Preview

- Objectives
- Ionic Compounds
- Formation of Ionic Compounds
- A Comparison of Ionic and Molecular Compounds
- Polyatomic Ions

Objectives

- **Compare** a chemical formula for a molecular compounds with one for an ionic compound.
- **Discuss** the arrangements of ions in crystals.
- **Define** *lattice energy* and explain its significance.
- **List** and compare the distinctive properties of ionic and molecular compounds.
- **Write** the Lewis structure for a polyatomic ion given the identity of the atoms combined and other appropriate information.

End Of Slide

Ionic Compounds

- Most of the rocks and minerals that make up Earth's crust consist of positive and negative ions held together by ionic bonding.
  - example: table salt, NaCl, consists of sodium and chloride ions combined in a one-to-one ratio—Na^+Cl^-—so that each positive charge is balanced by a negative charge.
- An **ionic compound** is composed of positive and negative ions that are combined so that the numbers of positive and negative charges are equal.

End Of Slide

Ionic Compounds

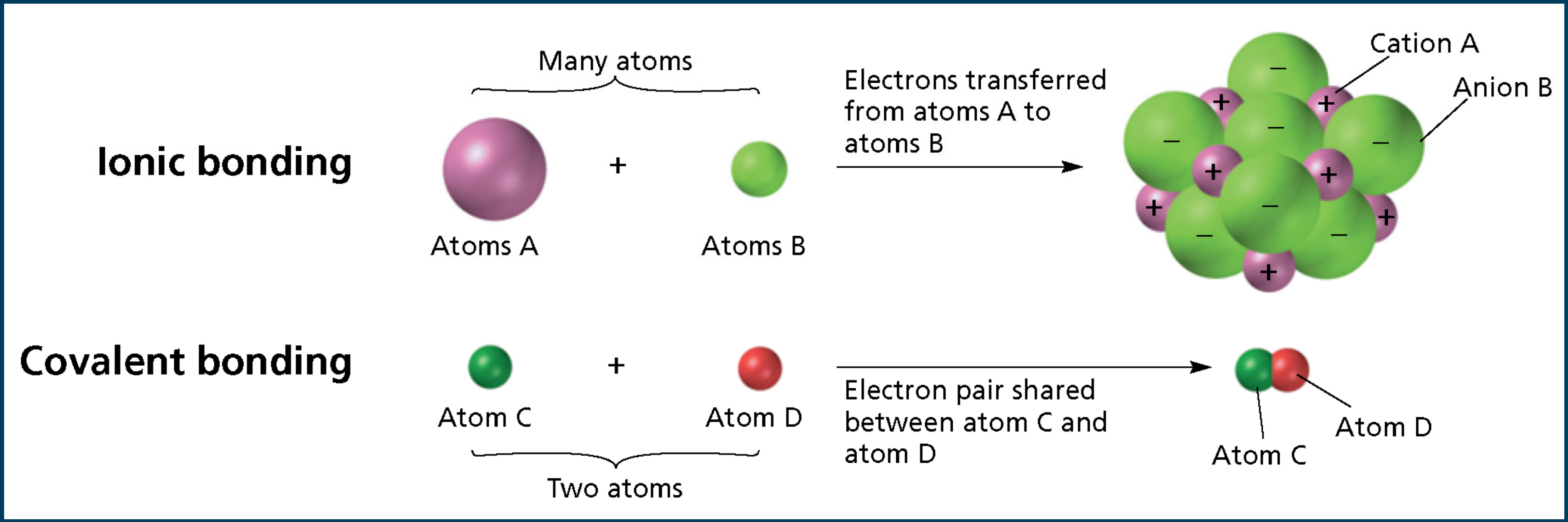
- Most ionic compounds exist as crystalline solids.
- A crystal of any ionic compound is a three-dimensional network of positive and negative ions mutually attracted to each other.
- In contrast to a molecular compound, an ionic compound is not composed of independent, neutral units that can be isolated.

Ionic Compounds, *continued*

- The chemical formula of an ionic compound represents not molecules, but the simplest ratio of the compound's ions.

- A **formula unit** is the simplest collection of atoms from which an ionic compound's formula can be established.

