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.

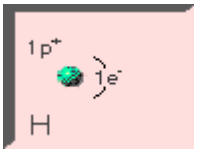
      iii) Do compounds keep the properties of the elements that make them up? Explain.

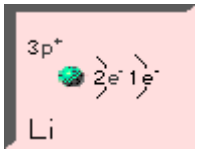
Activity #2 – Bohr Diagram Review

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)

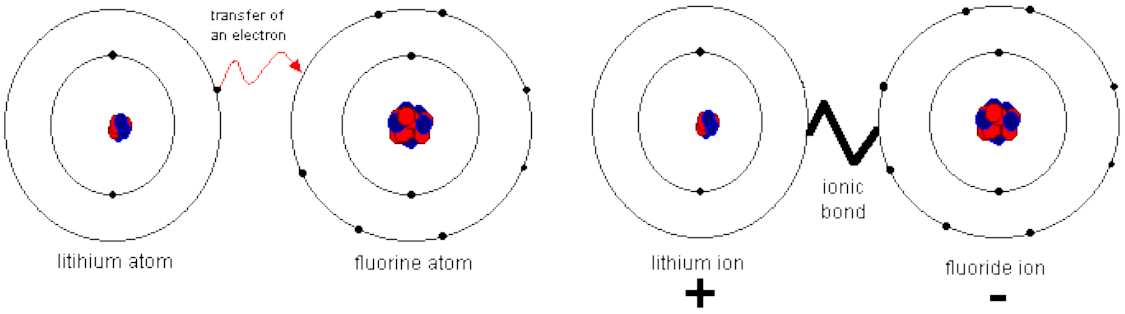
   b) neon (Ne)

   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 _____.



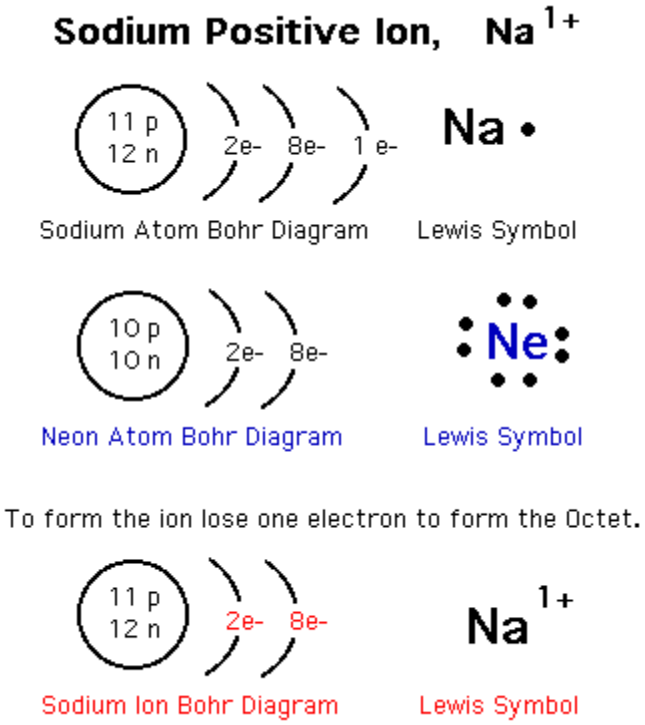
_____, with only a few electrons in the outer energy level, tend to _____electrons most readily. The energy required to remove an electron from a neutral atom is called the _____ _____.

Energy + Metal Atom → Metal (+) ion + e-

_____, 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.

Non-metal Atom + e- → Non-metal (-) ion + energy

Read Formation of Positive Ions.



6) Consider the group 1A metal, potassium (K).

   a) Predict how many valence electrons potassium will have. ___

   b) Verify your answer to part a by drawing a Bohr diagram. Check your diagram here.

   c) What is the nearest noble gas (from question #3) to potassium?

   d) How will potassium complete its octet?

   e) What charge would a potassium ion have?

   f) 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).

a) Predict how many valence electrons calcium will have. ___

b) Verify your answer to part a by drawing a Bohr diagram. Check your diagram here.

