

Unit 3 Study Guide, Part 1

Chemical Bonding - Ionic

Targets:

E5. Describe how atoms are joined by chemical bonding.

H9. Demonstrate an understanding that energy can be found in chemical bonds and can be used when it is released from those bonds.

Activity #1 – Introduction to Ionic Bonding

Open [Chemical Bonding](#). Define the words and answer the questions. The definitions can be found by clicking on the word in the reading.

- 1) Define:
 - a) element
 - b) compound

- 2) There are 118 or so elements on the periodic table. Why are there many more than 118 substances found in nature?

- 3) What did the American chemist Gilbert Newton Lewis propose in 1916 about the reason for chemical bonding?

- 4) Define
 - a) valence shell
 - b) valence electrons

- 5) Lewis determined that elements are most stable when they contain how many electrons in their outer shell?

- 6) What do elements with incomplete valence shells tend to do?

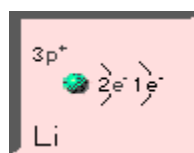
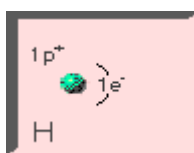
- 7) Define
- a) ion
 - b) ionic bond
 - c) ionic compound
- 8) Watch the Flash movie showing the [reaction of sodium and chlorine](#).
- a) Describe the properties of :
 - i) sodium:
 - ii) chlorine:
 - b) Drop the sodium into the chlorine gas. What happens?
 - c) Magnify the reaction.
 - i) Does sodium lose or gain an electron?
 - ii) Does chlorine lose or gain an electron?
 - iii) What is the charge of the sodium ion?
 - iv) What is the charge of the chlorine ion?
 - v) What holds the sodium and chlorine ions together?
 - d) Click “What compound is formed?”.
 - i) What is the common name for sodium chloride?
 - ii) Describe the properties of sodium chloride.
 - iii) Do compounds keep the properties of the elements that make them up? Explain.

Activity #2 – Bohr Diagram Review

Open 3.3.1a - [Bohr Diagram](#). Read the explanation of Bohr diagrams. In this tutorial p^+ is the symbol for a proton and e^- is the symbol for an electron.

Remember that

- the total number of electrons in a neutral atom is equal to the number of protons given by the atomic number on the periodic table
- the maximum number of electrons in the 1st energy level is 2 and in the 2nd energy level is 8



- 1) Look at a periodic table and the Bohr diagrams above.
 - a) In what group are hydrogen and lithium on the periodic table? ____ A
 - b) How many valence electrons (electrons in the outer shell) do hydrogen and lithium have? _____

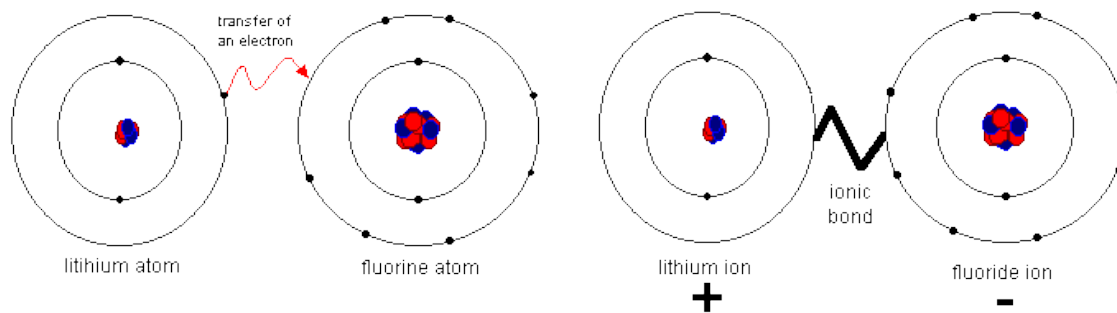
Remember: For A group representative elements, group # = # of valence e^-

- 2) Atoms that have full valence shells are very stable (chemically inert) and do not tend to form compounds. In what group would you find the most stable elements on the periodic table? Why? Check your answer [here](#).
- 3) Draw Bohr diagrams for the following noble gases. Fill in the group number and the number of valence electrons (electrons outermost energy level). (Check your answers [here](#).
 - a) helium (He)
 - b) neon (Ne)
 - c) argon (Ar)

- 4) Why do you think helium (with 2 valence electrons) is in the same group as the other noble gases (with 8 valence electrons)?

