Ions and Ionic Compounds

Chapter 5

Chapter 5

Section 1 – Simple Ions

Noble Gases Are the Least Reactive Elements

The noble gases show almost no chemical reactivity.

Noble gases have almost no chemical reactivity due to its outer principle energy level having 8 valence electrons. (except helium which only needs 2)

Alkali Metals and Halogens Are the Most Reactive Elements

Alkali metals are the most reactive metals because they want to only lose 1 electron to fulfill the octet rule.

Halogens are the most reactive nonmetals because they only want to gain 1 electron to fulfill the octet rule.

When an atom gains or loses an electron, the gain/loss occurs in the valence level.

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Section 1 – Simple Ions

Formation of Cations

A cation is an atom that has lost at least one electron from its valence shell.

The loss of an electron(s) will change the electron configuration.

Potassium Atom

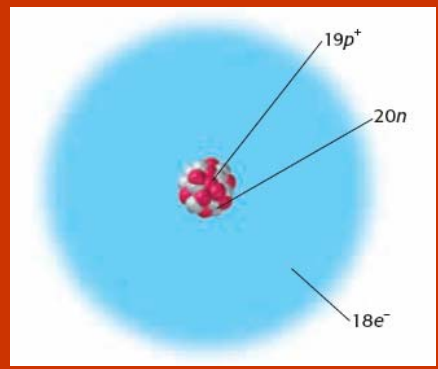
Potassium Ion

K $\longrightarrow$ e + K^+

Loss of electron

2-8-8-1

2-8-8



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Section 1 – Simple Ions

Formation of Anions

An anion is an atom that has gained at least one electron into its valence shell.

The gain of an electron(s) will change the electron configuration.

Chlorine Atom

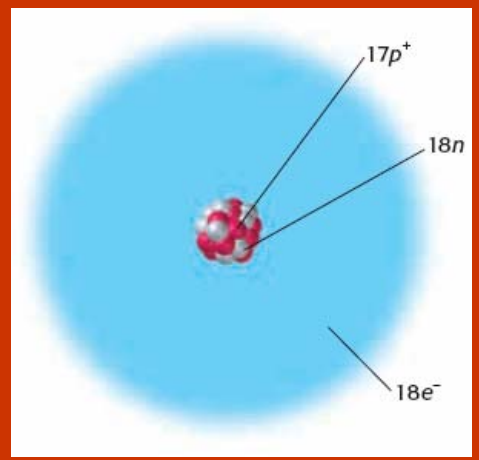
Chlorine Ion

Cl + e → Cl

gain of electron

2-8-7

2-8-8



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Section 1 – Simple Ions

Atoms and Ions

Many atoms form stable ions that have noble-gas configurations. It is important to remember that these elements do not actually *become* noble gases. Having identical electron configurations does not mean that a sodium cation is a neon atom. The sodium cation still has 11 protons and 12 neutrons, like a sodium atom that has not reacted to form an ion. But like a noble-gas atom, a sodium ion is very unlikely to gain or lose any more electrons.

Ions and Their Parent Atoms Have Different Properties

Because both sodium and chlorine are very reactive, you might expect a violent reaction when these two are brought together. This is exactly what happens. If a small piece of sodium is lowered into a flask filled with chlorine gas, there is a violent reaction that releases both heat and light. After the reaction is complete, all that remains is a white solid. Even though it is formed from two dangerous elements, it is something you probably eat every day—table salt. Chemists call this salt *sodium chloride*. Sodium chloride is made from sodium cations and chloride anions.

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Section 1 – Simple Ions - Review

Which ion has the same electron configuration as an H^- ion?

1. Cl^-
2. F^-
3. K^+
4. Li^+

An atom in the ground state contains 8 valence electrons. This atom is classified as a

1. metal
2. semimetal
3. noble gas
4. halogen

Which electron configuration is correct for a sodium ion?

1. 2-7
2. 2-8
3. 2-8-1
4. 2-8-2

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Section 1 – Simple Ions - Review

What is the total number of electrons in a Cu^{+} ion?

1. 28
2. 29
3. 30
4. 36

When a lithium atom forms an Li+ ion, the lithium atom

1. gains a proton
2. gains an electron
3. loses a proton
4. loses an electron

Which symbol represents a particle that has the same total number of electrons as S^{2} ?

1. O^{2}
2. Si
3. Se^{2}
4. Ar

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Section 1 – Simple Ions

Which symbol represents a particle with a total of 10 electrons?

