

Section 7.1 Ion Formation

Objectives

- **Define** a chemical bond.
- **Describe** the formation of positive and negative ions.
- **Relate** ion formation to electron configuration.

Review Vocabulary

octet rule: atoms tend to gain, lose, or share electrons in order to acquire eight valence electrons

New Vocabulary

chemical bond

cation

anion

MAIN Idea

Ions are formed when atoms gain or lose valence electrons to achieve a stable octet electron configuration.



Valence Electrons and Chemical Bonds

- A chemical bond is the force that holds two atoms together.
- Chemical bonds form by the attraction between the positive nucleus of one atom and the negative electrons of another atom.



Valence Electrons and Chemical Bonds (cont.)

- Atoms try to form the octet—the stable arrangement of eight valence electrons in the outer energy level—by gaining or losing valence electrons.

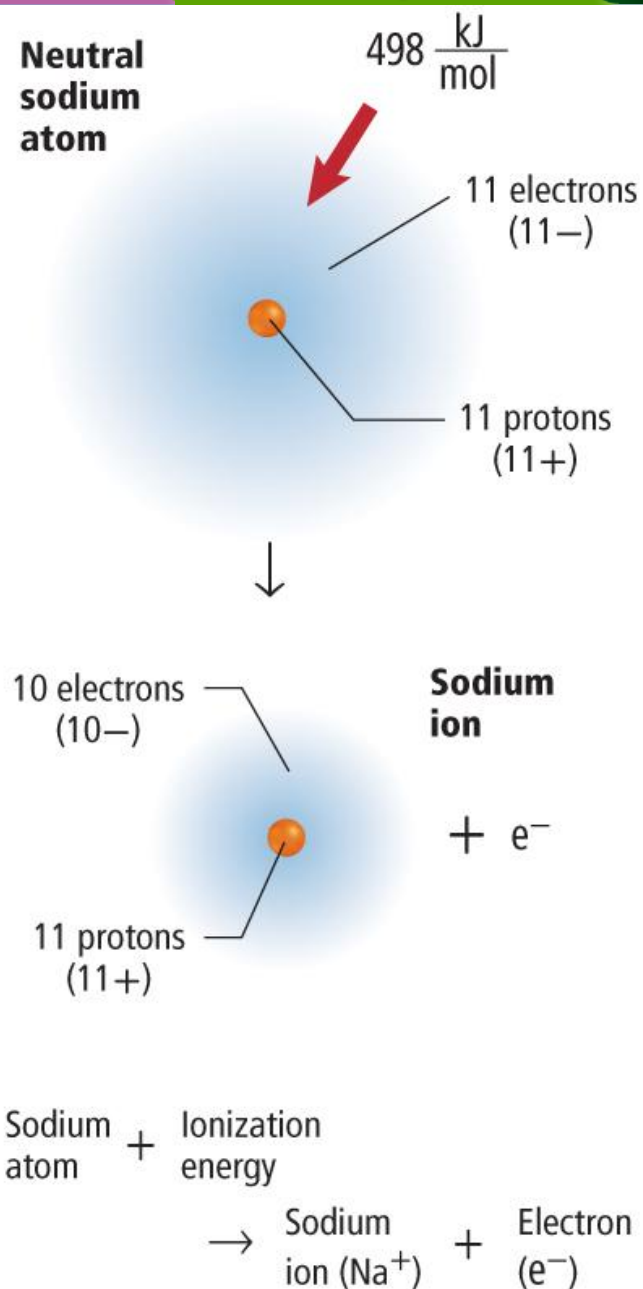
Table 7.1**Electron-Dot Structures**

Group	1	2	13	14	15	16	17	18
Diagram	Li·	·Be·	·B·	·C·	·N·	·O·	·F·	·Ne·



Positive Ion Formation

- A positively charged ion is called a **cation**.
- This figure illustrates how sodium loses one valence electron to become a sodium cation.