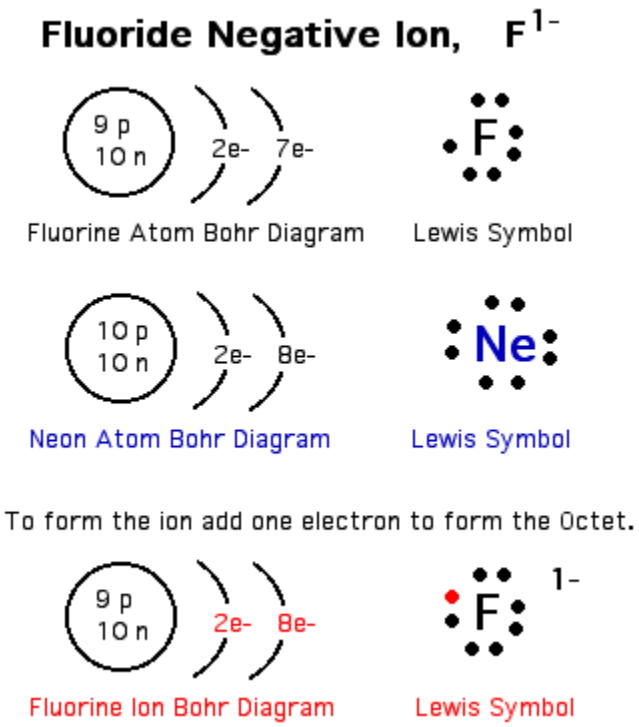
c) What is the nearest noble gas (from question #3) to calcium?

d) How will calcium complete its octet?

e) What charge would a calcium ion have?

f) Draw the Lewis symbol for a calcium ion and check here.

Read Formation of Negative Ions.



8) Consider the group 7A nonmetal, chlorine (Cl).

a) Predict how many valence electrons chlorine will have. ___

b) Verify your answer to part a by drawing a Bohr diagram. Check your diagram here.

c) What is the nearest noble gas (from question #3) to chlorine?

d) How will chlorine complete its octet?

e) What charge would a chlorine ion have?

f) 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).

a) Predict how many valence electrons nitrogen will have. ___

b) Verify your answer to part a by drawing a Bohr diagram. Check your diagram here.

c) What is the nearest noble gas (from question #3) to nitrogen?

d) How will nitrogen complete its octet?

e) What charge would a nitrogen ion have?

f) 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^- *(lost /gained)***	**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 – Naming Ionic Compounds

Open Ionic Compounds Activity. An ionic compound consists of cations and anions.

1) Click the ion of lithium (Li^+) and the ion of fluorine (F^-).
   a) What is the name of this compound?
   b) Which ion comes first in the name, the cation or the anion?
   c) What new ending does a group 7A ion get? (what replaces the *–ine* in *fluorine*?)
2) Consider an ionic compound of sodium and bromine.
   a) What do you think the name of this compound will be?
   b) What cation ion must you choose from the list?
   c) What anion must you choose from the list?
   d) Was your answer to part a correct? If not, what is the correct answer?
3) Some ions contain more than one element (polyatomic ions) and have special names. What is the name of the ion
   a) NH_4^+ ?
   b) SO_4^{2-} ?
4) 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.
   a) What is the name of the compound containing Fe^{2+} and OH^- ?
   b) What is the name of the compound containing Fe^{3+} and OH^- ?
   c) How does the name of the compound show which iron ion it contains?

5) Predict the names of the following compounds and then check your answers, correcting them if you were wrong.

ionic compound	cation	anion
	Pb^{2+}	SO_4^{2-}
	NH_4^+	S^{2-}
	Fe^{3+}	Cl^-

6) What ions compose the following compounds? Check your answers, correcting them if you were wrong.

ionic compound	cation	anion
iron (II) phosphate		
aluminum hydroxide		
barium fluoride		