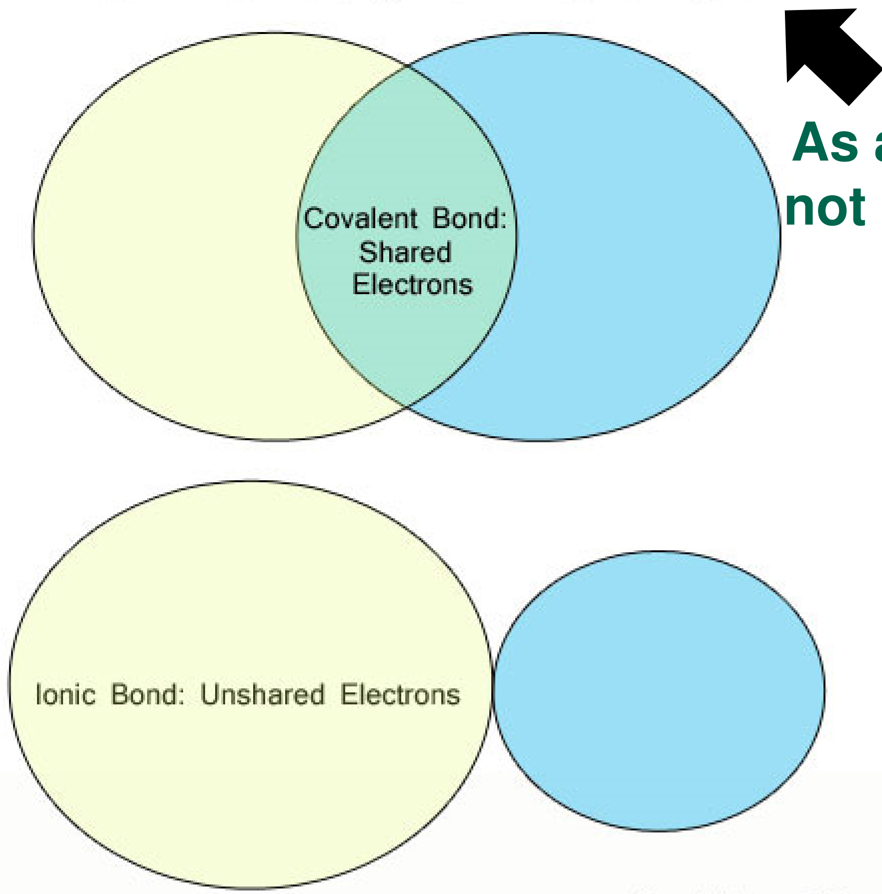
Ionic Vs. Covalent Bonding



Covalent vs. Ionic Bonds in Chemistry

Yes... It Really Is This Simple.

As a concept; not in practice



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Formation of Ionic Compounds

$\mathrm{Na}\cdot$ Sodium atom

$:\ddot{\mathrm{Cl}}\cdot$ Chlorine atom

- The sodium atom has two valence electrons and the chlorine atom has seven valence electrons.
- Atoms of sodium and other alkali metals easily lose one electron to form cations.
- Atoms of chlorine and other halogens easily gain one electron to form anions.

$$\underset{\text{Sodium atom}}{\mathrm{Na}\cdot} + \underset{\text{Chlorine atom}}{:\ddot{\mathrm{Cl}}\cdot} \longrightarrow \underset{\text{Sodium cation}}{\mathrm{Na}^{+}} + \underset{\text{Chloride anion}}{:\ddot{\mathrm{Cl}}:^{-}}$$

Formation of Ionic Compounds, *continued*

- In an ionic crystal, ions minimize their potential energy by combining in an orderly arrangement known as a *crystal lattice.*
  - Attractive forces exist between oppositely charged ions within the lattice.
  - Repulsive forces exist between like-charged ions within the lattice.
- The combined attractive and repulsive forces within a crystal lattice determine:
  - the distances between ions
  - the pattern of the ions' arrangement in the crystal