Positive Ion Formation (cont.)

- Metals are reactive because they lose valence electrons easily.

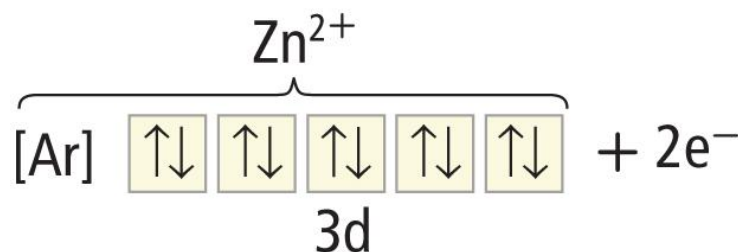
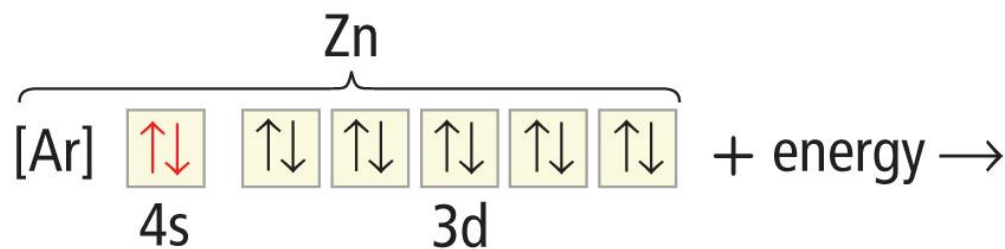
Table 7.2**Group 1, 2, and 13 Ions**

Group	Configuration	Charge of Ion Formed
1	[noble gas] ns^1	1+ when the s^1 electron is lost
2	[noble gas] ns^2	2+ when the s^2 electrons are lost
13	[noble gas] ns^2np^1	3+ when the s^2p^1 electrons are lost



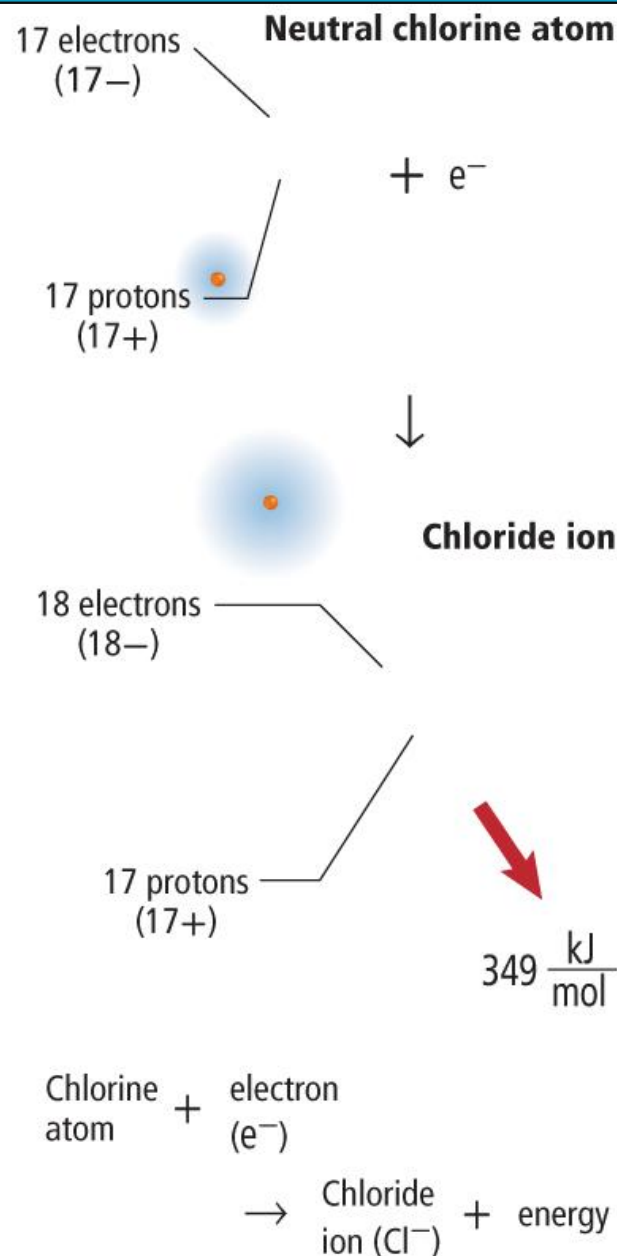
Positive Ion Formation (cont.)