Read [Introduction to Ionic Compounds](#) and fill in the blanks.

- 5) The formation of an **IONIC BOND** is the result of the _____ of one or more _____ from a _____ onto a _____.



_____, with only a few electrons in the outer energy level, tend to _____ electrons most readily. The energy required to remove an electron from a neutral atom is called the _____.

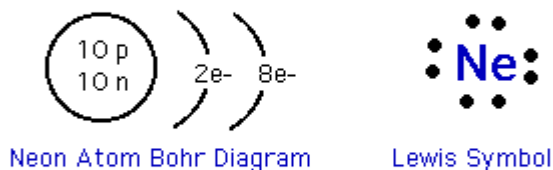
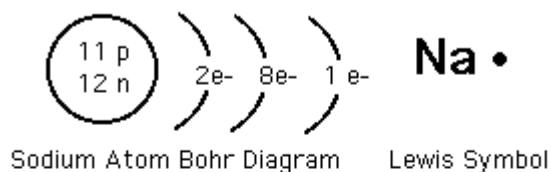


_____, which lack only one or two electrons in the outer energy level have little tendency to lose electrons - the ionization potential would be very high. Instead _____ have a tendency to _____ electrons. The _____ is the energy given off by an atom when it gains electrons.

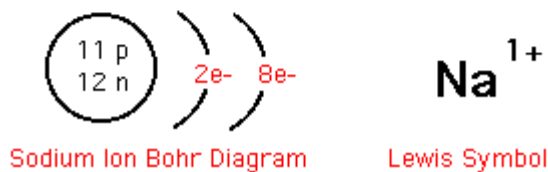


Read [Formation of Positive Ions](#).

Sodium Positive Ion, Na^{1+}



To form the ion lose one electron to form the Octet.



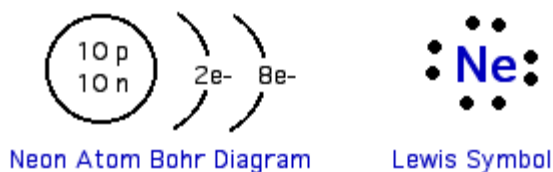
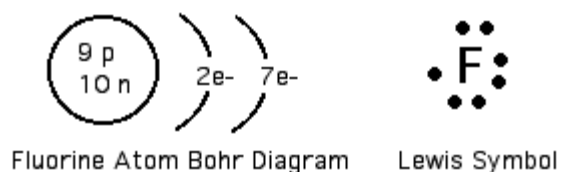
- 6) Consider the group 1A metal, potassium (K).
- Predict how many valence electrons potassium will have. ____
 - Verify your answer to part a by drawing a Bohr diagram. Check your diagram [here](#).
 - What is the nearest noble gas (from question #3) to potassium?
 - How will potassium complete its octet?
 - What charge would a potassium ion have?
 - Draw the Lewis symbol for a potassium ion and check [here](#). (Note: if the charge is +1 or -1, the numeral "1" can be left out and can be written as + or -)

7) Consider the group 2A metal, calcium (Ca).

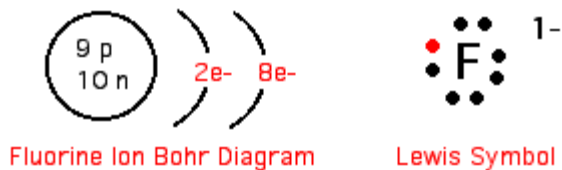
- Predict how many valence electrons calcium will have. ____
- Verify your answer to part a by drawing a Bohr diagram. Check your diagram [here](#).
- What is the nearest noble gas (from question #3) to calcium?
- How will calcium complete its octet?
- What charge would a calcium ion have?
- Draw the Lewis symbol for a calcium ion and check [here](#).

Read [Formation of Negative Ions](#).

Fluoride Negative Ion, F^{1-}



To form the ion add one electron to form the Octet.