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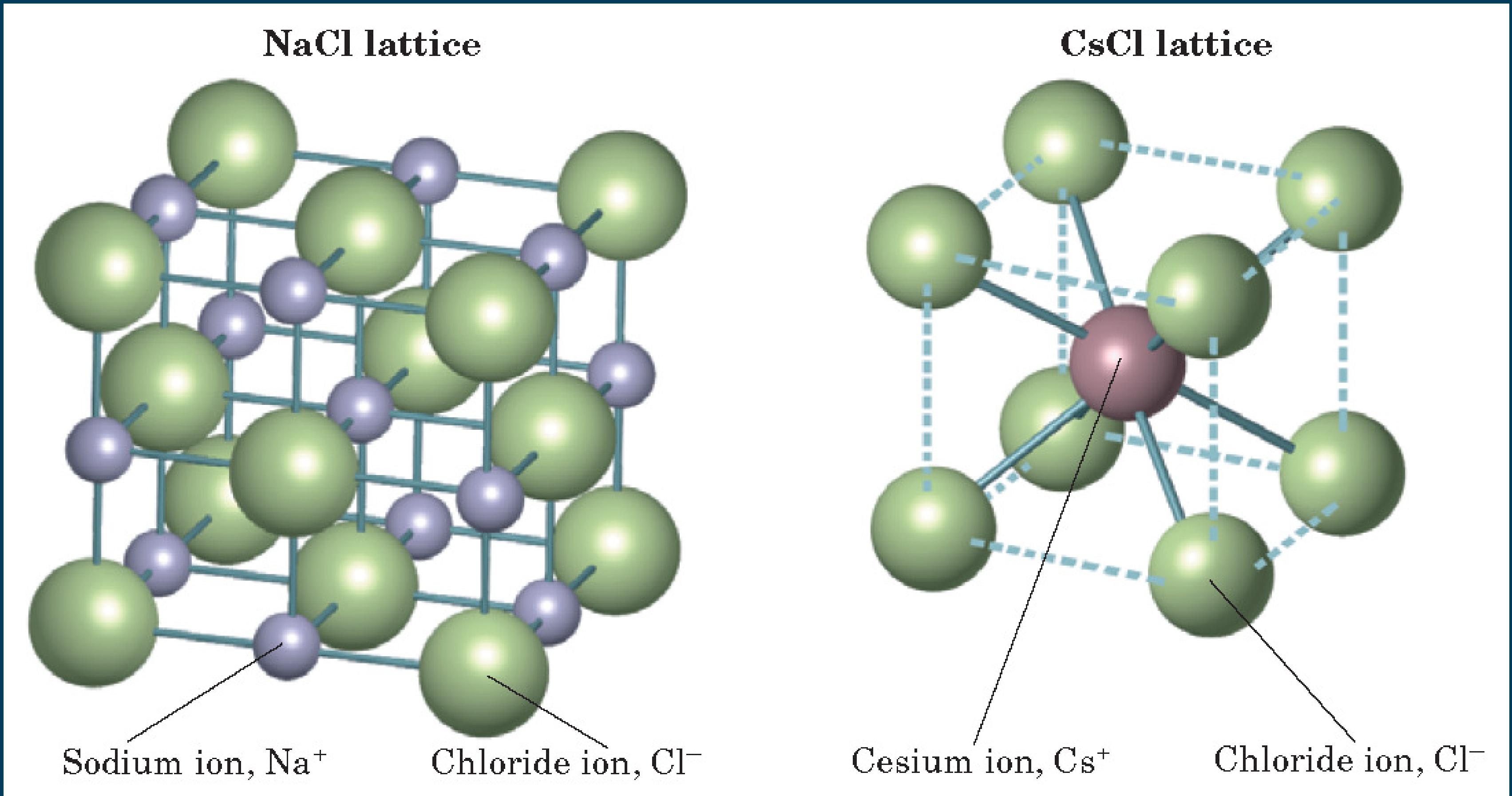
NaCl and CsCl Crystal Lattices



A Comparison of Ionic and Molecular Compounds

- The force that holds ions together in an ionic compound is a very strong electrostatic attraction.
- In contrast, the forces of attraction *between* molecules of a covalent compound are much weaker.
- This difference in the strength of attraction between the basic units of molecular and ionic compounds gives rise to different properties between the two types of compounds.