- Transition metals commonly form 2+ or 3+ ions, but can form greater than 3+ ions.
- Other relatively stable electron arrangements are referred to as pseudo-noble gas configurations.



Negative Ion Formation

- An **anion** is a negatively charged ion.
- The figure shown here illustrates chlorine gaining an electron to become a chlorine ion.



Negative Ion Formation (cont.)

- Nonmetal ions gain the number of electrons required to fill an octet.
- Some nonmetals can gain or lose electrons to complete an octet.

Table 7.3 **Group 15–17 Ions**

Group	Configuration	Charge of Ion Formed
15	[noble gas] ns^2np^3	3– when three electrons are gained
16	[noble gas] ns^2np^4	2– when two electrons are gained
17	[noble gas] ns^2np^5	1– when one electron is gained

Section 7.2 Ionic Bonds and Ionic Compounds

Objectives

- **Describe** the formation of ionic bonds and the structure of ionic compounds.
- **Generalize** about the strength of ionic bonds based on the physical properties of ionic compounds.
- **Categorize** ionic bond formation as exothermic or endothermic.

Review Vocabulary

compound: a chemical combination of two or more different elements



Section 7.2 Ionic Bonds and Ionic Compounds (cont.)

New Vocabulary

ionic bond

ionic compound

crystal lattice

electrolyte

lattice energy

MAIN Idea

Oppositely charged ions attract each other, forming electrically neutral ionic compounds.

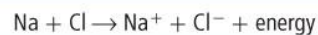


Formation of an Ionic Bond

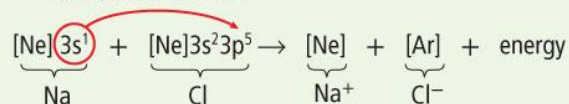
- The electrostatic force that holds oppositely charged particles together in an ionic compound is called an ionic bond.
- Compounds that contain ionic bonds are called ionic compounds.
- Binary ionic compounds contain only two different elements—a metallic cation and a nonmetallic anion.



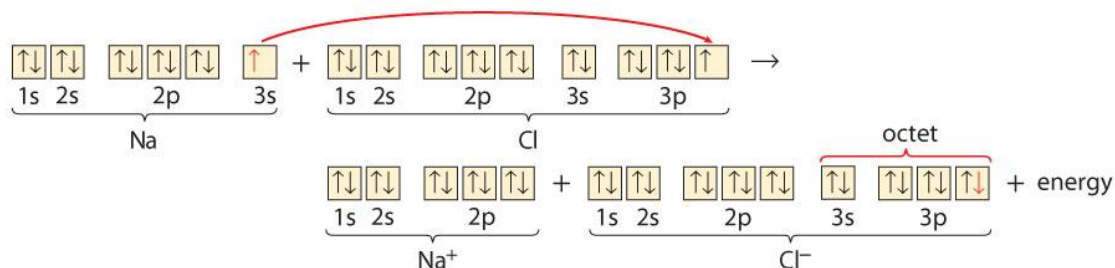
Formation of an Ionic Bond (cont.)

