⁺			Ag ¹⁺			Sn ²⁺ Sn ⁴⁺			I ¹⁻	
6		Ba ²⁺				Hg ₂ ²⁺ Hg ²⁺		Pb ²⁺ Pb ⁴⁺				

←———— CATIONS —————→ ←———— ANIONS —————→

10. Draw a stair-step line in Model 2 to separate the metals and nonmetals.

11. Consider the ions listed in Model 2.

- In general, do nonmetals form anions or cations?
- In general, do metals form anions or cations?
- Which nonmetal appears to be an exception to these guidelines?

Extension Questions

12. Name the family of elements that make $1-$ anions as shown in Model 2.
13. Name the family of elements that make $2+$ cations as shown in Model 2.
14. For the main group elements (excluding the transition elements), is it necessary to memorize the type of ion each element makes or could you predict the ion charge using a periodic table? Explain.
15. In Model 2 there are several elements whose atoms make more than one type of ion. Where in the periodic table are these elements usually found?