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 _____

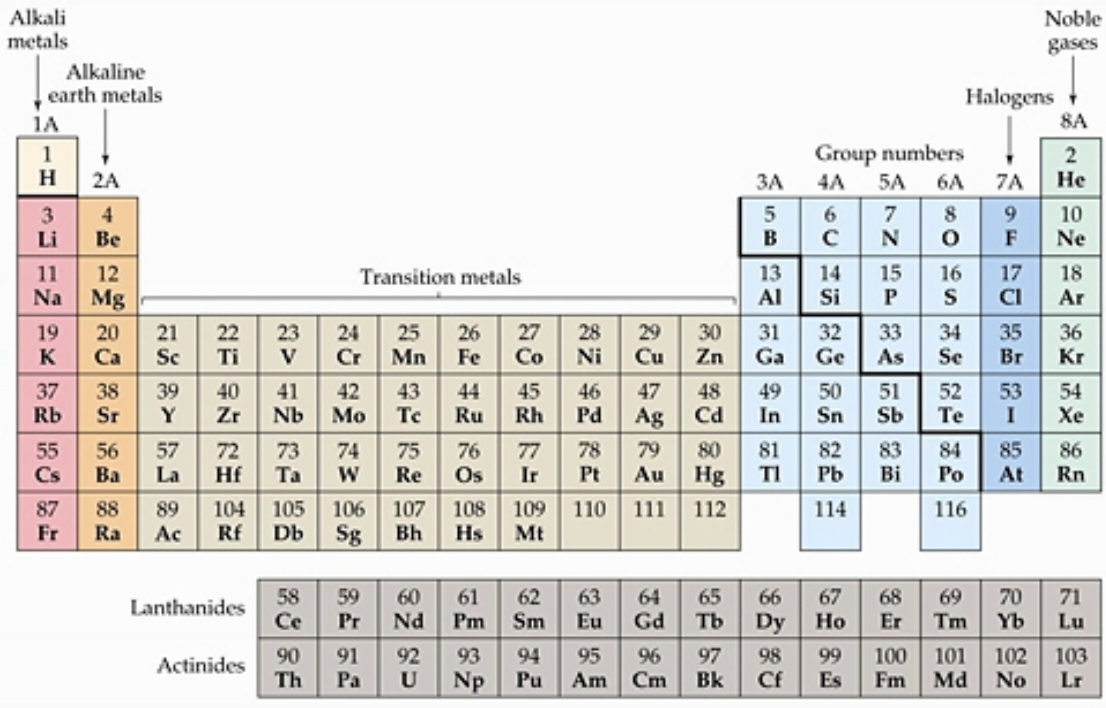
Open the flash animation, Binary Ionic Formulas.

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?)_____



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.

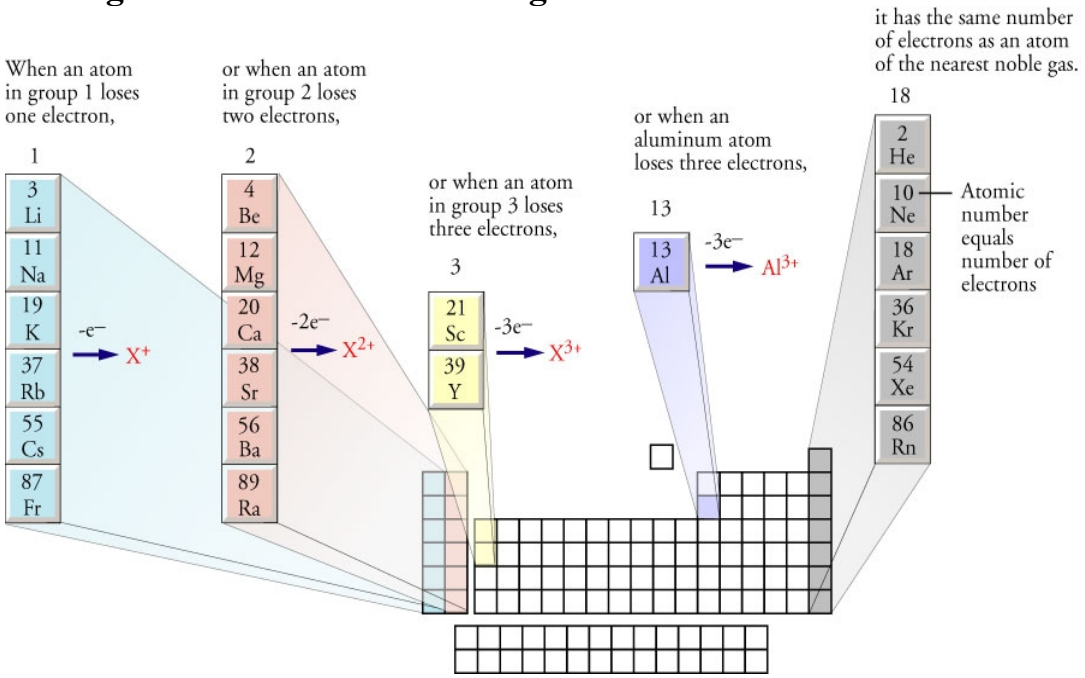
	compound name	formula unit	#	cation	#	anion
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						

