

Ions

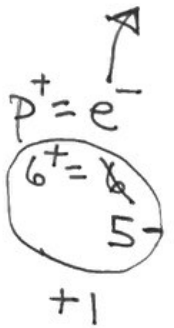
How are ions made from neutral atoms?

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	yes	yes	no	1+
Magnesium	metal	yes	yes	no	2+
Aluminum	metal	yes	yes	no	3+
Fluorine	nonmet	yes	yes	no	1-
Oxygen	nonmetal	yes	yes	no	2-
Nitrogen	nonmet	yes	yes	no	3-



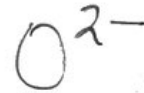
2. Based on the table you completed in Question 1, what distinguishes a neutral atom from an ion?

$\# e^-$

3. Examine the isotope symbols in Model 1.

- a. Where is the ion charge located in the isotope symbol?

upper right ${}^3_3\text{Li}^{1+}$



- b. Is a charge indicated on the neutral atoms? If yes, where is it located?

NO ${}^3_3\text{Li}$

4. Which subatomic particle carries a positive charge?

proton +

5. Which subatomic particle carries a negative charge?

electron -

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.

$\ast \boxed{\#p - \#e = \text{charge}} \ast$

Li $3 - 2 = +1$

Mg $12 - 10 = +2$

F $9 - 10 = -1$

N $7 - 10 = -3$



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	$^{88}_{38}\text{Sr}^{2+}$	$^{32}_{16}\text{S}^{2-}$	$^{70}_{31}\text{Ga}^{3+}$	$^{80}_{35}\text{Br}^{-}$
Atomic Number	38	16	31	35
Mass Number	88	32	70	80
Number of protons $+$	38	$p^+ = 16$	$p^+ = 31$	$p^+ = 35$
Number of electrons $-$	36	$e^- = 18$	$e^- = 28$	$e^- = 36$
Number of neutrons <small>mass # - at. #</small>	50	16	39	45
Cation or anion	cation $(+)$	anion	cation	anion

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

NO - Changing # p would change the identity of the element

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.

When you add an electron, you are adding a negative particle to a neutral atom. This results in an overall negative charge.

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

$$\#p - \#e = \text{charge of ion}$$

group # group or families

Model 2 - Ion Charges for Selected Elements

	1					III	IV	V	VI	VII	VIII 18
1	H ⁺										
2	Li ⁺					B		N ³⁻	O ²⁻	F ⁻	not form ions
3	Na ⁺	Mg ²⁺				Al ³⁺		P ³⁻	S ²⁻	Cl ⁻	gases do form ions
4	K ⁺	Ca ²⁺	3d Fe ²⁺ Fe ³⁺	Ni ²⁺ Ni ³⁺	Cu ⁺ Cu ²⁺	Zn ²⁺	Ga	As ³⁻ Sb ³⁻		Br ⁻	
5	Rb ⁺	Sr ²⁺	4d		Ag ⁺			Sn ²⁺ Sn ⁴⁺		I ⁻	
6		Ba ²⁺			Hg ₂ ²⁺ Hg ²⁺			Pb ²⁺ Pb ⁴⁺			

Handwritten notes on the table:
 - Group 1: lose 1 electron
 - Group 2: lose 2 electrons
 - Groups 3-10: transition elements
 - Group 11: lose 1 electron
 - Group 12: lose 2 electrons
 - Group 13: lose 3 electrons
 - Group 14: lose 4 electrons
 - Group 15: gain 3 electrons
 - Group 16: gain 2 electrons
 - Group 17: gain 1 electron
 - Group 18: noble gases do not form ions
 - Right side: have an octet

Arrows indicate: CATIONS (groups 1-10) and ANIONS (groups 13-17).

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?
 ↓
 gain electrons → (-)
 - In general, do metals form anions or cations?
 ↓
 lose electrons → (+)
 - Which nonmetal appears to be an exception to these guidelines? Hydrogen

Extension Questions

12. Name the family of elements that make 1- anions as shown in Model 2.
 halogens
13. Name the family of elements that make 2+ cations as shown in Model 2.
 alkaline earth metals
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.
 All elements in a group make ions with the same charge.
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?
 d-block to staircase - can have different charges
 transition