- 8) Consider the group 7A nonmetal, chlorine (Cl).
- Predict how many valence electrons chlorine will have. ____
 - Verify your answer to part a by drawing a Bohr diagram. Check your diagram [here](#).
 - What is the nearest noble gas (from question #3) to chlorine?
 - How will chlorine complete its octet?
 - What charge would a chlorine ion have?
 - Draw the Lewis symbol for a chlorine ion and check [here](#). (Note: if the charge is +1 or -1, the numeral "1" can be left out and can be written as + or -)
- 9) Consider the group 5A nonmetal, nitrogen (N).
- Predict how many valence electrons nitrogen will have. ____
 - Verify your answer to part a by drawing a Bohr diagram. Check your diagram [here](#).
 - What is the nearest noble gas (from question #3) to nitrogen?
 - How will nitrogen complete its octet?
 - What charge would a nitrogen ion have?
 - Draw the Lewis symbol for a nitrogen ion and check [here](#).
- 10) Fill in the table. Click [here](#) to check your Lewis Symbols.

chem. symbol	metal or nonmetal?	group #	# of valence e ⁻	# of e ⁻ (<i>lost/gained</i>)	charge of ion	Lewis symbol
Al	metal	3A	3	3, lost	+ 3	Al ³⁺
I	nonmetal	7A	7	1, gained	-1	I ⁻
Li						
Ba						
O						
P						

Activity #3 – Forming Ionic Compounds

Open the [Ionic Bonding](#) activity. An ionic compound consists of cations and anions.

- 1) Can you make sodium chloride?
 - a) What is the cation?
 - b) What is the anion?
 - c) What is the chemical formula of sodium chloride?
 - d) What comes first when naming an ionic compound, the cation or the anion?
 - e) What new ending does a group 7A ion get? (what replaces the *-ine* in *chlorine*?)
- 2) Can you make sodium oxide?
 - a) What is the charge of the sodium ion?
 - b) What is the charge of the oxygen ion?
 - c) What is the chemical formula of sodium oxide?
 - d) If you add the total positive charge of all the sodium ions to the negative charge of the oxygen ions, what do you get? What is the total charge of an ionic compound?
- 3) Can you make sodium hydroxide?
 - a) Some ions contain more than one element (polyatomic ions) and have special names. What is the hydroxide ion? What elements are in it?
 - b) What is the chemical formula of sodium hydroxide?
- 4) Can you make aluminum phosphate? What is the chemical formula?
- 5) Can you make aluminum oxide? What is the chemical formula?
- 6) Transition (group B) metals can form ions with different charges. Let's investigate how the names of compounds containing these ions show the charge of the metal ion. The next two questions have you make iron (II) oxide and iron (III) oxide.
 - a) What is the charge of the iron ion in iron (II) oxide?

- b) What is the chemical formula of iron (II) oxide?
 - c) What is the charge of the iron ion in iron (III) oxide?
 - d) What is the chemical formula of iron (III) oxide?
 - e) How does the name of the compound show which iron ion it contains?
- 7) In the last question, you are asked to make water. Water is not an ionic compound, but a polar covalent compound

Activity #4– Formulas of Binary Ionic Compounds

Read Predicting [*Formulas of Ionic Compounds*](#) and fill in the blanks.

Problem

Predict the formulas of the ionic compounds formed by the following elements:

- lithium and oxygen (Li and O)
- nickel and sulfur (Ni and S)
- bismuth and fluorine (Bi and F)
- magnesium and chlorine (Mg and Cl)

First, look at the locations of the elements on the _____ . Atoms in the same column as each other (_____) tend to exhibit similar _____ , including the number of _____ the elements would need to gain or lose to resemble the nearest _____ atom. To determine common ionic compounds formed by elements, keep the following in mind:

- Group I ions (alkali metals) have _____ charges.
- Group 2 ions (alkaline earth metals) have _____ charges.
- Group 6 ions (nonmetals) have _____ charges.
- Group 7 ions (halides) have _____ charges.
- There is no simple way to predict the charges of the transition metals. Look on a [table](#) listing charges (valences) for possible values. For introductory and general chemistry courses, the +1, +2, and +3 charges are most often used.

When you write the formula for an ionic compound, remember that the _____ ion is always listed first.

Write down the information you have for the usual charges of the atoms and _____ them to answer the problem.

		CHEMICAL FORMULA
1.	_____ Li^+ ions are required to balance _____ O^{2-} ion	_____
2.	_____ Ni^{2+} ion is required to balance _____ S^{2-} ion	_____
3.	_____ Bi^{3+} ion is required to balance _____ F^- ions	_____
4.	_____ Mg^{2+} ion is required to balance _____ Cl^- ions	_____

Open the flash animation, [Binary Ionic Formulas](#).