Table 7.4 Formation of Sodium Chloride
Chemical Equation

Electron Configurations

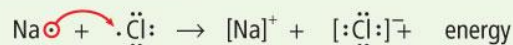
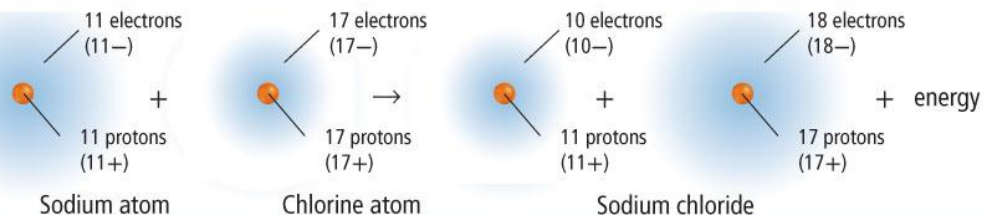
One electron is transferred.


Orbital Notation

One electron is transferred.

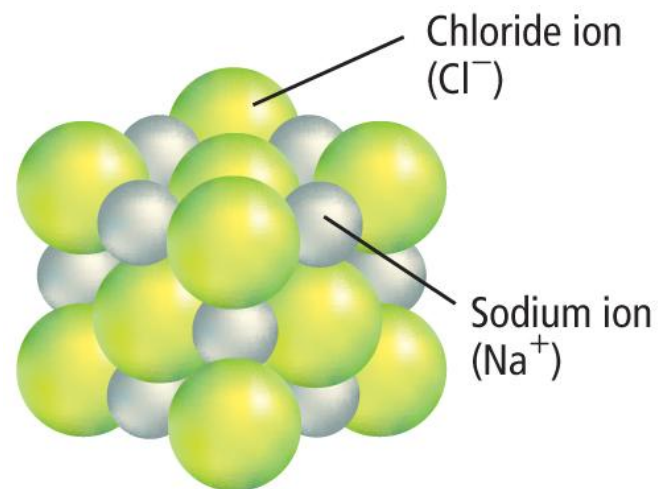

Electron-Dot Structures

One electron is transferred.


Atomic Models


Properties of Ionic Compounds

- Positive and negative ions exist in a ratio determined by the number of electrons transferred from the metal atom to the non-metal atom.
- The repeating pattern of particle packing in an ionic compound is called an ionic crystal.



Sodium chloride crystal



Properties of Ionic Compounds (cont.)

- The strong attractions among the positive and negative ions result in the formation of the crystal lattice.
- A crystal lattice is the three-dimensional geometric arrangement of particles, and is responsible for the structure of many minerals.



Properties of Ionic Compounds (cont.)

- Melting point, boiling point, and hardness depend on the strength of the attraction.

Table 7.5			Melting and Boiling Points of Some Ionic Compounds		
Compound		Melting Point (°C)		Boiling Point (°C)	
NaI		660		1304	
KBr		734		1435	
NaBr		747		1390	
CaCl ₂		782		>1600	
NaCl		801		1413	
MgO		2852		3600	