End Of Slide

A Comparison of Ionic and Molecular Compounds, *continued*

- Molecular compounds have relatively weak forces between individual molecules.
  - They melt at low temperatures.
- The strong attraction between ions in an ionic compound gives ionic compounds some characteristic properties, listed below.
  - very high melting points
  - hard but brittle
  - not electrical conductors in the solid state, because the ions cannot move

End Of Slide

Melting and Boiling Points of Compounds

Compound name	Formula	Type of compound	Melting point °C	Melting point K	Boiling point °C	Boiling point K
Magnesium fluoride	MgF_2	ionic	1261	1534	2239	2512
Sodium chloride	NaCl	ionic	801	1074	1413	1686
Calcium iodide	CaI_2	ionic	784	1057	1100	1373
Iodine monochloride	ICl	covalent	27	300	97	370
Carbon tetrachloride	CCl_4	covalent	–23	250	77	350
Hydrogen fluoride	HF	covalent	–83	190	20	293
Hydrogen sulfide	H_2S	covalent	–86	187	–61	212
Methane	CH_4	covalent	–182	91	–164	109

How to Identify a Compound as Ionic

You can carry out the following procedures in a laboratory to determine if a substance is an ionic compound.

- Examine the substance. All ionic compounds are solid at room temperature. If the substance is a liquid or gas, then it is not an ionic compound. However, if it is a solid, then it *may* or *may not* be an ionic compound.
- Tap the substance gently. Ionic compounds are hard and brittle. If it is an ionic compound, then it should not break apart easily. If it does break apart, the substance should fracture into tinier crystals and not crumble into a powder.

How to Identify a Compound as Ionic

- Heat a sample of the substance. Ionic compounds generally have high melting and boiling points.
- If the substance melts, use a conductivity apparatus to determine if the melted substance conducts electric current. Ionic compounds are good conductors of electric current in the liquid state.
- Dissolve a sample of the substance in water. Use a conductivity apparatus to see if it conducts electric current. Ionic compounds conduct electric current when dissolved in water.

Polyatomic Ions

- Certain atoms bond covalently with each other to form a group of atoms that has both molecular and ionic characteristics.
- A charged group of covalently bonded atoms is known as a **polyatomic ion.**
- Like other ions, polyatomic ions have a charge that results from either a shortage or excess of electrons.

End Of Slide

Polyatomic Ions

- An example of a polyatomic ion is the ammonium ion: NH_4^+. It is sometimes written as $[NH_4]^+$ to show that the group of atoms *as a whole* has a charge of 1+.
- The charge of the ammonium ion is determined as follows:
    - The seven protons in the nitrogen atom plus the four protons in the four hydrogen atoms give the ammonium ion a total positive charge of 11+.

End Of Slide

Polyatomic Ions, *continued*

- The charge of the ammonium ion is determined as follows, *continued:*
  - When nitrogen and hydrogen atoms combine to form an ammonium ion, one of their electrons is lost, giving the polyatomic ion a total negative charge of 10–.
  - The total charge is therefore (11+) + (10–) = 1+.

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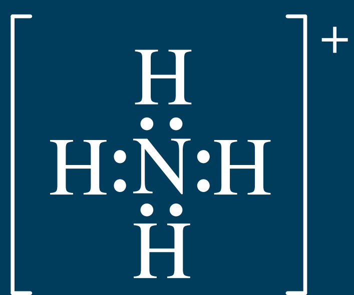
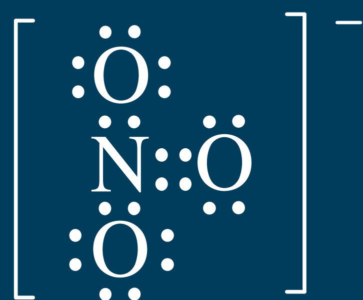
Polyatomic Ions, *continued*

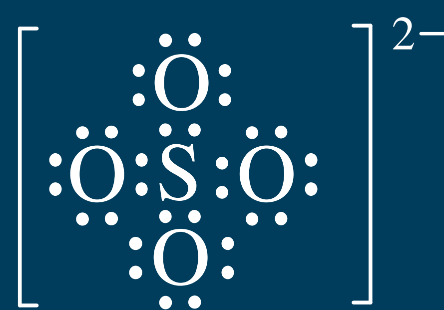
- Some examples of Lewis structures of polyatomic ions are shown below.