1. Add one cation and one anion to each side of the balance.
2. Add another ion to whichever side is higher.
3. Continue adding one ion at a time to the higher side until the positive and negative charges balance.
4. Record your results in the table below.
5. Click "new compound" to get a new problem. Do 15 total.

(Note: The names of the compounds on this simulation use an older system that we will not be using.)

cation (+)			anion (-)			formula unit
Lewis Symbol	# used	total + charge	Lewis Symbol	# used	total - charge	

In each of the ionic compounds above, what is the sum of the total positive and negative charges?) _____

Alkali metals		Alkaline earth metals		Transition metals										Group numbers					Noble gases	
1A	2A											3A	4A	5A	6A	7A	8A			
1 H	2 He											3 B	4 C	5 N	6 O	7 F	8 Ne			
3 Li	4 Be											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar			
11 Na	12 Mg	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr			
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe			
55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn			
87 Fr	88 Ra	89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110	111	112	114		116						
Lanthanides		58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu					
Actinides		90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr					

Open [Nomenclature of Binary Ionic Compounds Containing a Metal Ion With a Fixed Charge](#). Read “Rules for Naming Binary Ionic Compounds Containing a Metal Ion With a Fixed Charge” and do the first 10 questions, recording your answers in the table below.

Note: you may not be filling in all columns for every question. Also note that everyone may not have the same questions!

	compound name	formula unit	#	cation	#	anion
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

Open [Binary Ionic Compounds Containing a Metal Ion With a Variable Charge](#). Read “Rules for Naming Binary Ionic Compounds Containing a Metal Ion With a Variable Charge” and do the first 10 questions, recording your answers in the table below.

	compound name	formula unit	#	cation	#	anion
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

Activity #5 – Polyatomic Ions

Open the [Polyatomic Ion Game](#).

A **polyatomic ion** is a charged particle containing two or more covalently bonded atoms. This game will get you familiar with some of these ions. Build the given polyatomic ion by moving the element symbols into the boxes above. If you need more than one atom of that element, drag more to the same box. Do the same with the charge until you have the correct charge. There is a table of polyatomic ions in the back of the packet to help you. Race the person at the computer next to you. The first person to 30 points wins! Have your teacher initial below.

your score _____ teacher's initials _____

After playing this game, would you say most polyatomic ions are negative or positive?

Open [Predicting Formulas of Compounds with Polyatomic Ions](#). Read and fill in the blanks below.

Problem

Predict the formulas of these compounds, which contain polyatomic ions:

1. barium hydroxide
2. ammonium phosphate
3. potassium sulfate

When you write the formula for an ionic compound, remember that the _____ ion is always listed first. When there are two or more polyatomic ions in a formula, enclose the polyatomic ion in _____.

Write down the information you have for the charges of the component ions and balance them to answer the problem.

CHEMICAL FORMULA

1. _____ Ba^{2+} ion is required to balance _____ OH^- ions _____
2. _____ NH_4^+ ions are required to balance _____ PO_4^{3-} ion _____
3. _____ K^+ ions are required to balance _____ SO_4^{2-} ion _____

Open [Ionic Compounds Containing Polyatomic Ions](#). Read "Rules for Naming Ionic Compounds Containing Polyatomic Ions" and do the first 20 questions, recording your answers below.

	compound name	formula unit	#	cation	#	anion
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						

Activity #6 – Ionic Compound Naming & Formula Review

Open [Chemical Compounds Practice Quiz](#). Check off the following and hit “start.”

CHEMICAL COMPOUNDS PRACTICE QUIZ

This online quiz is intended to give you extra practice in naming compounds, writing formulas and calculating molar masses (formula weights).