1. N
2. N^{3+}
3. Al
4. Al^{3+}

When metals combine with nonmetals, the metallic atoms tend to

1. lose electrons and become positive ions
2. lose electrons and become negative ions
3. gain electrons and become positive ions
4. gain electrons and become negative ions

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Section 2 – Ionic Bonding and Salts

Ionic Bonding

Because opposite charges attract, cations and anions should attract one another. This is exactly what happens when an ionic bond is formed.

Ionic Bonds Form Between Ions of Opposite Charge

Salt: common word for ionic solids

Remember that sodium gives up its only valence electron to form a stable Na^+ cation. Chlorine, with seven valence electrons, acquires that electron. As a result, a chlorine atom becomes a stable Cl^- anion.

$$Na \longrightarrow 1e + Na^+ \qquad Cl + 1e \longrightarrow Cl$$

2-8-1 2-8 2-8-7 2-8-8

Gives up 1 electron to chlorine

Gains the electron from sodium

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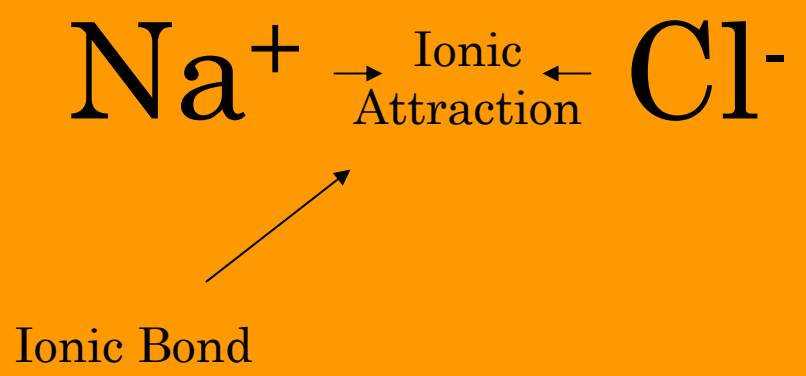
Section 2 – Ionic Bonding and Salts

The force of attraction between the 1+ charge on the sodium cation and the 1− charge on the chloride anion creates the ionic bond in sodium chloride.



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Section 2 – Ionic Bonding and Salts

All these salts are ionic compounds that are electrically neutral. They are made up of cations and anions that are held together by ionic bonds in a simple, whole-number ratio. For example, sodium chloride consists of sodium cations and chloride anions bonded in a 1:1 ratio. To show this 1:1 ratio, chemists write the formula for sodium chloride as NaCl.

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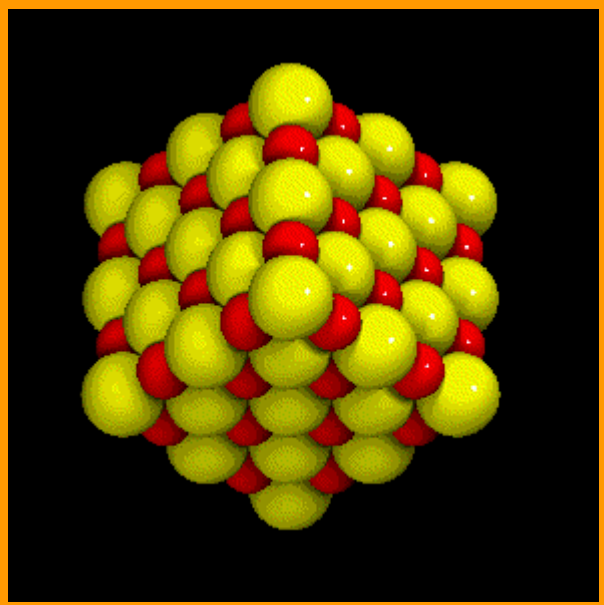
Section 2 – Ionic Bonding and Salts

However, the attractions between the ions in a salt do not stop with a single cation and a single anion. These forces are so far reaching that one cation attracts several different anions. At the same time, each anion attracts several different cations. In this way, many ions are pulled together into a tightly packed structure. The tight packing of the ions causes any salt, such as sodium chloride, to have a distinctive crystal structure.



The smallest crystal of table salt that you could see would still have more than a billion billion sodium and chloride ions.