Ammonium ion



Nitrate ion



Sulfate ion

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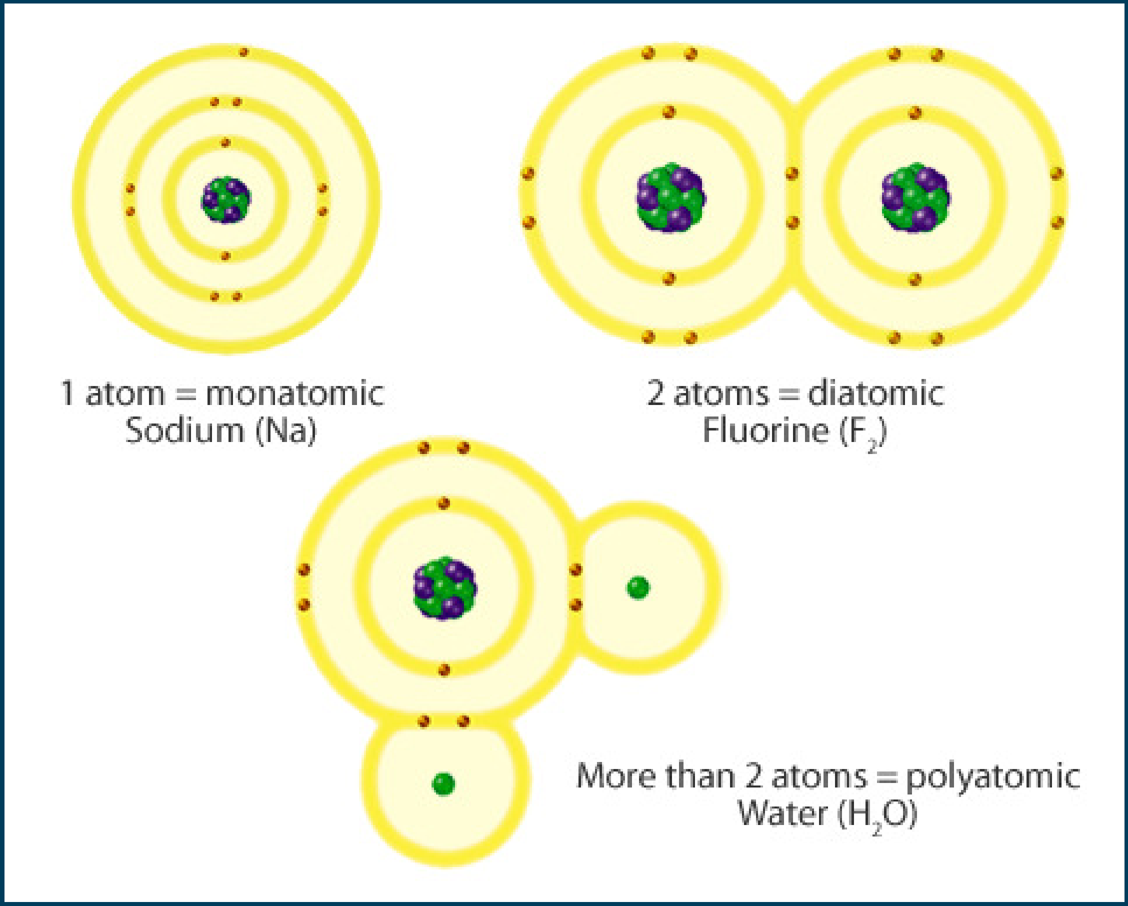
Comparing Monatomic, Polyatomic, and Diatomic Structures



Preview

- Objectives
- Metallic Bonding
- The Metallic-Bond Model

Objectives

- **Describe** the electron-sea model of metallic bonding, and explain why metals are good electrical conductors.
- **Explain** why metal surfaces are shiny.
- **Explain** why metals are malleable and ductile but ionic-crystalline compound are not.

End Of Slide

Metallic Bonding

- Chemical bonding is different in metals than it is in ionic, molecular, or covalent-network compounds.
- The unique characteristics of metallic bonding gives metals their characteristic properties, listed below.
  - electrical conductivity
  - thermal conductivity
  - malleability
  - ductility
  - shiny appearance