Activity #6 – Ionic Compound Naming & Formula Review

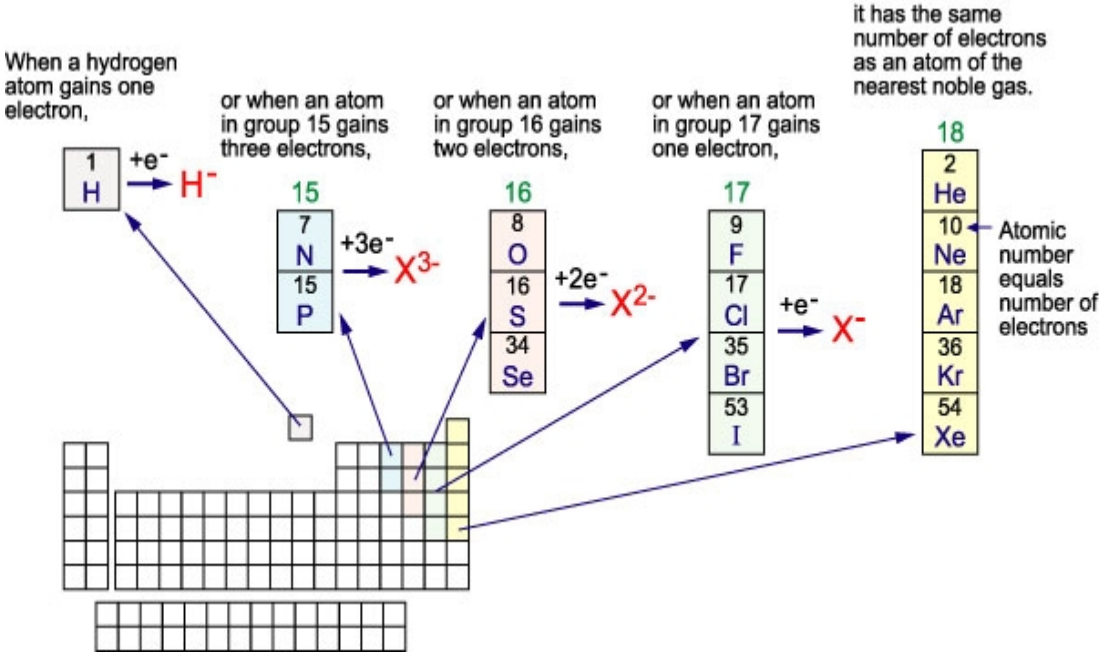
Open the links for Part 1 and Part 2 and complete the table.

#	compound name	formula unit
Part 1		
1		Al_2O_3
2		NH_4NO_3
3		$SrSO_4$
4		$Ba(ClO_3)_2$
5		$Mg(OH)_2$
6		$KHCO_3$
8		Hg_2O
10		Cu_2O
11		$KMnO_4$
12		$NaC_2H_3O_2$
13		$Ba(ClO)_2$
14		$CoCr_2O_7$
15		BeS
16		NaCN
17		PbO_2
18		NH_4HSO_4
Part 2		
1	luminum oxalate	
2	calcium fluoride	
3	the Roman numeral in ionic formulas refers to	○ the charge on the cation ○ the charge on the anion ○ the number of cations ○ the number of anions ○ none of these
4	potassium dihydrogen phosphate	
5	zinc perchlorate	
6	ammonium chloride	
7	sodium bicarbonate	
8	platinum(IV) chloride	
9	strontium nitride	
10	potassium dichromate	
11	iron(III) oxide	
12	potassium permanganate	
13	sodium Acetate	
14	cesium bromide	

Predicting Monatomic Cation Charges



Predicting Monatomic Anion Charges



POLYATOMIC IONS

Symbol	***Name***
CH_3COO^{1-}	acetate ion
NH_4^{1+}	ammonium ion
AsO_4^{3-}	arsenate ion
$C_6H_5COO^{1-}$	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
$C_6H_5O_7^{3-}$	citrate ion
CN^{1-}	cyanide ion
$Cr_2O_7^{2-}$	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
$C_2O_4^{2-}$	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
$S_2O_3^{2-}$	thiosulfate ion

MONATOMIC IONS

Symbol	***Name***
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