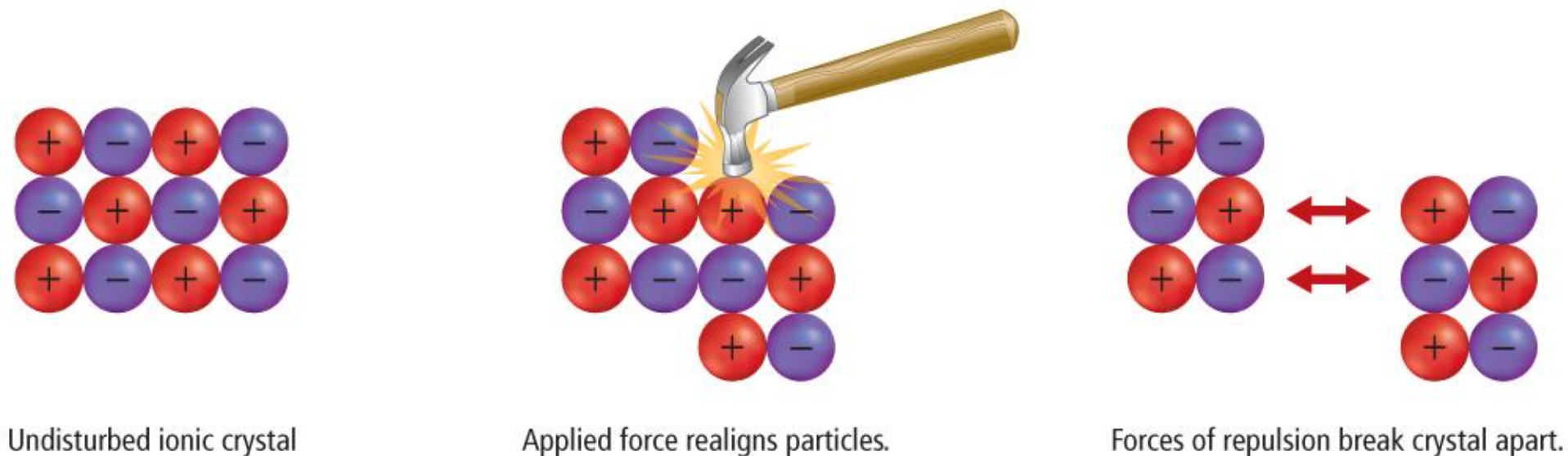
Properties of Ionic Compounds (cont.)

- In a solid, ions are locked into position and electrons cannot flow freely—solid ions are poor conductors of electricity.
- Liquid ions or ions in aqueous solution have electrons that are free to move, so they conduct electricity easily.
- An ion in aqueous solution that conducts electricity is an electrolyte.



Properties of Ionic Compounds (cont.)

- This figure demonstrates how and why crystals break when an external force is applied.



Energy and the Ionic Bond

- Reactions that absorb energy are endothermic.
- Reactions that release energy are exothermic.
- The energy required to separate 1 mol of ions in an ionic compound is referred to as the lattice energy.
- Lattice energy is directly related to the size of the ions that are bonded.



Energy and the Ionic Bond (cont.)

- Smaller ions form compounds with more closely spaced ionic charges, and require more energy to separate.
- Electrostatic force of attraction is inversely related to the distance between the opposite charges.
- The smaller the ion, the greater the attraction.



Energy and the Ionic Bond (cont.)

- The value of lattice energy is also affected by the charge of the ion.

**Table
7.6**

**Lattice Energies of Some Ionic
Compounds**

Compound	Lattice Energy (kJ/mol)	Compound	Lattice Energy (kJ/mol)
KI	632	KF	808
KBr	671	AgCl	910
RbF	774	NaF	910
NaI	682	LiF	1030
NaBr	732	SrCl ₂	2142
NaCl	769	MgO	3795



Study Guide **Section 7.2 Ionic Bonds and Ionic Compounds**

Key Concepts

- Ionic compounds contain ionic bonds formed by the attraction of oppositely charged ions.
- Ions in an ionic compound are arranged in a repeating pattern known as a crystal lattice.
- Ionic compound properties are related to ionic bond strength.
- Ionic compounds are electrolytes; they conduct an electric current in the liquid phase and in aqueous solution.
- Lattice energy is the energy needed to remove 1 mol of ions from its crystal lattice.



Section 7.4 Metallic Bonds and the Properties of Metals

Objectives

- **Describe** a metallic bond.
- **Relate** the electron sea model to the physical properties of metals.
- **Define** alloys, and categorize them into two basic types.

Review Vocabulary

physical property: a characteristic of matter that can be observed or measured without altering the sample's composition



Section 7.4 Metallic Bonds and the Properties of Metals (cont.)

New Vocabulary

electron sea model

delocalized electron

metallic bond

alloy

MAIN < Idea

Metals form crystal lattices and can be modeled as cations surrounded by a “sea” of freely moving valence electrons.