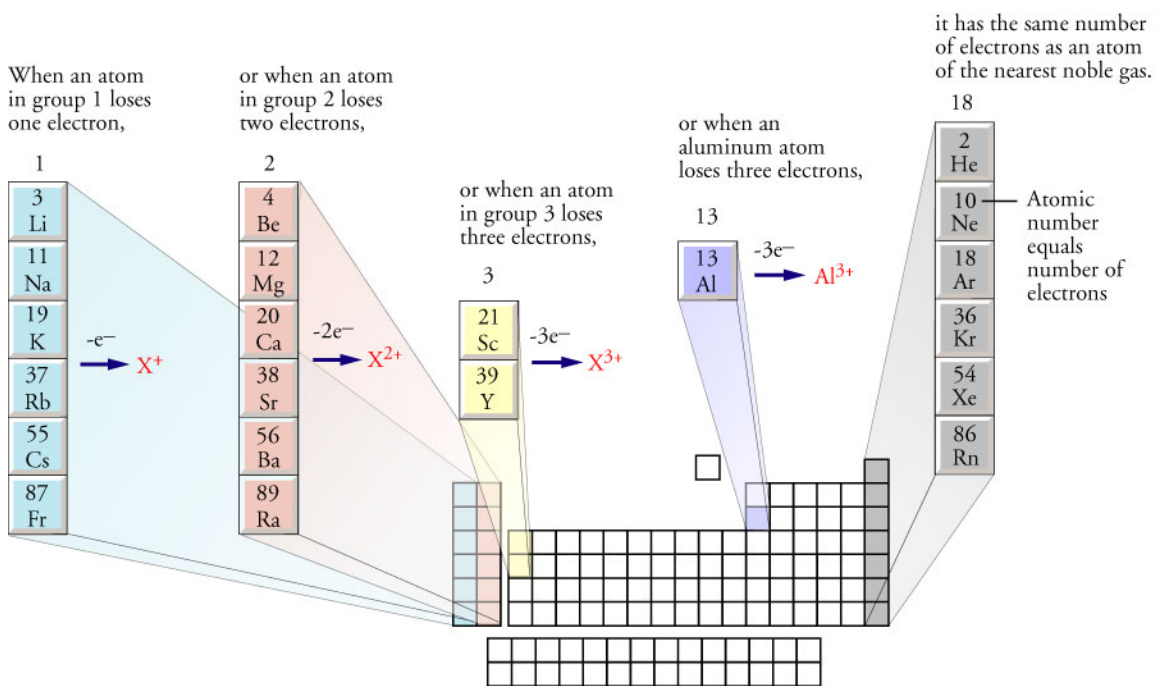
Select your preferences below and click 'Start' to give it a try!

Quiz type:	<input checked="" type="radio"/> Names & formulas <input type="radio"/> Molar Mass (aka formula weight) <input type="radio"/> Both!
Number of items:	<input type="radio"/> 5 <input type="radio"/> 10 <input checked="" type="radio"/> 25 <input type="radio"/> 50 <input type="radio"/> 100!
Compound types:	<input type="checkbox"/> Acids <input checked="" type="checkbox"/> Ionic compounds <input type="checkbox"/> Molecular compounds
Names or formulas:	<input type="radio"/> I want formulas only <input type="radio"/> I want names only <input checked="" type="radio"/> Mix & match
<input type="button" value="START!"/>	

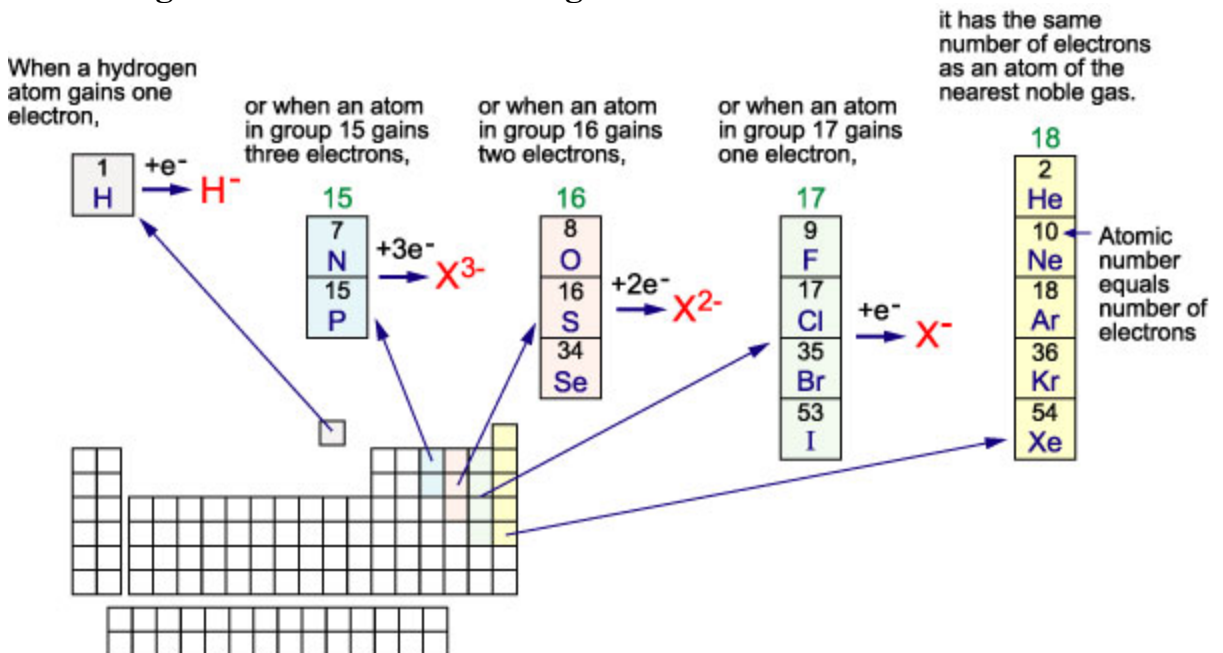
If you're given a formula, write the name; if you're given a name, write the formula. After you are done, hit the button to grade your quiz and correct the ones that you got wrong. There is a data table on the next page in which to record your quiz questions and answers.