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Section 2 – Ionic Bonding and Salts

Ionic Compound Properties

- Almost always form between a metal atom and nonmetal atom
- Stronger the electronegativity difference the greater the ionic properties
- Will conduct electricity when a liquid or dissolved in water (aqueous)
- High melting and boiling points
- Crystalline structures
- They are not molecules (bonded compound between nonmetals)
- Hard and brittle

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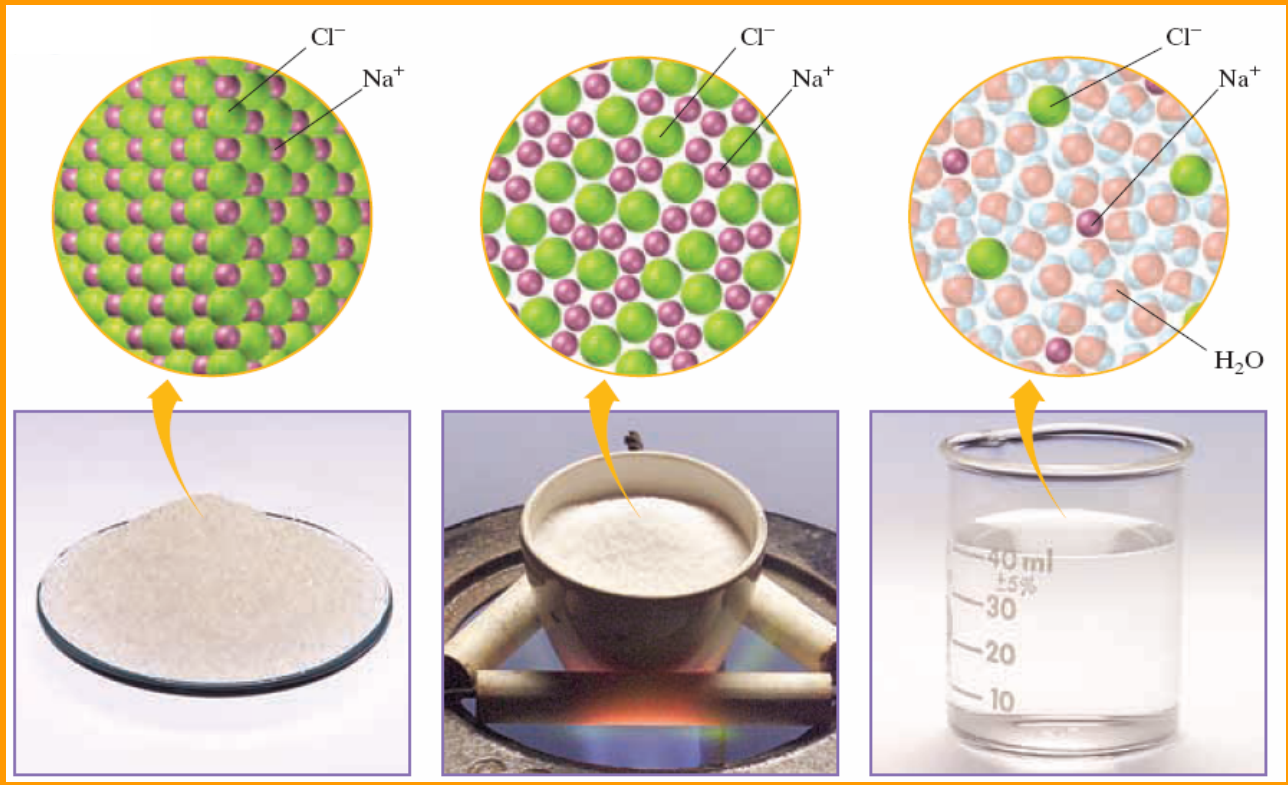
Section 2 – Ionic Bonding and Salts

How to make an ionic compound conduct electricity.

First you must know that electric current is when a charged particle is able to move. If the charged particle is fixed in place it is unable to conduct current.



Combine the following anions and cations for show the ionic compound That will form from each.

Li^{+}	F^{-}	LiF
Al^{3+}	Br^{-}	$AlBr_3$
Cu^{2+}	S^{2-}	CuS
Ni^{2+}	P^{3-}	Ni_3P_2
Sr^{2+}	C^{4-}	Sr_2C
Au^{3+}	Se^{2-}	Au_2Se_3
Cs^{+}	O^{2-}	Cs_2O
Pt^{4+}	O^{2-}	PtO_2

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Section 2 – Ionic Bonding and Salts Review

A white crystalline salt conducts electricity when it is melted and when it is dissolved in water. Which type of bond does this salt contain?

1. ionic
2. metallic
3. covalent
4. network

A chemical bond between two atoms results from a simultaneous

1. attraction by the protons for the neutrons
2. attraction by the two nuclei for the electrons
3. repulsion by the valence electrons of the atoms
4. repulsion by the protons in the two nuclei

Which formula represents a molecular substance?