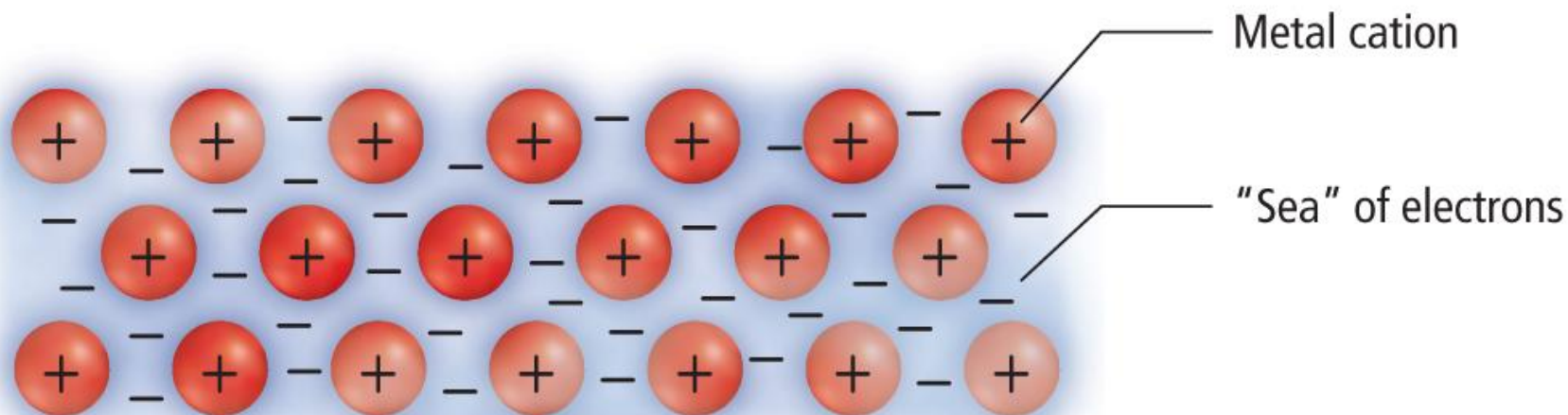
Metallic Bonds and the Properties of Metals

- Metals are not ionic but share several properties with ionic compounds.
- Metals also form lattices in the solid state, where 8 to 12 other atoms closely surround each metal atom.
- Within the crowded lattice, the outer energy levels of metal atoms overlap.
- The electron sea model proposes that all metal atoms in a metallic solid contribute their valence electrons to form a "sea" of electrons.



Metallic Bonds and the Properties of Metals (cont.)

- The electrons are free to move around and are referred to as delocalized electrons, forming a metallic cation.
- A metallic bond is the attraction of an metallic cation for delocalized electrons.



Metallic Bonds and the Properties of Metals

(cont.)

- Boiling points are much more extreme than melting points because of the energy required to separate atoms from the groups of cations and electrons.