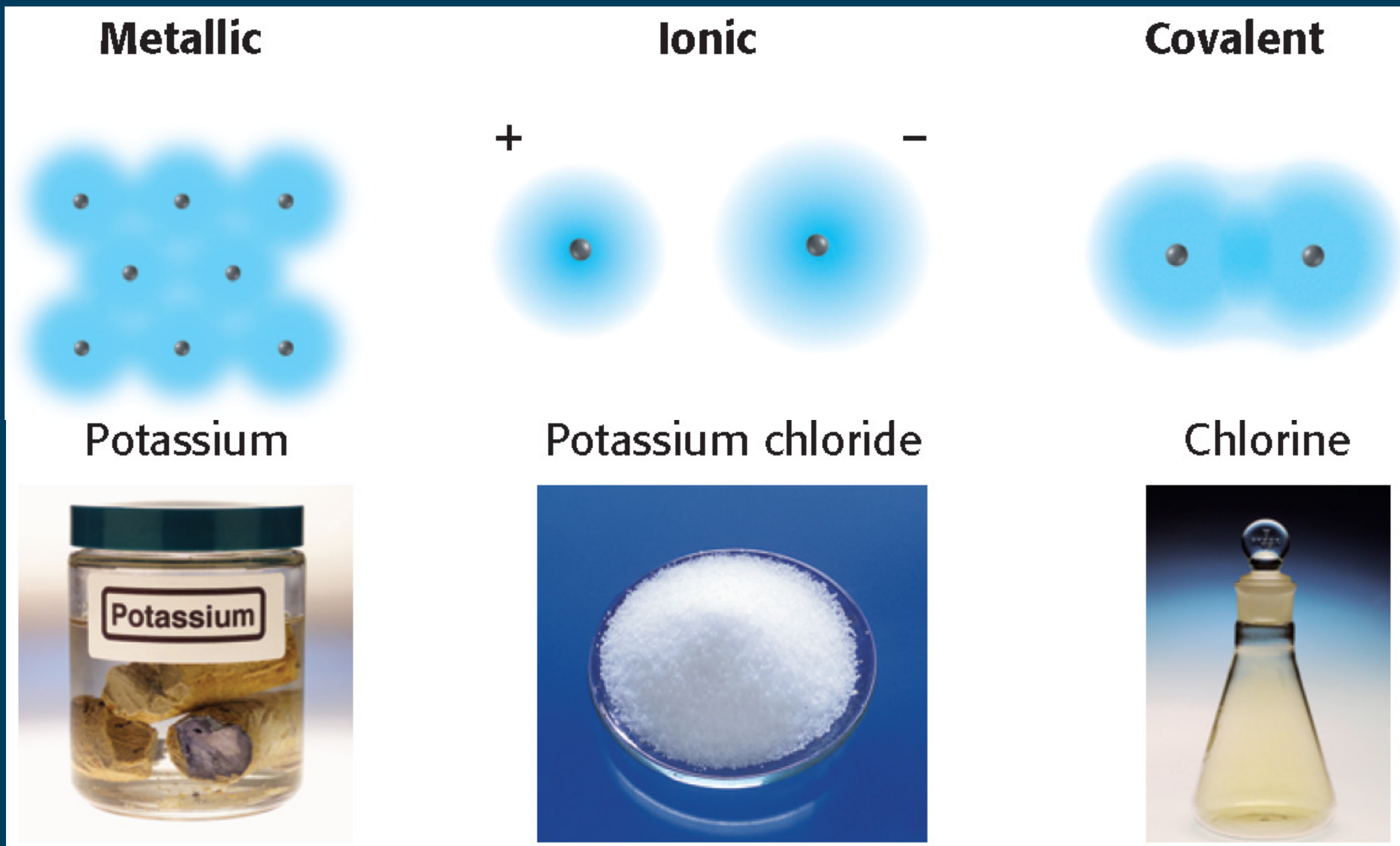
End Of Slide

Metallic Bonding, *continued*

- **Malleability** is the ability of a substance to be hammered or beaten into thin sheets.

- **Ductility** is the ability of a substance to be drawn, pulled, or extruded through a small opening to produce a wire.

Properties of Substances with Metallic, Ionic, and Covalent Bonds



The Metallic-Bond Model

- In a metal, the vacant orbitals in the atoms' outer energy levels overlap.
- This overlapping of orbitals allows the outer electrons of the atoms to roam freely throughout the entire metal.
- The electrons are *delocalized,* which means that they do not belong to any one atom but move freely about the metal's network of empty atomic orbitals.
- These mobile electrons form a *sea of electrons* around the metal atoms, which are packed together in a crystal lattice.

The Metallic-Bond Model, *continued*

- The chemical bonding that results from the attraction between metal atoms and the surrounding sea of electrons is called **metallic bonding.**

End Of Slide