1. CaO
2. CO
3. Li_2O
4. Al_2O^3

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Section 2 – Ionic Bonding and Salts Review

Which compound contains ionic bonds?
1. NO
2. NO_2
3. CaO
4. CO_2

If the electronegativity difference between the elements in compound Na*X* is 2.1, what is element *X*?
1. bromine
2. chlorine
3. fluorine
4. oxygen

Which type of bond is formed when electrons are transferred from one atom to another?
1. covalent
2. ionic
3. hydrogen
4. metallic

Chapter 5
Section 2 – Ionic Bonding and Salts Review

The data table below represents the properties determined by the analysis of substances *A*, *B*, *C*, and *D*.

Substance	Melting Point (°C)	Boiling Point (°C)	Conductivity
A	-80	-20	none
B	20	190	none
C	320	770	as solid
D	800	1250	in solution

Which substance is an ionic compound?

1. A
2. B
3. C
D

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Section 3 – Names and Formulas of Ionic Compounds

Naming Ionic Compounds

Simple cations borrow their names from the names of the elements

K	K^+
Potassium	Potassium Ion

When an element forms two or more cations, the ion names include roman numerals to indicate charge.

Cu	Cu^+	Cu^{2+}
Copper	Copper (I) Ion	Copper (II) Ion

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Section 3 – Names and Formulas of Ionic Compounds

The name of a simple anion is also formed from the name of the element, but it ends in ***-ide***

Br	Br^-
Bromine	Bromide

The Names of Ions Are Used to Name an Ionic Compound

Naming binary ionic compounds is simple. The name is made up of just two words: the name of the cation followed by the name of the anion.

NaCl sodium chloride	$CuCl_2$ copper(II) chloride
ZnS zinc sulfide	Mg_3N_2 magnesium nitride
K_2O potassium oxide	Al_2S_3 aluminum sulfide

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Section 3 – Names and Formulas of Ionic Compounds

Polyatomic Ions

The adjective *simple* describes an ion formed from a single atom. A simple ion could also be called ***monatomic***, which means "one-atom." Just as the prefix *mon-* means "one," the prefix *poly-* means "many." The term ***polyatomic*** means a charged group of two or more bonded atoms that can be considered a single ion. A polyatomic ion as a whole forms ionic bonds in the same way that simple ions do.

The Names of Polyatomic Ions Can Be Complicated

Naming polyatomic ions is not as easy as naming simple cations and anions. Even so, there are rules you can follow to help you remember how to name some of them. However you will not have to know these rules. Your Reference Table has all of the polyatomic ions that you are responsible to use listed on table E on the front page.

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Section 3 – Names and Formulas of Ionic Compounds

You will recognize many of the polyatomic ions due to there endings. Many share common endings such as -ate and -ite,.

Just to confuse many of you there are some that have an -ide ending. These are: cyanide, hydroxide, and peroxide.

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Section 3 – Names and Formulas of Ionic Compounds

Compound Name	Written Formula
Tin (IV) Chloride	$SnCl_4$
Lead (II) Sulfite	$PbSO_3$
Calcium Sulfate	$CaSO_4$
Chloride Ion	Cl^-
Sodium ion	Na^+

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Section 3 – Names and Formulas of Ionic Compounds

Compound Name	Written Formula
Ammonium Sulfide	$(NH_4)_2S$
Strontium Oxide	SrO
Iron (III) Nitrate	$Fe(NO_3)_3$
Cobalt (III) Nitride	CoN
Francium Iodide	FrI

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Section 3 – Names and Formulas of Ionic Compounds

Compound Name	Written Formula
Mercury (II) Hydroxide	$Hg(OH)_2$
Sodium Carbonate	Na_2CO_3
Sodium Fluoride	NaF
Magnesium Phosphate	$Mg_3(PO_4)_2$
Potassium Sulfide	K_2S

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Section 3 – Names and Formulas of Ionic Compounds

Compound Name	Written Formula
Gallium	Ga
Tungsten Carbide	W_4C_6
Rubidium Selenide	Rb_2Se
Iodide Ion	I^-
Manganese (III) Permanganate	$Mn(MnO_4)_3$

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Section 3 – Names and Formulas of Ionic Compounds

Compound Name	Written Formula
Ammonium Hydrogen Sulfate	NH_4HSO_4
Osmium (IV) Chlorite	$Os(ClO_2)_4$
Lithium Phosphide	Li_3P
Gold (I) Thiocyanate	$AuSCN$
Nickel (III) Acetate	$Ni(C_2H_3O_2)_3$

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Section 3 – Names and Formulas of Ionic Compounds

Compound Name	Written Formula
Zirconium Sulfite	$Zr(SO_3)_2$
Antimony (V) Carbonate	$Sb_2(CO_3)_5$
Titanium (II) Thiosulfate	$Ti(S_2O_3)_2$
Iron (III) Nitrate	$Fe(NO_3)_3$
Cesium Ion	Cs^+

The End