**Table
7.12**

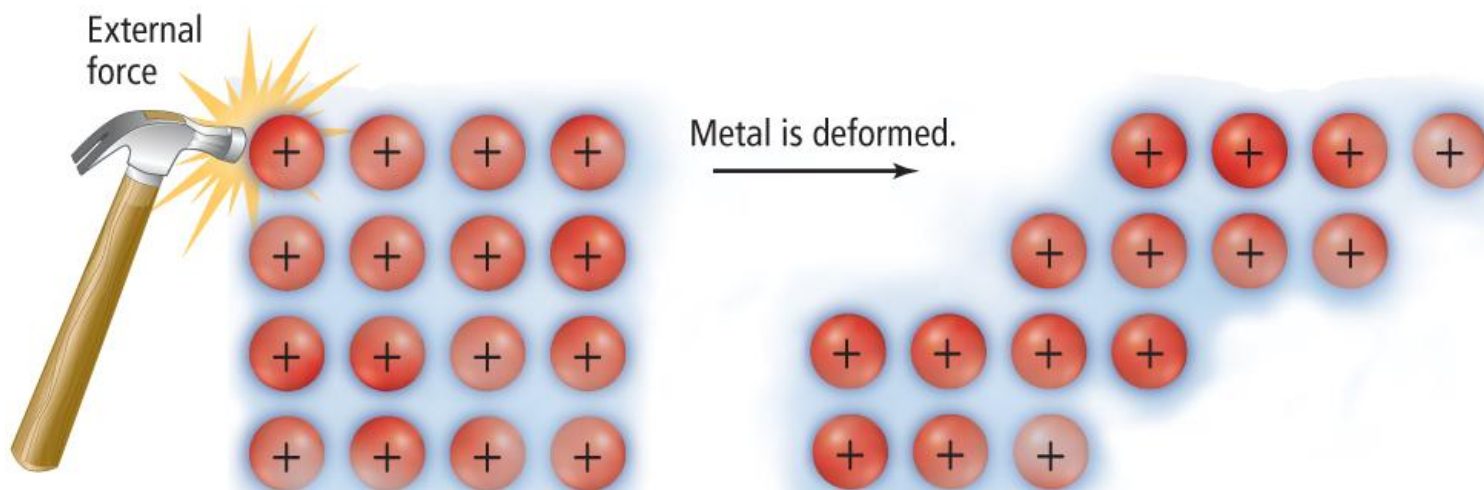
**Melting and
Boiling Points**

Element	Melting Point (°C)	Boiling Point (°C)
Lithium	180	1347
Tin	232	2623
Aluminum	660	2467
Barium	727	1850
Silver	961	2155
Copper	1083	2570



Metallic Bonds and the Properties of Metals (cont.)

- Metals are malleable because they can be hammered into sheets.
- Metals are ductile because they can be drawn into wires.



Metallic Bonds and the Properties of Metals

(cont.)

- Mobile electrons around cations make metals good conductors of electricity and heat.
- As the number of delocalized electrons increases, so does hardness and strength.
- An alloy is a mixture of elements that has metallic properties.
- The properties of alloys differ from the elements they contain.



Metal Alloys (cont.)

Table 7.13

Commercial Alloys

Common Name	Composition	Uses
Alnico	Fe 50%, Al 20%, Ni 20%, Co 10%	magnets
Brass	Cu 67–90%, Zn 10–33%	plumbing, hardware, lighting
Bronze	Cu 70–95%, Zn 1–25%, Sn 1–18%	bearings, bells, medals
Cast iron	Fe 96–97%, C 3–4%	casting
Gold, 10-carat	Au 42%, Ag 12–20%, Cu 37.46%	jewelry
Lead shot	Pb 99.8%, As 0.2%	shotgun shells
Pewter	Sn 70–95%, Sb 5–15%, Pb 0–15%	tableware
Stainless steel	Fe 73–79%, Cr 14–18%, Ni 7–9%	instruments, sinks
Sterling silver	Ag 92.5%, Cu 7.5%	tableware, jewelry

Metal Alloys (cont.)

- Substitutional alloys are formed when some atoms in the original metallic solid are replaced by other metals of similar atomic structure.
 - Ex) Brass = Cu (70%) and Zn (30%)
- Interstitial alloys are formed when small holes in a metallic crystal are filled with smaller atoms.
 - Ex) Steel = Carbon and Iron



Study Guide Section 7.4 Metallic Bonds and the Properties of Metals

Key Concepts

- A metallic bond forms when metal cations attract freely moving, delocalized valence electrons.
- In the electron sea model, electrons move through the metallic crystal and are not held by any particular atom.
- The electron sea model explains the physical properties of metallic solids.
- Metal alloys are formed when a metal is mixed with one or more other elements.