#	compound	Name/formula	corrections
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
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25			

Predicting Monatomic Cation Charges



Predicting Monatomic Anion Charges



POLYATOMIC IONS

<u><i>Symbol</i></u>	<u><i>Name</i></u>
$\text{CH}_3\text{COO}^{1-}$	acetate ion
NH_4^{1+}	ammonium ion
AsO_4^{3-}	arsenate ion
$\text{C}_6\text{H}_5\text{COO}^{1-}$	benzoate ion
HCO_3^{1-}	bicarbonate ion
BrO_3^{1-}	bromate ion
CO_3^{2-}	carbonate ion
ClO_3^{1-}	chlorate ion
ClO_2^{1-}	chlorite ion
CrO_4^{2-}	chromate ion
$\text{C}_6\text{H}_5\text{O}_7^{3-}$	citrate ion
CN^{1-}	cyanide ion
$\text{Cr}_2\text{O}_7^{2-}$	dichromate ion
OH^{1-}	hydroxide ion
ClO^{1-}	hypochlorite ion
IO_3^{1-}	iodate ion
PO_3^{1-}	phosphite ion
NO_3^{1-}	nitrate ion
NO_2^{1-}	nitrite ion
$\text{C}_2\text{O}_4^{2-}$	oxalate ion
ClO_4^{1-}	perchlorate ion
IO_4^{1-}	periodate ion
MnO_4^{1-}	permanganate ion
PO_4^{3-}	phosphate ion
SiO_3^{2-}	silicate ion
SO_4^{2-}	sulfate ion
SO_3^{2-}	sulfite ion
$\text{S}_2\text{O}_3^{2-}$	thiosulfate ion

MONATOMIC IONS

<u><i>Symbol</i></u>	<u><i>Name</i></u>
Cd^{2+}	cadmium ion
Cr^{2+}	chromium (II) ion
Cr^{3+}	chromium (III) ion
Co^{2+}	cobalt (II) ion
Co^{3+}	cobalt (III) ion
Cu^{1+}	copper (I) ion
Cu^{2+}	copper (II) ion
Au^{1+}	gold (I) ion
Au^{3+}	gold (III) ion
Fe^{2+}	iron (II) ion
Fe^{3+}	iron (III) ion
Pb^{2+}	lead (II) ion
Pb^{4+}	lead (IV) ion
Pt^{2+}	platinum (II) ion
Pt^{4+}	platinum (IV) ion
Sn^{2+}	tin (II) ion
Sn^{4+}	tin (IV) ion
Ti^{3+}	titanium (III) ion
Ti^{4+}	titanium (IV) ion
W^{4+}	tungsten (IV) ion
W^{5+}	tungsten (V) ion
U^{3+}	uranium (III) ion
U^{4+}	uranium (IV) ion
U^{5+}	uranium (V) ion
U^{6+}	uranium (VI) ion
V^{3+}	vanadium (III) ion
V^{4+}	vanadium (IV) ion
V^{5+}	vanadium (V) ion

